THE EFFECT OF COMBINING CULTIVARS OF LOLIUM PERENNE IN AN ALL GRASS SWARD ON TOTAL AND SEASONAL YIELD

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by

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INTRODUCTION

During the present century there has been a radical change in the components of seeds mixtures used in Britain. At the turn of the century the mixtures in use were of the type proposed by Elliot of Clifton Park and contained up to ten grass species, three clovers and various herbs.

In the light of modern knowledge the value of these extremely complex mixtures is very much in doubt and Stapledon in his introduction to Elliot's book, Elliot (1943) said "He (Elliot) could have obtained the results he desired with a reduced number of species and with a considerable consequential saving of money".

The first move away from the Clifton Park type of mixture came as a result of Gilchrist's work at Cockle Park. He reduced the number of species included and was also the first to appreciate the value of using specific strains. The success of his mixtures may be judged by the fact that today, some fifty years later, the so-called general-purpose mixtures which are widely used are of the Cockle Park type.

A further simplification of mixtures took place following on the work of Stapledon and his colleagues at the Welsh Plant Breeding Station. Their investigations directed interest to the differences that exist between cultivars of the same species and in particular the relative values of unselected commercial cultivars and those bred for a specific purpose. From this evolved today's "simple" mixtures of several cultivars of one or two grass species.

Although these mixtures are relatively simple they are complicated by the fact that differences in growth habit and cycle between cultivars of the same species can be as great as differences between species.

As it is an accepted fact that grass species compete with each other in a sward it is logical to assume that intra-specific competition will occur when cultivars of varying type are combined.

There is, however, relatively little information available pertaining to inter-cultivar competition and its effect on seasonal and total production. Doubtless the difficulty of identifying cultivars of a sroduction. Doubtless the difficulty of identifyin cultivars of aon-ships.

As the "simple" mixture is used today on a country-wide basis it is of some importance to determine the compatibility of cultivars and the contribution, both seasonal and total, that they make towards the productivity of a sward. Also to be considered is the persistency of cultivars under differing grazing and cutting managements and the interaction of these with cultivar productivity.

The investigations reported herein were carried out in order to measure the competition between cultivars of perennial ryegrass (Lolium perenne L.) which is the most important and widely used grass in Britain.

It was necessary in the course of the work to devise a technique whereby the cultivars could be identified when growing in the close association of a sward. Three related experiments (using the technique developed) were carried out. First, the yields and development of three chosen cultivars of Lolium perenne were measured, over three years, under simulated sward conditions. Secondly, a study of the effects of sheep grazing and hay-taking on inter-cultivar (Lolium perenne) relationships was made over two years. And, thirdly, the inter-competition of Lolium cultivars, during the establishment phase of a sward, was investigated during one growing season.

REVIEW OF LITERATURE

Inter-specific Competition

One of the theories put forward in support of mixtures containing more than one grass species is that the varying growth cycles displayed will dovetail together. Theoretically, this should lead to a more level seasonal production since, when one grass has passed through its most productive phase, another will make the running. As a consequence of this, a higher total production should also be possible.

Blaser, Skrdla and Taylor (1952) in their review of literature relating to the problems of compounding seeds mixtures stated that there was no increase in total production following the use of complex mixtures since any increase shown by one species was balanced by a corresponding loss in another. Neither could they find any instance reported whereby a more level seasonal production had been obtained as a result of using several species. They also stress that in farm practice it is impossible to find a management suitable for all components of a mixture and that therefore some will be favoured while others are depressed. This must ultimately lead to the species most suited to the management and environment becoming dominant.

The failure of complex mixtures is attributed by Stapledon (1939) to the selective grazing of animals removing the more palatable species and also to the great differences in growth form that can pertain between species.

A trial using mixtures containing timothy (Phleum pratense L.), cocksfoot (Dactylis glomerata L.), bent (Agrostis alba L.) and smooth stalked meadow grass (Pos pratensis L.) which was reported by Henson and Hein (1941) showed an advantage for the more complex mixtures in the first year when a higher yield was obtained than from meadow grass alone. Subsequently, however, all mixtures rapidly became dominated by meadow grass and at no time was mid-summer growth increased by the inclusion of several species.

Gregor (1940) reported that a mixture of perennial ryegrass, cocksfoot and timothy soon became completely dominated by the ryegrass and that the yield from the mixture in the second year was less than that from pure ryegrass or cocksfoot swards.

The trial reported by Wilson and Peake (1956) in which smooth brome (Zerna inermis Leyss) cocksfoot and red fescue (Festuca rubra L.) were grown alone and in all combinations was designed to test the assumption that a grass will maintain its individual growth characteristics when grown in combinations with other grasses. They found that cocksfoot, being the strongest growing grass, inhibited the other species so that they were unable to display their normal growth cycles. Aberg, Johnson and Wilsie (1943) working with mixtures of lucerne (Medicago sativa L.), red clover (Trifolium pratense L.), timothy and smooth brome found no significant gain or loss by combining species, any increase in one being offset by a loss in another. They state that the response of species in mixtures is of the complementary type rather than mutually beneficial or antagonistic.

The evidence against the materialisation of the theoretical advantages of more level seasonal production and higher total yield claimed for complex mixtures is, therefore, very strong.

Inter-cultivar Competition

The reasons underlying the inclusion of several cultivars of a species in a mixture are somewhat similar to those advanced for mixtures of species viz - more level seasonal output and greater ease of management due to differences in growth forms and palatability being less than between species. Stapledon (1939) did, however, acknowledge the fact that competition can exist between cultivars as in a mixture of hay and pasture cultivars a bulky hay crop may smother the prostrate pasture cultivar. Stapledon also pointed out that grazing in early spring, at the time when the hay cultivar is growing actively, will tend to suppress it. Conversely lax grazing in early spring followed by heavy grazing will be harmful to the late pasture cultivars. He did, however, regard the inclusion of early and late cultivars in a mixture as beneficial in giving more even herbage growth, at least in the early life of a ley. Davies (1939) suggested that since S.23 perennial ryegrass is so late in spring a mixture with any early growing cultivar is called for. Hunt (1957) also was of the opinion that a blend of cultivars would result in more even production provided the early growing types did not smother the later ones.

Jones (1958a) has described an experiment in which the competition between early and late cultivars of perennial ryegrass was measured. He confirmed Stapledon's statement that by varying the management in terms of time of cutting either the early or late cultivar would be favoured.

According to Charles (1961a) a mixture of early and late cultivars of the same species gave a more level production over the season in the early years of the trial but that this was later lost, due to the dominance of one cultivar over the others. He also reported that the persistence of Irish and S.24 perennial ryegrass was reduced when sown with S.23 perennial ryegrass. This, however, was influenced by management since after 5 years rotational grazing 95% of the tillers from an Irish/S.23 sward were of the S.23 type and 72% were S.23 in an S.24/S.23 sward. At another centre, after 6 years of continuous hard grazing, S.23 tillers made up 99% and 97% of the Irish and S.24 swards respectively. Differences in total yield of these ryegrass cultivar mixtures were small and mixtures containing one cultivar were as productive as those with two.

Gregor (1940) found a higher yield was obtained by combining Ayrshire and a late flowering ryegrass and similarly a mixture of early and late cocksfoots gave the highest yield. In agreement with this Hanson, Garber and Myers (1952) reported higher yields from mixtures containing two or more cultivars of smooth stalked meadow grass compared to the yields of single cultivars. In another trial Gregor and Watson (1954) found the competition between contrasting types of perennial ryegrass to be intense. Their results indicated that when grown alone all types were persistent but in competition one flourished at the expense of its partner in the mixture.

The complementary nature of the growth cycles of ryegrass cultivars is stressed by Hughes (1951), Hunt (1959), Hunt and Thomson (1955) and Prendergast and Brady (1955, 1955a). These workers found that the most successful method of utilizing the contrasting growth cycles of early and late ryegrasses was by sowing them in separate mixtures. By so doing each cultivar was able to exhibit, to the full, its own growth rhythm. This provided a more even spread of herbage growth and a longer grazing season. Prendergast (1959) suggested that as early types tend to become dominated by late types swards of different ages developed from mixed sowings may show the complementary advantages gained from separate sowings of early and late cultivars. He also reported on a trial in which a mixture of Irish and New Zealand gave a more productive sward than either alone.

Hunt and Thomson (1955) suggested that the tendency for quick growing early cultivars to dominate the late cultivars in the first year of a sward may be reduced by sowing a greater quantity of seed of the late type.

From the information available it can be appreciated that the simplification of mixtures to cultivars of a single species does not necessarily meet the needs of the farmer in supplying a high annual production of herbage, in steady increments, throughout the year. The position was well summed up by Jones (1939) who wrote "..... when a farmer includes in his seeds mixtures many strains of a species, the type of management practised during the first few years must, to a large extent, decide which of these types or strains will eventually dominate the sward".

Production of Ryegrass Cultivars

Much of the early work at the Welsh Plant Breeding Station was concerned with the evaluation of indigenous and commercial cultivars. The investigations reported by Jenkin (1930), Stapledon (1924), Stapledon and Jones (1925), Davies (1939) and Jones (1939) showed that in general the indigenous, or late, cultivars were less productive in the first harvest year but that, thereafter, their yields were better than commercial cultivars. This was not always the case as some trials showed the indigenous to out-yield the commercial even in the first year(Stapledon (1924)). Cooper and Saeed (1949) found Irish to commence active growth earlier in spring but that after the second cut its productivity decreased and total yield was significantly below bred cultivars. Davies (1952) also considered Irish to be of low productivity and persistency. These investigations, Jenkin (1930), Stapledon (1924), Stapledon and Jones (1925), Davies (1939) and Jones (1939), also demonstrated the effect of management on the relative yields of early and late cultivars, the early cultivars being favoured by a more lenient system of cutting and the late types showing at their best under hard grazing.

Sonneveld (1955) and Van den Bergh, de Boer and Van de Kaa (1958) have also shown that the management imposed on a sward influences the types of grass that survive. Cutting for hay was found to increase the number of early flowering hay types surviving, while grazing favoured the late prostrate types.

Gardner (1960) demonstrated that selection occurred in a population of Irish ryegrass under grazing conditions. After 11 years the surviving plants were slightly later in maturing and more leafy in autumn than newly propagated plants.

In Scotland co-ordinated trials on the relative production of ryegrass cultivars have been carried out by Copeman, Heddle, Hunt and Sampford (1958). Yields were determined by monthly cutting by an autoscythe and under this system Irish and New Zealand considerably outyielded S.23 although the difference was not so marked when 12 cwt. of 'Nitro-chalk' was applied during the growing season. The New Zealand cultivar was outstanding in all trials having the highest yield and a very level seasonal output.

A somewhat similar trial carried out in Northern Ireland by McFetridge, Boyd, Kelly and Linehan (1958) placed the cultivars in much the same rank as the Scottish workers. The relative yields for New Zealand, Irish and

S.23 were given as 111, 99 and 93 respectively. No interactions were recorded between cultivars and level of nitrogenous manuring and since cultivar differences amounted to only 18% between the highest and the lowest and manuring differences were as high as 85% it was concluded that choice of cultivar was of little importance.

Another Irish trial reported by Proudfoot (1957) again confirmed the findings of Copeman et al. (1958) that earlier flowering cultivars were more productive than later flowering.

Hughes (1956) compared Irish and S.24, which is a similar type to New Zealand, under grazing and hay-and-aftermath treatments. He found that S.24 was by far the better cultivar and outyielded Irish under all management systems. When the production of the "Irish sward" as a whole (including unsown species) was compared with the "S.24 sward" the superiority of the S.24 component was masked especially where no additional nitrogen had been applied. The spread of the unsown species, rough stalked meadow grass (Poa trivalis L.) and an increase in the white clover contribution boosted the yield of the "Irish sward." A similar effect was noted by Proudfoot (1957), Hunt and Thomson (1955) and Prendergast (1959).

Trials carried out by Heddle, Dawson and Gregor (1950), showed that time of cutting can influence the results obtained in cultivar comparisons. When the plots were cut according to stage of growth rather than by calendar date the late cultivars gave much higher yields whereas when a monthly cutting regime was imposed results similar to those already mentioned, Copeman et al. (1958), McFetridge et al. (1958) and Proudfoot (1957) were obtained.

A grazing trial conducted by Hunt and Thomson (1955) showed a slight advantage for S.23 over Irish in both herbage and livestock starch equivalent production. This result is a reversal of the position as found by

Hunt (1956) when S.23 and Irish were compared by monthly cuts. This was partly attributed to the fact that, when cut by an autoscythe, the yield of S.23 was underestimated as much of the herbage was below the level of the cutting bar.

Jones (1958) compared an early and late cultivar of cocksfoot cut by autoscythe and hand shears and found that the yield of the early cultivar as estimated by the autoscythe was 86% of the hand shear cut, while for the late cultivar it was only 39%. Davies (1956) found that by using hand shears S.23 yielded as much as Irish, even in spring, when the early growing Irish should have had the advantage. In another experiment Davies (1960) reported that although S.23 had similar tiller numbers and weight per tiller as Irish in spring, yields estimated by mower cuts placed Irish well ahead.

It is apparent from the foregoing reports that the yield of cultivars is strongly influenced by (a) frequency of defoliation, (b) height of cut and (c) level of nitrogenous manuring. The interaction between cultivars and method of assessment makes it very important to interpret results with this fact clearly in mind.

<u>Morphological and Physiological Background to Cultivar Differences</u>

The persistence of cultivars of perennial ryegrass has been shown by Cooper and Saeed (1949) to be closely linked to the number and frequency of flowering tillers produced. These workers reported that early hay types, such as Irish, which produce large numbers of flowering heads weaken themselves in the process. When the flowering shoot elongates the ~~auxiliary~~ AXILLARY buds are inhibited and relatively little leaf is produced. This reduction in photosynthetic area must lower the rate of carbohydrate production which means less material available to initiate regrowth after defoliation. They further state that, during flowering, there is a movement of the reserve carbohydrates from the roots to the flowering shoots which causes a stoppage in root growth and loss in weight. This has also been noted by Roberts and Hunt (1936), Baker (1957), Weinmann (1948), Jones (1958) and Roberts and Struckmeyer (1946). Soper (1958) found that death of plants after flowering was directly proportional to the amount of flowering. Crider (1955) reported a stoppage of root growth in grasses following defoliation.

Davies (1956) observed that pasture cultivars regrew more quickly after cutting than hay cultivars. This was explained by a hypothesis that, when a plant is cut during a period of head production, any reproductive tillers that are cut will die and that in consequence the higher the ratio of fertile to barren tillers the more pronounced the depression in growth. Davies (1956) also showed that persistence and aftermath shooting are related since a plant producing many heads in autumn cannot store a sufficient reserve. As autumn shooting is one of the characteristics of early cultivars their lack of persistence can be partly attributed to this habit.

Jones (1958) discussed an experiment with timothy cultivars in which it was found that when cutting only removed vegetative portions, without damage to stem apices, each tiller was capable of immediate regrowth. When the stem apex was removed or damaged that tiller was incapable of regrowth and the basal buds were stimulated to grow. These new tillers were, however, slower to develop than uninjured tillers. Early cultivars, which are more erect than late cultivars will therefore suffer a setback as described, thus making their recovery after defoliation slow in comparison with prostrate, late cultivars. Davies (1952) attributed the poor persistence of early commercial cultivars to their being more erect and in consequence being eaten out by stock. According to Langer (1959) when shoot apices were removed by cutting,the ability of the plant to recover was dependent on the number of vegetative tillers remaining and the capacity of the plant to produce new tillers.

Sullivan & Sprague (1943) followed changes in the carbohydrate content of perennial ryegrass roots following cutting and found that the water soluble carbohydrate decreased for a few days and then increased. This was considered as evidence that these compounds were in fact reserve substances that were mobilized to promote fresh growth after cutting. When defoliated plants were placed in a darkroom, the soluble carbohydrates fell continuously to the point of exhaustion thus showing the necessity for photosynthesis in replenishing the reserves. Contrary to this Mitchell (1954) found no evidence to suggest that after defoliation the roots supplied carbohydrates to the developing leaves. He was of the opinion that the decrease in root growth following cutting could be explained by the failure of fresh assimilate to reach the roots, rather than a transference from the roots to the tops.

Mode of Competition

Weaver and Clements (1938) have defined competition as "essentially a decrease in the amount of water, nutrients or light available for each individual". They largely discount competition for actual space both above and below ground. Their findings suggested that the greatest competition is between individuals or species which make similar demands on the available nutrients and light, and least among plants absorbing at different levels and whose vegetative development is at different heights.

Varma (1938) found that competition was usually most severe between unlike species but in some cases the reverse could be true. The general pattern of competition outlined showed that similar individuals could exist together even if in an impoverished condition. As differences between individuals developed there was a greater chance of one becoming dominant over the other. Competition increased up to a maximum as differences widened, then, beyond this, competition decreased again until a point was reached where the species were so different as to be complementary in their growth habits and competition was at a minimum.

Such a sequence was suggested by Jones (1958) when he showed that competition was greater between an early ryegrass and cocksfoot than between an early ryegrass and bent (Agrostis spp.). The bent was so late growing in spring that it did not interfere with the recovery period of the early ryegrass whereas the cocksfoot did.

Davies (1928) considered that mutual shading was the main factor in competition between plants. He largely discounted root competition pointing out that Italian ryegrass was equally aggressive towards lucerne and rough stalked meadow grass which exhibit completely contrasting rooting habits. Ahlgren and Aamodt (1939) on the other hand found harmful root interactions between species. In subsequent investigations Donald (1946) and Aberg, Johnson and Wilsie (1943) could not confirm that there were any harmful root interactions and rejected this as a mode of competition.

Varma (1938) and Benedict (1941) demonstrated that decaying roots could produce toxic compounds which would depress the growth of an associated plant. Varma's experiments with Brassicas also suggested that competition between plants might be due in part to soluble toxic substances exuded by living roots.

The importance of light in determining pasture yield is stressed by Donald (1951) who said that if water and nutrients are in adequate supply the ceiling yield will be determined by competition for light.

Mitchell (1953, 1953a, 1954, 1954a) demonstrated from a series of investigations the role that light plays in the development of ryegrass and also the comparative effects of defoliation and shading. He showed that the rate of leaf formation was dependent on the amount of light available. Plants cut down to 1 inch and grown in a greenhouse which excluded only 35% of available light soon produced numerous new tillers but when severely shaded only 2 or 3 tillers developed in the next 27 days (1953a). Mitchell (1954a) also found that shading to 30% daylight gave as great a reduction in tissue formation as two defoliations a week apart. Another report by Mitchell and Coles (1955) indicated that the number of tillers formed by a plant was dependent on the total light energy available and not merely that penetrating to the base of the plant. Lucanus, Mitchell, Pritchard and Calder (1960) demonstrated how shading ryegrass plants to 20 - 25% daylight showed a reduced survival in the ratio 100:54. FOR UNSHADED AND SHADED PLANTS.

Davidson and Donald (1958) in their work with subterranean clover (Trifolium subterranean L.) maintained that as a plant grew the upper leaves of the canopy shaded the lower ones to such an extent that the respiratory losses of the lower leaves were greater than their gain by photosynthesis. These leaves then became parasitic, obtaining their metabolite by translocation from the upper leaves. Should the lower parts of the plant become so deeply shaded that the respiratory losses of the plant as a whole are greater than its photosynthetic activity, it will die unless it discards some of the lower leaves. These statements do, of course, refer to clover and, as pointed out by Brougham (1958), pasture species with narrow leaves will allow more light to pass into the lower layers. Therefore a considerable proportion of all leaf blades will receive some light and senescence of leaves by shading will be reduced. Grass leaves can, however, exert a considerable shading effect as shown by Sprague and Garber (1950) who found that cutting grass when it was 8 - 10 inches high permitted good clover development but allowing it to reach a more advanced stage markedly reduced the amount of clover present.

Blackman and Black (1959) reported a differential response to shading of cultivars of perennial ryegrass, cocksfoot and timothy. With cocksfoot and timothy the early hay cultivars were least tolerant of shade. But comparing S.24 and S.23 perennial ryegrass they found that S.23 was superior in growth rate except in the deepest shade.

Norman (1960) in a series of trials which assessed the effects of defoliation and competition under pasture conditions showed how shading can induce a plant to assume a more upright habit and so render itself more vulnerable to defoliation. He also showed how competition can increase the top root ratio which again weakens a plant after cutting or grazing, and that selective grazing considerably reduces the relative vigour of a species making it more easily suppressed by subsequent competition.

The competition for light and nitrogen and the interaction between them has been studied by Donald (1958) using perennial ryegrass as the aggressor species and canary grass (Phalaris tuberosa, L.) as the suppressed species. The technique employed was such that four levels of competition could be studied - no competition, competition for light, competition for nitrogen and competition for both light and nitrogen. His results showed that competition for nitrogen reduced leaf development in the canary grass by 75%. Thus its capacity to utilize light was indirectly affected. Similarly, shading of the canary grass by the ryegrass not only reduced photosynthetic activity but reduced the uptake of nitrogen by 20%. When both forms of competition were operating the resultant depression of canary grass was much larger than the sum of the two separate forms of competition. The actual effect on the canary grass was to reduce both the size and number of tillers.

Chippindale (1932) demonstrated that seedlings of a suppressed species could persist in an arrested form for a considerable time and recover on the removal of the aggressive species.

It is apparent that, when the supply of moisture and nutrients are not limiting, the main factor in competition between pasture species is mutual shading. This effect is indirect because the plants' reduced ability to photosynthesise reduces the uptake of nutrients.

Experiment 1.

The Yield, Persistency and Development of Perennial Ryegrass Cultivars when Grown Together Under Sward Conditions.

INTRODUCTION

The use of contrasting cultivars of perennial ryegrass in a seeds mixture is justified by the hypothesis that the varying growth cycles will be complementary and result in a more even distribution of production. While the percentage of tillers of certain cultivars in mixtures has been investigated Charles (1961), the actual contribution to seasonal and total yield has never been determined.

Experiment 1 was designed to provide information on these aspects by measuring the yield of cultivars of perennial ryegrass when grown in the close association of a sward and also to record their persistence and development. A condensed account of the techniques used in this investigation has already been published, Gardner (1960a).

The cultivars chosen were Irish commercial, New Zealand Certified (mother strain) and S.23, which are described as "stemmy-early", "leafy-early" and "late maturing", respectively.

EXPERIMENTAL METHOD

Design and Treatments

The treatments consisted of 3 cutting frequencies applied to the 7 possible combinations of Irish, New Zealand and S.23 ryegrass.

A split-plot randomised-block layout was chosen as the treatments readily lent themselves to this arrangement. Since the greatest interest lay in the comparisons between cultivar combinations these were treated as sub plots. The cutting-frequencies therefore became the main ~~plots~~ TREATMENTS which was convenient for sampling since a complete ~~main~~ plot could be cut at each date. With 4 replications (BLOCKS) this gave a total of 84 SUB plots.

The frequencies of cutting, which comprised the 3 main plots of the experiment, were determined by the time taken for each cultivar to reach a grazable height of 18 cm. when grown alone. Thus for the so-called Irish cutting frequency all sub-plots within this main plot, including its sub plots of pure sowings of New Zealand, S.23, Irish and their combinations, were cut every time the pure sown Irish sub-plot reached a height of 18 cm.

Similarly the New Zealand and S.23 cutting frequencies were associated with the time when their New Zealand and S.23 sub-plots respectively reached 18 cm.

This meets the criticism frequently made of experiments comparing early and late cultivars that one chosen frequency of cutting will favour one or other type and be disadvantageous to the other.

Equipment for Identification of Cultivars

As the three cultivars of ryegrass used are indistinguishable under pasture conditions a technique was devised to allow rapid and easy identification and sampling when the plants were growing in the field.

The basic equipment was a wire mesh fixed at soil level in which the plants were grown. Galvanised steel rods $\frac{1}{8}$" diameter welded together in a 2" square mesh were used (this material is sold commercially as "Weldmesh" by the B.R.C. Engineering Co. Ltd., Stafford).

Before placing the mesh in position the wires of each square, within the sampling areas, were painted either red, blue or yellow as shown in figures 1.1 and 1.2. This colour code was used throughout the experiment to represent Irish, New Zealand and S.23 ryegrass respectively.

A sampling area consisted of 36 squares occupied by 1 cultivar or by 18 plants of each of 2 cultivars or by 12 plants of each of 3 cultivars. The 36 squares of the sampling area were surrounded by 2 discard rows thus completing a plot. The arrangement of 1 replicate and the detail of 2 plots are shown in figure 1.3. A total of 1740 plants was required per replicate. Of these only 756 were actually used in sampling, the remainder being necessary as discards to minimise edge effects.

Source of Seed

The S.23 seed was obtained from the Welsh Plant Breeding Station and the Irish and New Zealand by arrangement with a seeds merchant.

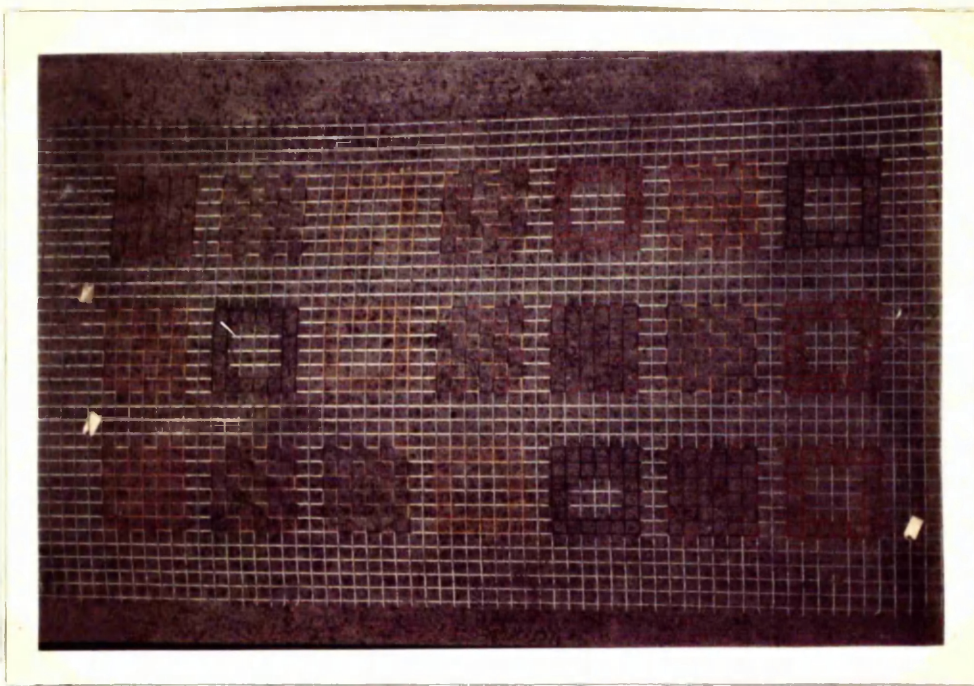


Figure 1.1 A complete replicate showing coloured sampling areas. The three main plots lie in the horizontal plane and each one contains the same seven cultivar treatments (sub plots).

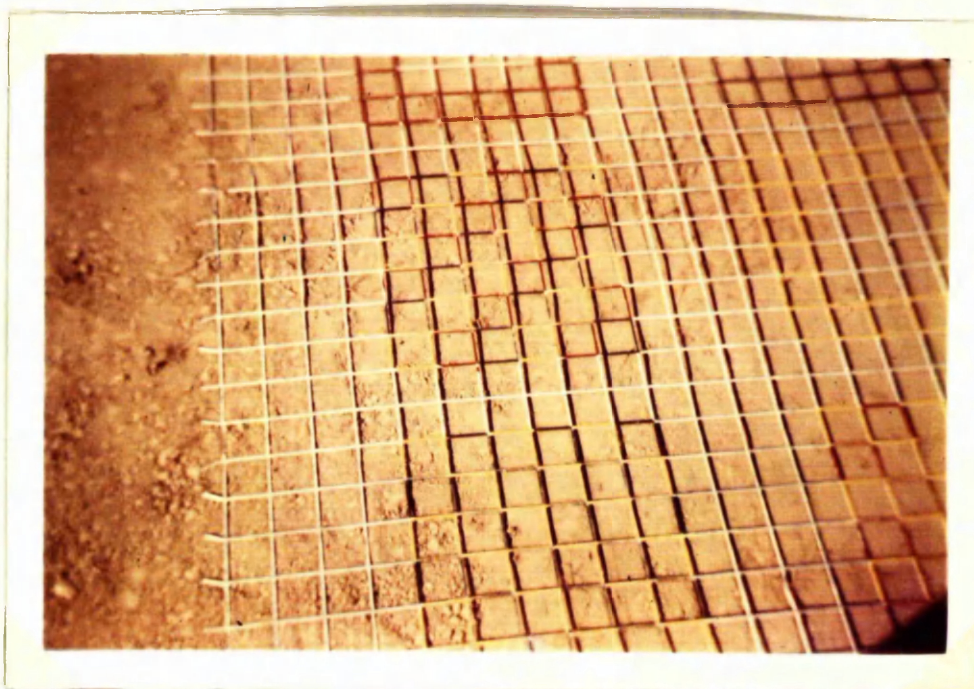


Figure 1.2 Wire mesh in position prior to planting. The coloured squares are the sampling areas.

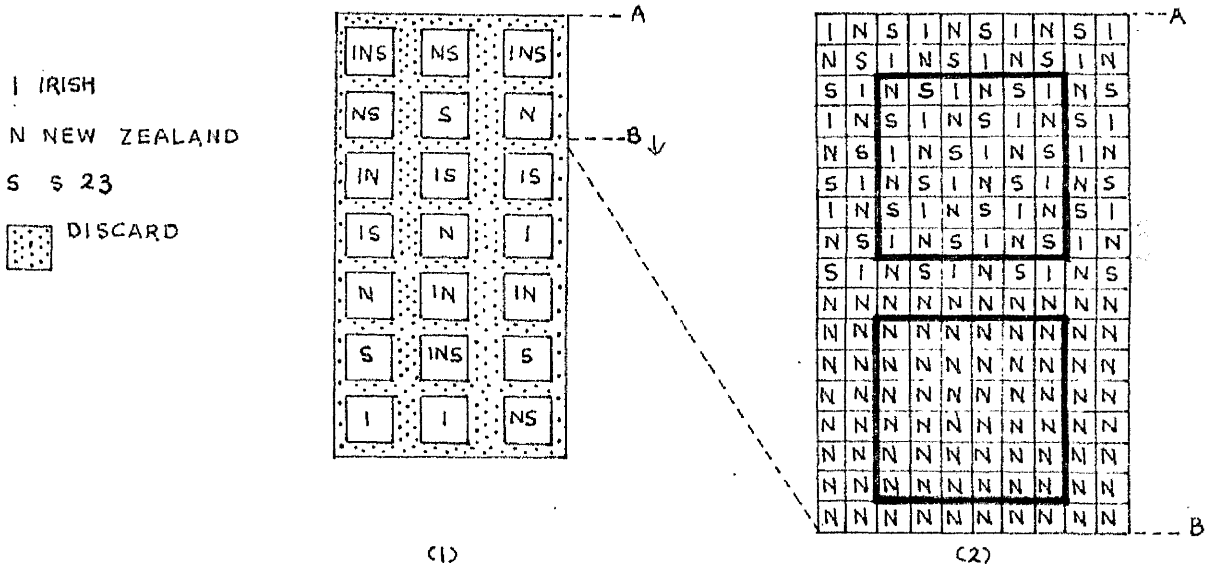


Figure 1.3 (1) Arrangement of plots in one replicate and (2) arrangement of plants within two plots. The sampling areas are enclosed by the heavy lines.

Equipment for Plant Propagation

To guard against the possibility of seed being washed or blown from one square to another during the establishment period the plants were propagated in a greenhouse in individual paper containers by a modified version of the technique described by McAlister (1943). The construction of the boxes (which held the paper containers) was simplified by nailing short lengths of wood (5" x 7/8" x ½") at ⅛" spacing at either end of a box. These being ½" thick allowed a degree of tolerance in the length of the boxes, which varied slightly, and provided support for the metal slides which held the paper containers in position while the box was being filled. Figure 1.4 shows a partly filled box with the slides in position and figure 1.5 a completed box.

Newsprint cut into 5" x 5" squares was used as containers. The square section was obtained by wrapping the paper squares tightly around the wood and metal device shown in figure 1.6. Six squares could be shaped at a time, then slipped into position (in this also the method differed from that of McAlister). Approximately 750 containers were fitted into each box and with 4 boxes per cultivar an ample margin was allowed for possible loss of plants.

The soil to fill the paper containers was sieved and the equivalent of 3 cwt. per acre 'Nitro-chalk' worked in before filling.

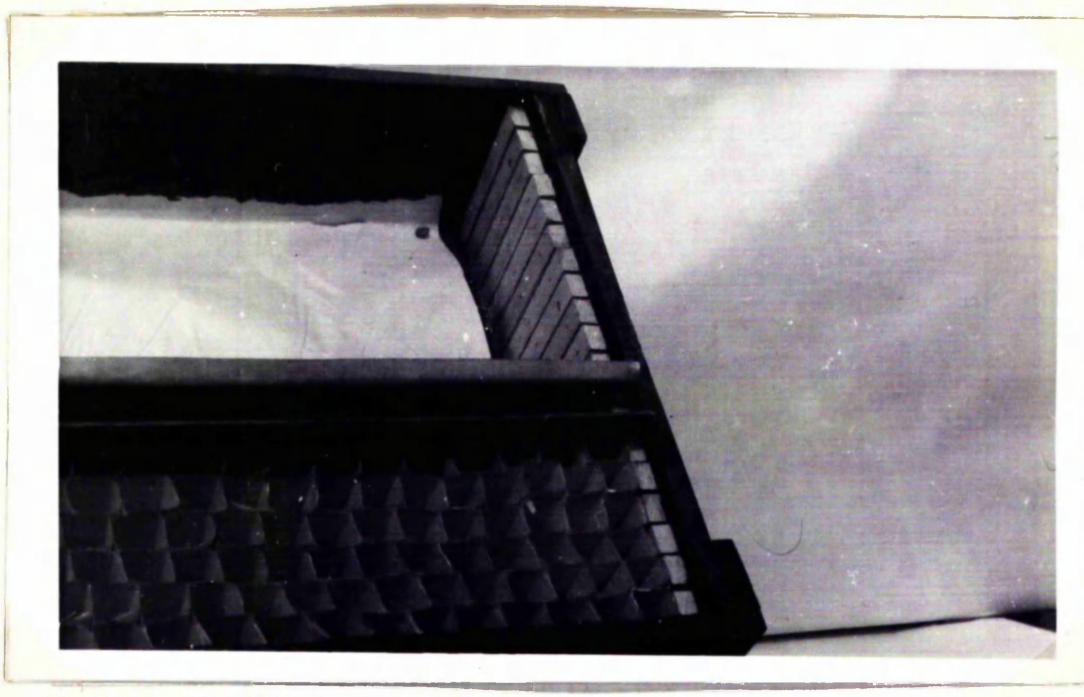


Figure 1.4 A box partly filled with paper containers. The metal slides which held the paper containers in position while a row was being completed can be seen.

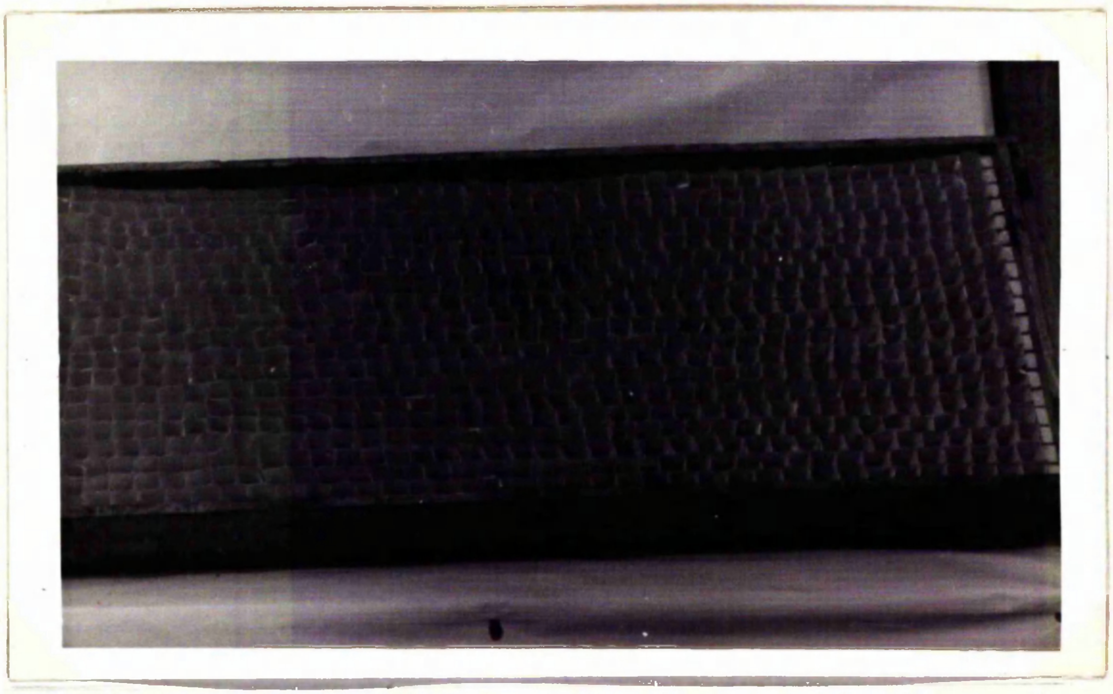


Figure 1.5 A box completely filled by paper containers ready to receive soil and seed. Twelve such boxes were required.

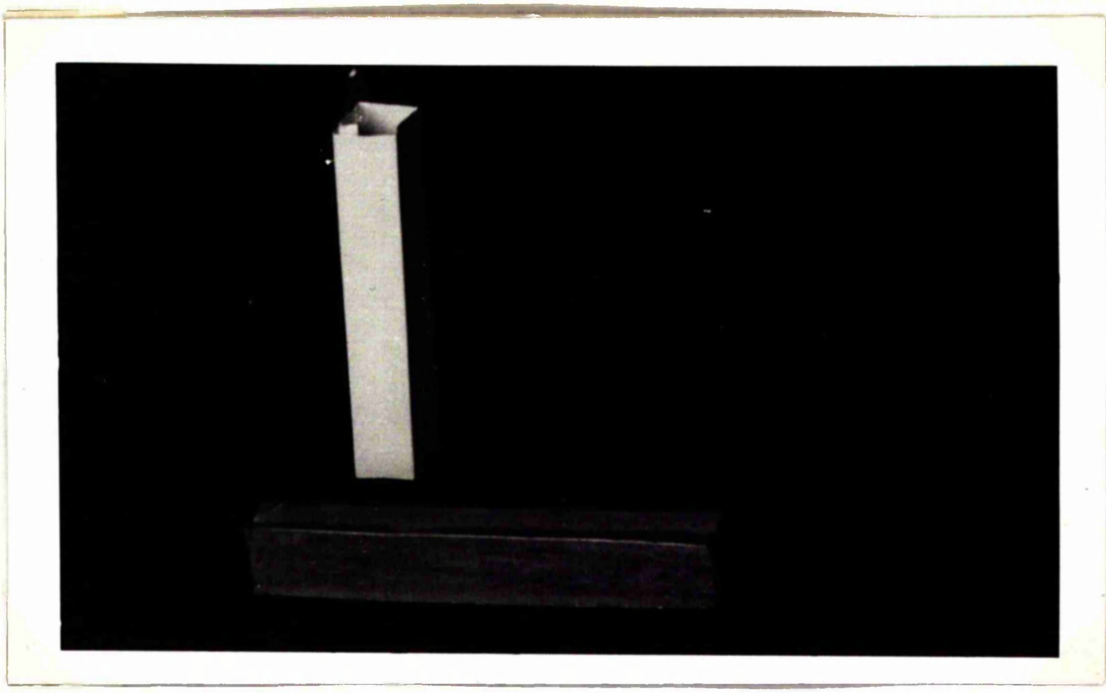


Figure 1.6 Wooden block with metal edges used to shape paper containers, one of which is also shown.

Propagation and Field Establishment of Plants

The seeds were germinated on blotting paper then transferred to an unheated greenhouse where one seed was planted in each container during the last week of April 1957. A 100% stand was obtained but after a few weeks the plants were seen to be yellowing. This was corrected by watering on a solution of potassium nitrate as it was suspected that the breakdown of the paper containers was causing a nitrogen deficiency.

The field site was prepared by ploughing out a meadow fescue sward followed by rotovation, levelling and rolling. Stones and weeds were removed by hand. The wire meshes were laid in position and held flat by looped wires and corner stakes driven into the ground. Dibbling the plants into their pre-determined positions was commenced on June 28th and completed by July 3rd, 1957. Figure 1.7 shows the plants in their paper containers at this stage and figure 1.8 gives a general view of the 4 replicates with the artificial swards established.

Sampling

Identification of sampling areas The sampling area within each sub plot was marked by 4 upright wires. The wire in one corner was painted in the colour or colour combination representing the cultivars within that area. These aids proved invaluable in speeding up sampling by removing the necessity for counting squares and facilitated the identification of squares where the paint on the mesh had become obscured or removed.

Exposing the sample The late summer and autumn of 1957 was used to work out a sampling technique which could be rapidly executed, easily demonstrated, and ensure identical treatment for every plant.

Figure 1.7 Plants in paper containers at the time of planting out.

Figure 1.8 General view of the four replicates showing the established swards which, at this time, had just been clipped.

The first step was obviously to expose the sampling area by cutting away the discard rows. To ensure complete separation of discard from sampling area an attempt was made to slip a hardboard box over the 4 corner wires of a sampling area then cutting away the discard plants, removing the box, and taking the actual sample. This was found to be very slow and was abandoned. It soon became obvious that a method of ensuring an even height of cutting was necessary as, with several people sampling, the personal factor was certain to exert an influence.

Both of these problems were overcome by the use of pieces of hardboard 2" high, slightly longer than the sampling area, and held in an upright position by a block of wood (2" x 1") attached to one end (Figure 1.9). This was slipped along the dividing wire between the discard and sampling areas then each plant of the discard area was gathered individually in one hand, pulled upright and cut with sheep shears resting on the top edge of the hardboard.

Taking the sample Having exposed the plants to be sampled they were cut row by row in a similar manner to the discard after pushing the hardboard strip along behind the row to be cut. As each plant was clipped its top-growth was placed in a wooden container of the same colour as the square from which it came (Figure 1.10). This process was repeated until all six rows of the sampling area had been cut. The grass in the coloured boxes was then transferred to small cotton bags in which it was oven dried overnight at 98°C.

Each spring it was found necessary to expose the surface of the wires before sampling could commence as they had, in many cases, become obscured by soil.

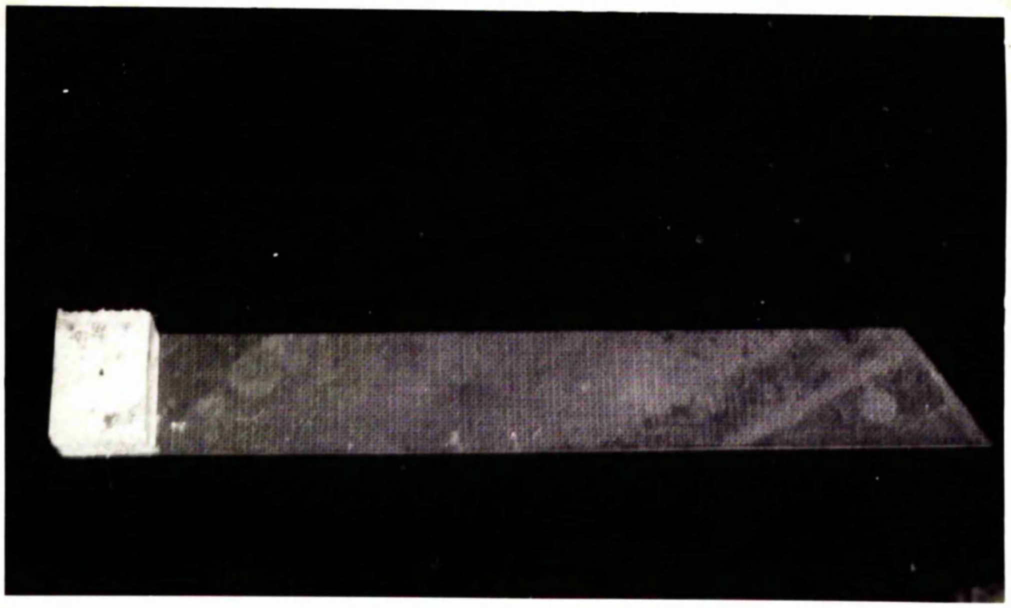


Figure 1.9 Hardboard strip used in sampling to ensure a constant height of cut and to separate the rows.

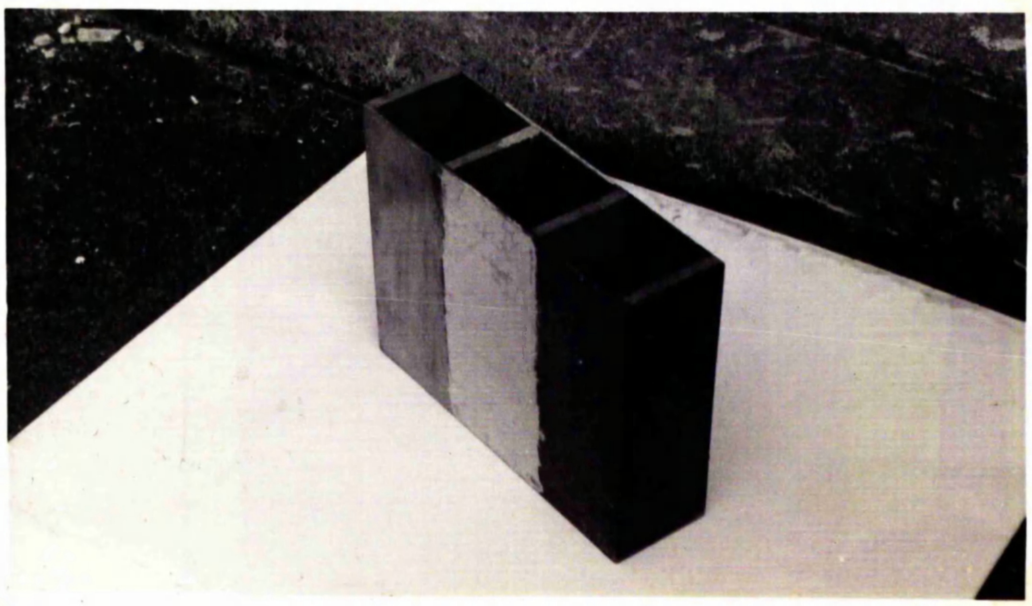


Figure 1.10 Boxes for collection of herbage cut in the field. Each division was coloured either red, blue or yellow to correspond to the coloured squares of the wire mesh.

By the end of the second harvest year when many squares of the mesh were blank and some plants had spread beyond their original square, charts of each plot were drawn on squared paper showing the position and approximate shape of each plant. Subsequent samplings were considerably speeded up by consulting the charts.

Measurement of Plant Height

The plant height measurements which decided when the plots were to be cut were made on 4 randomly selected plants from each of the respective single cultivar plots. The measurement was done by gathering a plant in one hand, pulling it upright and judging the modal height against a centimetre rule held at ground level. A cut was taken when the mean modal height of the plants in the 4 replicates was 18 cm.

Manuring

Following planting in June 1957 all plots received the equivalent of 3 cwt. 15% nitrochalk, 2 cwt. 18% supers and 1 cwt. 60% muriate of potash per acre. On April 9th, 1958 all plots received ammonium phosphate and potassium nitrate in solution to give a dressing equivalent to 58.5 lb. N, 80.6 lb. P_2O_5 and 134 lb. K_2O. Subsequent to this all manuring was on the basis of the technique described by McNeur (1953) by which a fertilizer mixture approximating the chemical composition of the herbage is applied in proportion to the amount of herbage removed. The mixture employed consisted of sulphate of ammonia, superphosphate, muriate of potash, blood and bone meal and dried blood. The chemical composition, as a percentage of the dry matter, was, nitrogen 11.4%, phosphate as P_2O_5 3.3%, potash as K_2O 10.7% and organic matter 66.4%. This mixture was returned to the plots at the rate of 184 g. per lb. of herbage dry matter removed. Ground limestone, to correct acidity, was added to the mixture before application at 65 g. per lb. of herbage dry matter.

Plant and Tiller Counts

Plant counts were made after the first cut each spring and again after the last cut each autumn.

Tillers were counted on 10th July, 1957 shortly after the plants had been established in the field. As the cultivar combinations had not had time to influence the results only the plots containing a single cultivar were counted. Twelve plants (along the 2 diagonals) were counted per plot.

Tiller counts were made on 6 plants of each cultivar in all plots each autumn. The counts were made along the diagonals chosen at random and where plants were missing the counting was continued to neighbouring rows until 6 were counted. At the final count in November 1960 all plants were lifted and the tillers counted indoors. When more than 6 plants were present a sample was drawn by the use of random numbers.

Statistical Analysis

All basic data were analysed by the analysis of variance technique. The formula for significant differences for split plot analysis were obtained from Cochrane and Cox (1957).

In the analysis of the data for tiller numbers per plant at July 1957 the design was considered to be a completely randomised one, since no treatments had at that time been imposed, and the variability between cultivars was tested against the variability within cultivars.

RESULTS

The results for each of the 3 harvest years of experiment 1 are presented in the following order.

(a) Dry matter yield of cultivars growing alone and in mixtures at each cut and accumulatively.

(b) Effect on yield of combining cultivars.

(c) Percentage distribution of seasonal production.

(d) Actual percentage, and potential percentage, contribution to yield of the components of cultivar mixtures at each cut and to annual total.

(e) Plant and tiller numbers.

(f) Actual percentage, and potential percentage, contribution to tiller production by the components of cultivar mixtures.

Terminology

In referring to main plot cutting frequency treatments the following terminology has been adopted.

The main plot (containing the 7 sub plot cultivar treatments) cut according to the growth of Irish ryegrass growing alone is termed "Section 1".

The main plot (containing the 7 sub plot cultivar treatments) cut according to the growth of New Zealand ryegrass growing alone is termed "Section 2".

The main plot (containing the 7 sub plot cultivar treatments) cut according to the growth of S.23 ryegrass growing alone is termed "Section 3".

Abbreviations

Where the cultivar treatments are composed of one cultivar only the full name of the cultivar is used, i.e. Irish, New Zealand and S.23.

Where the cultivar treatments are composed of more than 1 cultivar, they are abbreviated to the initial letter of each cultivar present, i.e.

Irish + New Zealand	as IN
Irish + S.23	" IS
New Zealand + S.23	" NS
Irish + New Zealand + S.23	" INS

Statistical Interpretation

In all tables (unless where otherwise stated) the least significant differences (L.S.D.) at $P < 0.05$ are numbered from 1 - 4 and can be applied in the following comparisons:-

1. Between cutting section means (Main Plots).
2. " cultivar treatment means (Sub Plots).
3. " cultivar treatments within any cutting section.
4. " cutting sections of any cultivar treatment.

Where an "F" value failed to reach the required level for significance this is denoted by the letters N.S.

FIRST HARVEST YEAR

Dry Matter Yield of Cultivars Growing Alone and in Mixtures at Each Cut and Accumulatively

Yield per Cut

The yields of dried herbage for the 9 cuts taken in 1958 and total for 1958 are given in table 1.1 and diagramatically in figures 1.11, 1.12 and 1.13.

Cutting frequencies Cutting dates and intervals between cuts are summarised in table 1.2. During the first year all 3 sections reached the required 18 cm. growth on 9 occasions. The dates of cutting sections 1 and 2 coincided for the first 4 cuts and thereafter section 1 was cut at less frequent intervals so that by the autumn it was being cut at, or nearly at, the same time as section 3.

The S.23 behaved in a typical fashion and its section (No. 3) became due for cutting late in the spring but at shorter intervals during the middle of the year.

The yield represented by the 18 cm. cut was high for the first cut, averaging 31.8 g. with a range from 12.1 g. up to 65.9 g. and much lower for subsequent cuts ranging from 7.8 g. up to 25.6 g.

Significant differences between the sections means (main plot treatments) were recorded at all cuts except cut 3 and cut 9 and also for the total production for the year (see table A2.1).

Differences between cultivar treatment means (sub plot treatments) were significant for all cuts except cuts 7, 8 and 9 and total for the year.

The interaction between sections and cultivar treatments was significant for cuts 5, 6 and 8 and just failed to reach significance at

Table 1.1 Yield of dry matter (grams per plot) during 1958 and total for the year.

Cut	Section	Date	Cultivar Treatments I	N	S	IN	IS	NS	INS	$\bar{x}$	L.S.D.
1	1	8/5	26.0	15.9	23.8	24.8	26.9	24.5	22.9	23.5	1. = 6.1
	2	8/5	19.8	12.1	17.7	22.6	22.8	22.2	20.2	19.6	2. = 5.7
	3	26/5	65.9	46.7	45.6	60.4	44.5	48.0	54.8	52.3	3 & 4 = N.S.
	$\bar{x}$		37.2	24.9	29.0	35.9	31.4	31.6	32.6	31.8	C.V. = 21.7%
2	1	3/6	9.5	11.6	16.0	10.9	11.8	14.1	12.7	12.4	1. = 1.3
	2	3/6	9.0	11.5	16.3	11.0	12.2	11.7	10.1	11.7	2. = 2.1
	3	20/6	8.0	8.8	15.7	8.2	9.9	10.6	11.6	10.4	3 & 4 = N.S.
	$\bar{x}$		8.8	10.7	16.0	10.0	11.3	12.2	11.5	11.5	C.V. = 22.1%
3	1	24/6	12.0	11.2	18.2	12.8	16.9	13.9	16.1	14.4	1. = N.S.
	2	24/6	11.0	8.8	14.3	11.3	14.0	15.5	12.3	12.5	2. = 1.9
	3	4/7	7.8	10.3	12.6	9.4	11.0	10.8	10.5	10.4	3 & 4 = N.S.
	$\bar{x}$		10.3	10.1	15.1	11.2	14.0	13.4	13.0	12.4	C.V. = 18.1%
4	1	7/7	10.2	12.4	16.3	11.9	14.7	14.3	13.2	13.3	1. = 1.1
	2	7/7	10.1	8.9	14.0	11.2	13.6	14.1	12.0	12.0	2. = 1.9
	3	18/7	13.2	14.9	16.0	13.1	12.6	12.8	13.5	13.7	3 & 4 = N.S.
	$\bar{x}$		11.2	12.1	15.4	12.1	13.7	13.7	12.9	13.0	C.V. = 17.7%
5	1	26/7	15.8	17.1	23.9	19.2	21.3	19.1	20.2	19.5	1. = 2.4
	2	24/7	13.2	12.9	16.2	16.1	17.8	17.7	14.1	15.4	2. = 1.9
	3	1/8	10.9	12.3	11.6	11.0	10.8	10.0	11.2	11.1	3. = 3.2
	$\bar{x}$		13.3	14.1	17.2	15.4	16.6	15.6	15.2	15.4	4. = 5.6
											C.V. = 14.8%
6	1	18/8	17.3	19.3	25.6	21.4	22.2	22.4	21.4	21.4	1. = 2.7
	2	12/8	12.7	11.7	15.5	13.9	16.2	15.4	12.8	14.0	2. = 2.0
	3	19/8	15.8	14.2	13.9	13.7	11.6	12.8	13.6	13.7	3. = 3.5
	$\bar{x}$		15.3	15.0	13.4	16.4	16.7	16.9	16.0	16.4	4. = 6.2
											C.V. = 15%
7	1	2/9	12.7	12.6	15.1	13.1	13.9	13.4	13.1	13.4	1. = 1.6
	2	27/8	11.1	9.6	11.3	11.8	11.1	11.8	11.1	11.1	2, 3 & 4 =
	3	2/9	12.2	11.6	10.6	9.6	9.1	9.6	10.0	10.4	N.S.
	$\bar{x}$		12.0	11.2	12.4	11.5	11.4	11.6	11.4	11.6	C.V. = 14.6%
8	1	18/9	11.2	11.8	11.9	11.0	10.8	11.2	11.4	11.3	1. = 1.8
	2	12/9	14.3	13.6	13.9	14.7	13.2	14.2	12.7	13.8	2. = N.S.
	3	17/9	11.7	11.7	10.2	10.4	9.3	9.7	10.3	10.5	3. = 2.1
	$\bar{x}$		12.4	12.4	12.0	12.0	11.1	11.7	11.5	11.9	4. = 2.5
											C.V. = 12.3%
9	1	16/10	11.7	12.5	13.2	12.6	11.6	12.6	11.8	12.3	1, 2, 3 & 4
	2	4/10	12.5	11.6	11.4	13.5	11.2	12.7	11.0	12.0	= N.S.
	3	16/10	12.9	11.9	10.7	12.7	11.3	12.4	12.2	12.0	C.V. = 15.4%
	$\bar{x}$		12.4	12.0	11.8	12.9	11.4	12.6	11.6	12.1	
Total for 1958	1		127	124	164	138	150	146	143	142	1. = 13.0
	2		114	101	131	126	132	135	116	122	2, 3 & 4 =
	3		158	142	147	148	130	137	148	144	N.S.
	$\bar{x}$		133	122	147	138	138	139	136	136	C.V. = 12.8%

Table 1.2 Dates on which the sections were cut during 1958 and intervals between cuts.

Section		Cut 1.	2.	3.	4.	5.	6.	7.	8.	9.
1	Date of cut	8/5	3/6	24/6	7/7	26/7	18/8	2/9	18/9	16/10
	Interval between cuts	0	26	21	13	19	23	15	16	28
2	Date of cut	8/5	3/6	24/6	7/7	24/7	12/8	27/8	12/9	4/10
	Interval between cuts	0	26	21	13	17	19	15	16	22
3	Date of cut	26/5	20/6	4/7	18/7	1/8	19/8	2/9	17/9	16/10
	Interval between cuts	0	25	14	14	14	18	14	15	29

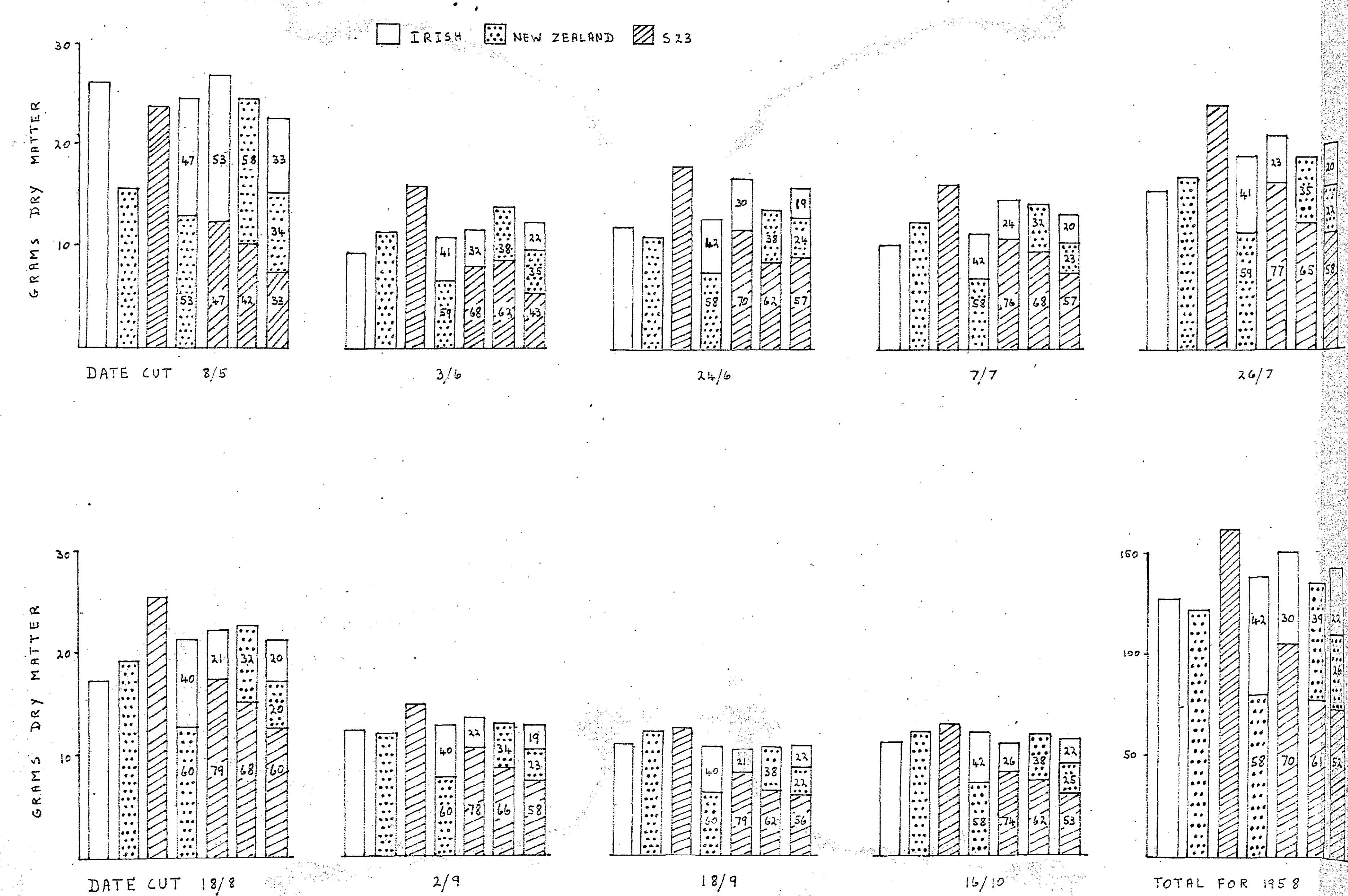

IRISH
NEW ZEALAND
S 23
GRAMS DRY MATTER
30
20
10
DATE CUT 8/5
47 53 58 33
53 47 42 34 33
3/6
41 32 38 22
59 68 63 35 43
24/6
42 30 38 19 24
58 70 62 57
7/7
42 24 32 20 23
58 76 68 57
26/7
41 23 35 20 23
59 77 65 58
GRAMS DRY MATTER
DATE CUT 18/8
40 21 32 20 20
60 79 68 60
2/9
40 22 34 19 23
60 78 66 58
18/9
40 21 38 22 22
60 79 62 56
16/10
42 26 38 22 25
58 74 62 53
150
100
50
TOTAL FOR 1958
42 30 39 22 26
58 70 61 52

Figure 1.11 Yield of dry matter in section 1 at each cut in 1958 and total for 1958. The contribution to the total yield by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total yield that it represents is quoted.

Figure 1.12 Yield of dry matter in section 2 at each cut in 1958 and total for 1958. The contribution to the total yield by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total yield that it represents is quoted.

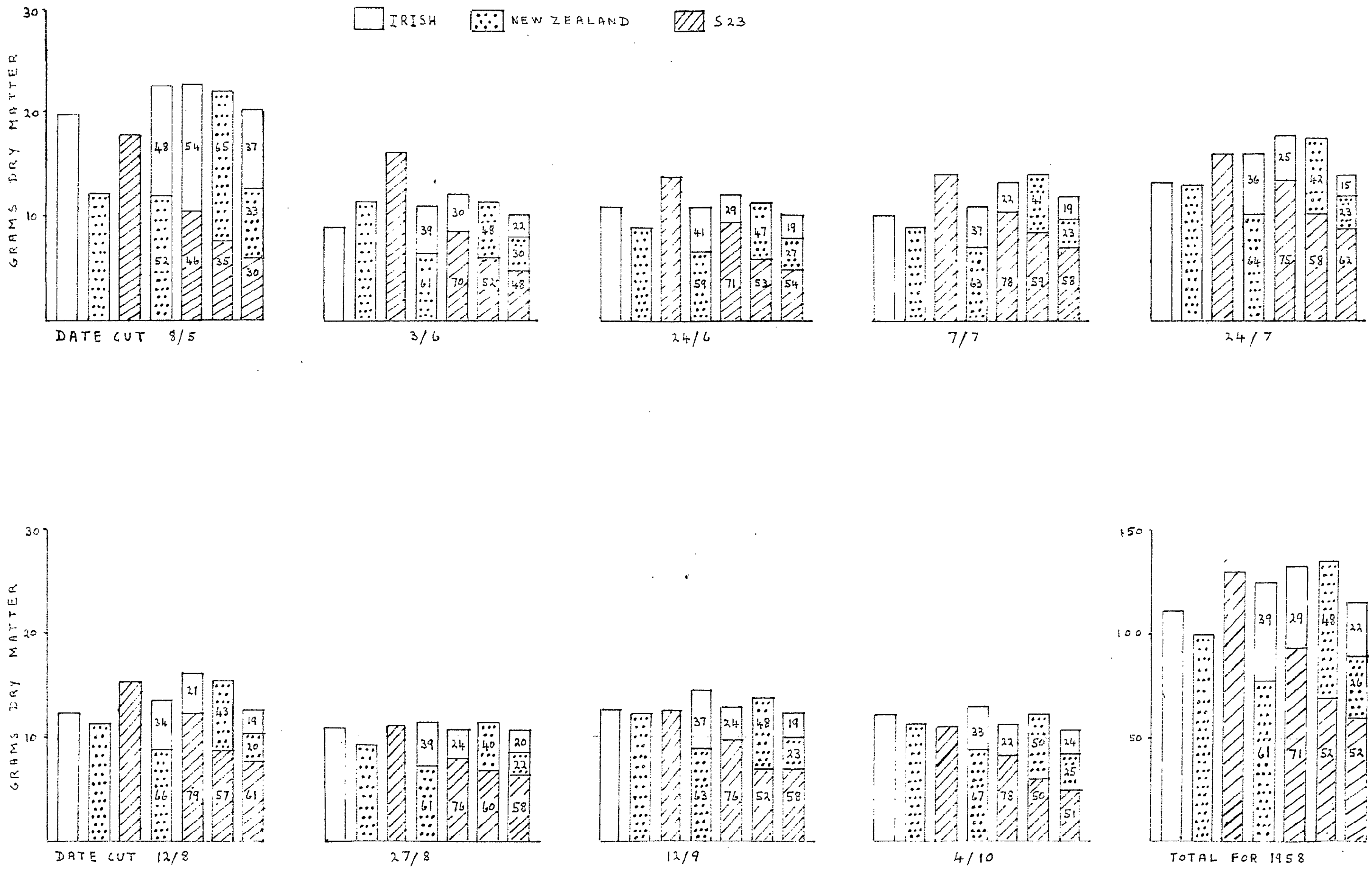
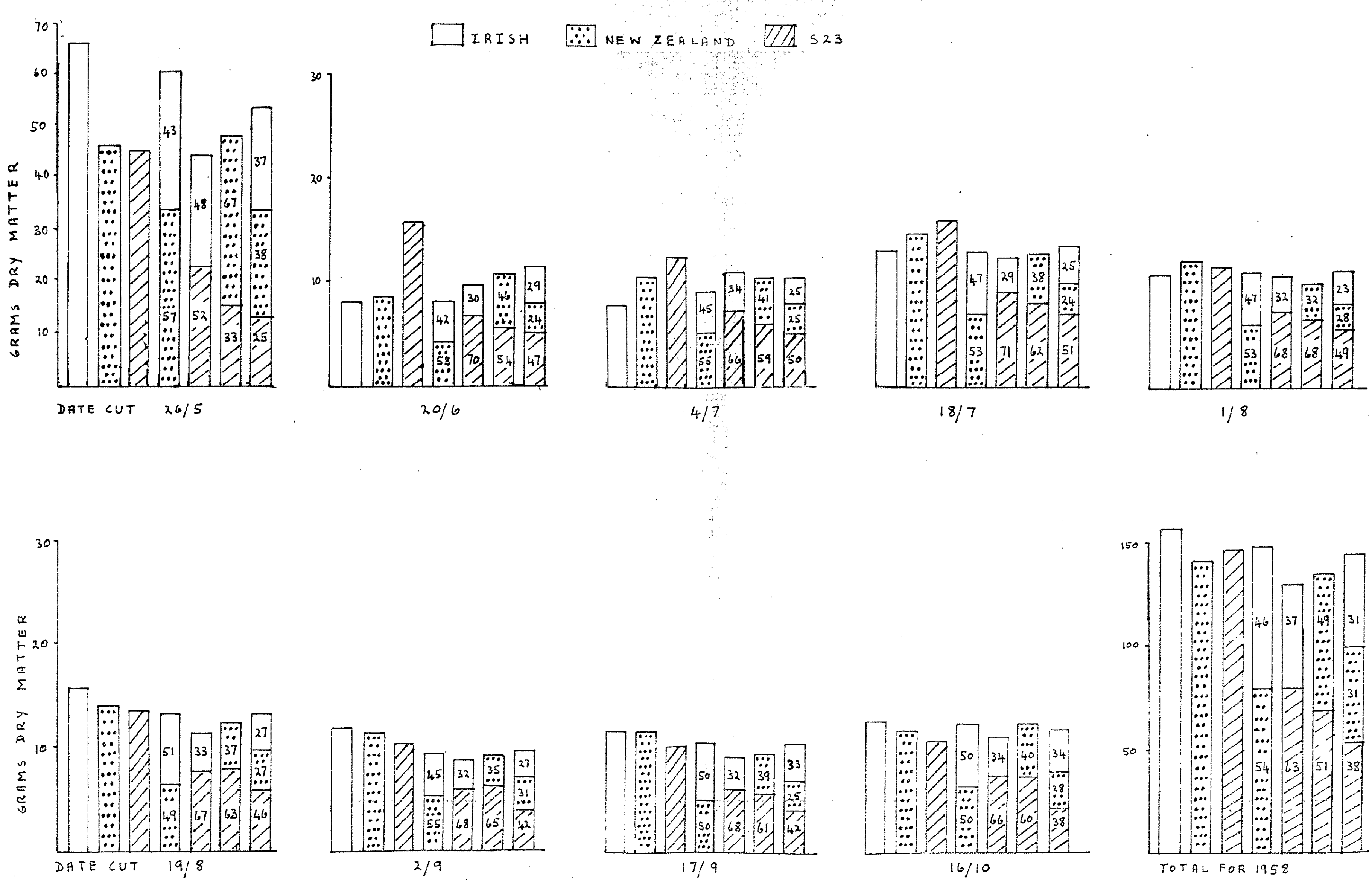

IRISH
NEW ZEALAND
S23
GRAMS DRY MATTER
10
20
30
DATE CUT 8/5
48 54 65 37
52 46 35 33 30
3/6
39 30 48 22
61 70 52 30 48
24/6
41 29 47 19
59 71 53 27 54
7/7
37 22 41 19
63 78 59 23 58
24/7
36 25 42 15
64 75 58 23 62
GRAMS DRY MATTER
10
20
30
DATE CUT 12/8
34 21 43 19
66 79 57 20 61
27/8
39 24 40 20
61 76 60 22 58
12/9
37 24 48 19
63 76 52 23 58
4/10
33 22 50 24
67 78 50 25 51
50
100
150
TOTAL FOR 1958
39 29 48 22
61 71 52 26 52

Figure 1.13 Yield of dry matter in section 3 at each cut in 1958 and total for 1958. The contribution to the total yield by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total yield that it represents is quoted.


IRISH
NEW ZEALAND
S23
GRAMS DRY MATTER
DATE CUT 26/5
43
48
67
37
38
57
52
33
25
20/6
42
58
30
70
46
54
29
24
47
4/7
45
55
34
66
41
59
25
25
50
18/7
47
53
29
71
38
62
25
24
51
1/8
47
53
32
68
32
68
23
28
49
GRAMS DRY MATTER
DATE CUT 19/8
51
49
33
67
37
63
27
27
46
2/9
45
55
32
68
35
65
27
31
42
17/9
50
50
32
68
39
61
33
25
42
16/10
50
50
34
66
40
60
34
28
38
TOTAL FOR 1958
46
54
37
63
49
51
31
31
38

cut 1 and for total annual growth. Where this interaction was not significant differences between cultivar treatments within any one section differing from the mean values over all sections must be accepted with reserve. Conversely where the interaction is significant results averaged over all sections may not be very meaningful.

First cuts At the early cut (May 8th) all cultivars were in the leafy stage but when section 3 was cut (May 26th) the flowering heads of the Irish and New Zealand plants were extended and the herbage could be considered in the silage stage. This was reflected in the greatly increased yield of all treatments at the later cut.

Averaged over the cutting sections Irish and New Zealand growing alone were the highest and lowest yielders respectively. S.23 alone was intermediate, not significantly greater than New Zealand, but significantly less than Irish. The treatments combining cultivars formed a group, within which there were no significant differences. The yields of this group came between those of the high yielding Irish and intermediate S.23. Within this group the mixtures where S.23 originally made up 50% of the plants (IS and NS) were significantly lower yielding than Irish but the other two, (IN and INS) gave yields not significantly less.

Although there was no significant interaction between sections and cultivar treatments some differences were sufficiently large and interesting to merit comment. In the sections 1 and 2 the differences between the cultivars when growing alone were not large and could be ranked in the same order (Irish S.23 New Zealand) in both sections. This would be expected since both sections were cut on the same day. In section 3, cut 18 days later, the yield differences were much larger and New Zealand had overtaken S.23 to rank next to Irish, which had greatly increased its yield.

Also of importance was the fact that the yield of the IN mixture had markedly increased and was only slightly less than Irish alone, whereas, the yield of the IS mixture was of the same order as S.23 alone. The mixture of all three cultivars (INS) was greater than IS but still below Irish alone or IN.

<u>Second cuts</u> Sections 1 and 2 again represented identical treatments and their means and the yields and rankings of their sub plot treatments were very similar. Section 3 gave a significantly lower yield and this difference is of interest since the three cutting treatments concern regrowths of 26, 26 and 25 days respectively. Evidently the rate of growth of the treatments within section 3 was less, following a high yield at cut 1 in which the plants had headed, than that of sections 1 and 2. It is interesting to note that the yield of S.23 growing alone (the only cultivar which had not headed at either of the first cuts) did not differ markedly in any section.

Comparing the average yields of the cultivar treatments over the three cutting sections, the outstanding feature was the high yield of S.23 compared to Irish and New Zealand which were not significantly different. Of the treatments containing more than one cultivar those with S.23 were significantly higher than Irish but not than New Zealand and all were significantly less than S.23. The IN mixture yield came between those of its constituents.

<u>Third cuts</u> Sections 1 and 2 were again cut on the same day, 21 days after the second cut, and the interval between the second and third cuts of section 3 was only 14 days. This indicates the more rapid growth rate of S.23 during this period.

Of the cultivars growing alone, S.23 was again by far the highest in yield (averaged over the three sections). The yields of Irish and New Zealand grown alone were almost identical.

It is noteworthy that all mixtures containing S.23 gave relatively high yields and only INS was just significantly less than S.23 alone. The IN mixture while yielding more than Irish or New Zealand was not significantly greater and was still considerably below S.23 growing alone.

Fourth cuts Section 3 had one day more between cuts than sections 1 and 2 and produced a slightly higher yield. Up to this date sections 1 and 2 had been cut the same number of times on the same days but now displayed slightly but significantly different yields. This could have been caused by the accumulative effect of the higher fertilizer returns which had been made to section 1 which had always yielded rather more than section 2.

As at the previous cuts the highest yields came from plots where S.23 was growing alone or mixed with Irish or New Zealand and these treatments were not significantly different. Irish and New Zealand growing alone and their combination were the lowest yielders and again did not differ significantly. Where all three cultivars were growing together an intermediate yield resulted which was significantly less than S.23 alone but not significantly higher than either Irish or New Zealand.

Fifth cuts Section 1 was cut two days after section 2 indicating a reduction in the growth rate of Irish growing alone. Section 3 had three fewer regrowth days than section 2 and this was reflected in the average yield which was significantly lower than the other sections. The section 1 yield was significantly higher than that of section 2.

The interaction between cutting sections and cultivar treatments was significant and was apparent in the fact that there were no significant differences between the treatments in section 3, whereas in section 1 S.23 outyielded both Irish and New Zealand and was only significantly approached in yield by the IS mixture. Irish growing alone was significantly less than all other cultivar treatments but New Zealand was only significantly less than the two highest (S.23 and S.23 + Irish).

In section 2 the IS and NS combinations were highest in yield although not significantly greater than S.23 alone or the IN combination. New Zealand was the lowest yielding treatment, significantly less than S.23 and the IS and NS mixtures.

Comparing the yields of the same cultivar treatments in the different sections, it can be seen that neither Irish nor New Zealand differed significantly from section to section but, S.23 gave a significantly higher yield in section 1 which had the longest interval between cuts. All other cultivar treatments increased significantly between sections 3 and 1 and the IS and NS mixtures also showed significant increases between the sections 3 and 2.

<u>Sixth cuts</u> There were 23 days between the fifth and sixth cuts of section 1 and 19 and 18 days for sections 2 and 3 respectively. This meant that section 1, which was 18 days ahead of section 3 at the first cut, was now only one day ahead and represented a less intensive utilization cycle for the plants in section 1. Section 2 was cut seven days before section 1 which showed a loss of eleven days from the first cut. These differences in cutting frequencies are mentioned as they highlight the relative growth rates of the cultivars growing alone. As a result of the longer growing period afforded section 1 for this cut its mean yield was significantly higher than sections 2 and 3.

S.23 was the highest in yield in section 1 but not significantly greater than IS or NS. Irish occupied the lowest position and was significantly lower yielding than all treatments except New Zealand.

In section 2, IS was highest in yield but there were no significant differences between treatments except for New Zealand which was significantly lower than S.23, IS and NS.

In section 3 a different picture emerged, Irish being the highest in yield and IS the lowest. The only significant difference was between these extreme yields.

Seventh cuts Only the mean yields of the cutting sections were significantly different at these cuts when it was seen that section 3 yield was lowest and significantly so from that of section 1.

The yields of the cultivar treatments were very close and not significantly different but on average S.23 produced slightly more than any other treatment.

Eighth cuts At this time section 2 mean yield was greater than the other two sections although all had had a nearly equal time for regrowth.

The mean cultivar treatments yields were not significantly different but the interaction of sections and cultivar treatments was and therefore only means within the body of the table will be compared.

In section 1 all yields were extremely close and not significantly different and the same was true in section 2 although the range between highest and lowest was greater. In section 3 the IS mixture gave the lowest yield and was significantly less than Irish or New Zealand growing alone which were identical and slightly higher than all others.

The interesting fact emerging from this table was that S.23 and its mixtures were no longer the highest yielders and in the instance noted above gave less than Irish or New Zealand.

Ninth cuts No significant differences were recorded between any treatments in these cuts and an examination of the means shows them to be indeed very alike. Sections 1 and 3 could have been cut one week before they were as the modal height had been static just below 18 cm. from that time. The further week had been allowed to see if further growth would take place.

Total for 1958 Comparing the mean yields for the three cutting sections, section 2 was significantly lower, due probably to more frequent cutting. The "F" values for cultivar treatments and their interaction with cutting frequencies did not quite reach significance at the 5% level but some of the observed differences are worthy of comment.

The early maturing cultivars (Irish and New Zealand) gave their highest yields in section 3 which had been cut latest in spring, and Irish was in fact the top yielder. In the other sections, however, both Irish and New Zealand were considerably outyielded by S.23.

None of the mixtures containing S.23 gave a substantially greater yield than S.23 alone and in most cases the yield was lower. The IN mixture, however, was superior to Irish or New Zealand in both sections 1 and 2 and slightly greater than New Zealand in section 3.

Accumulative Yield

The accumulative yield of all cultivar treatments during 1958 are presented in figures 1.14, 1.15 and 1.16 for sections 1, 2 and 3 respectively.

Section 1 The range of yields was small at the beginning of the season and gradually widened so that total yields showed a considerable divergence in productivity.

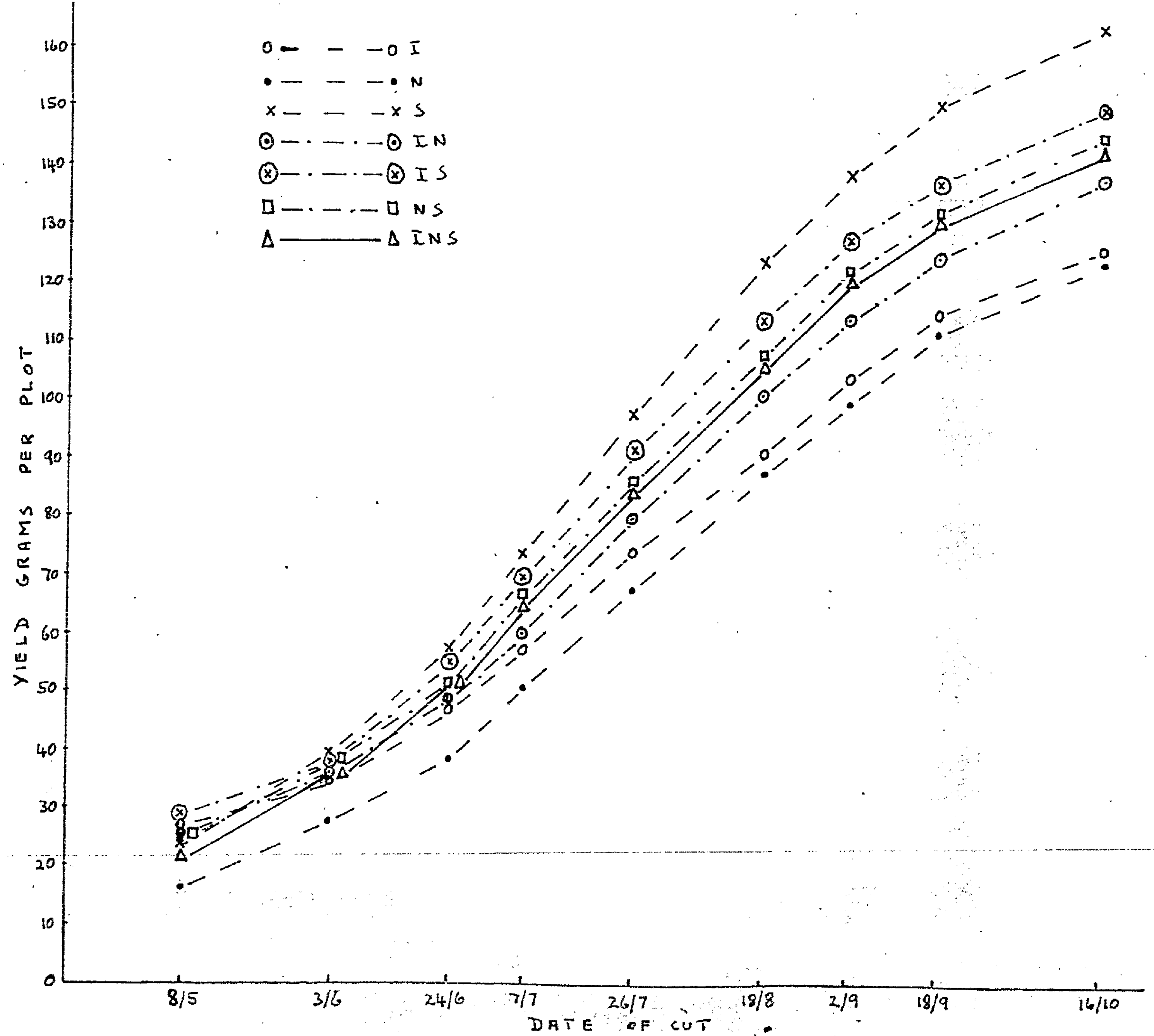


Figure 1.14 Accumulative dry matter yield of cultivars growing alone and in mixtures in section 1 during 1958.

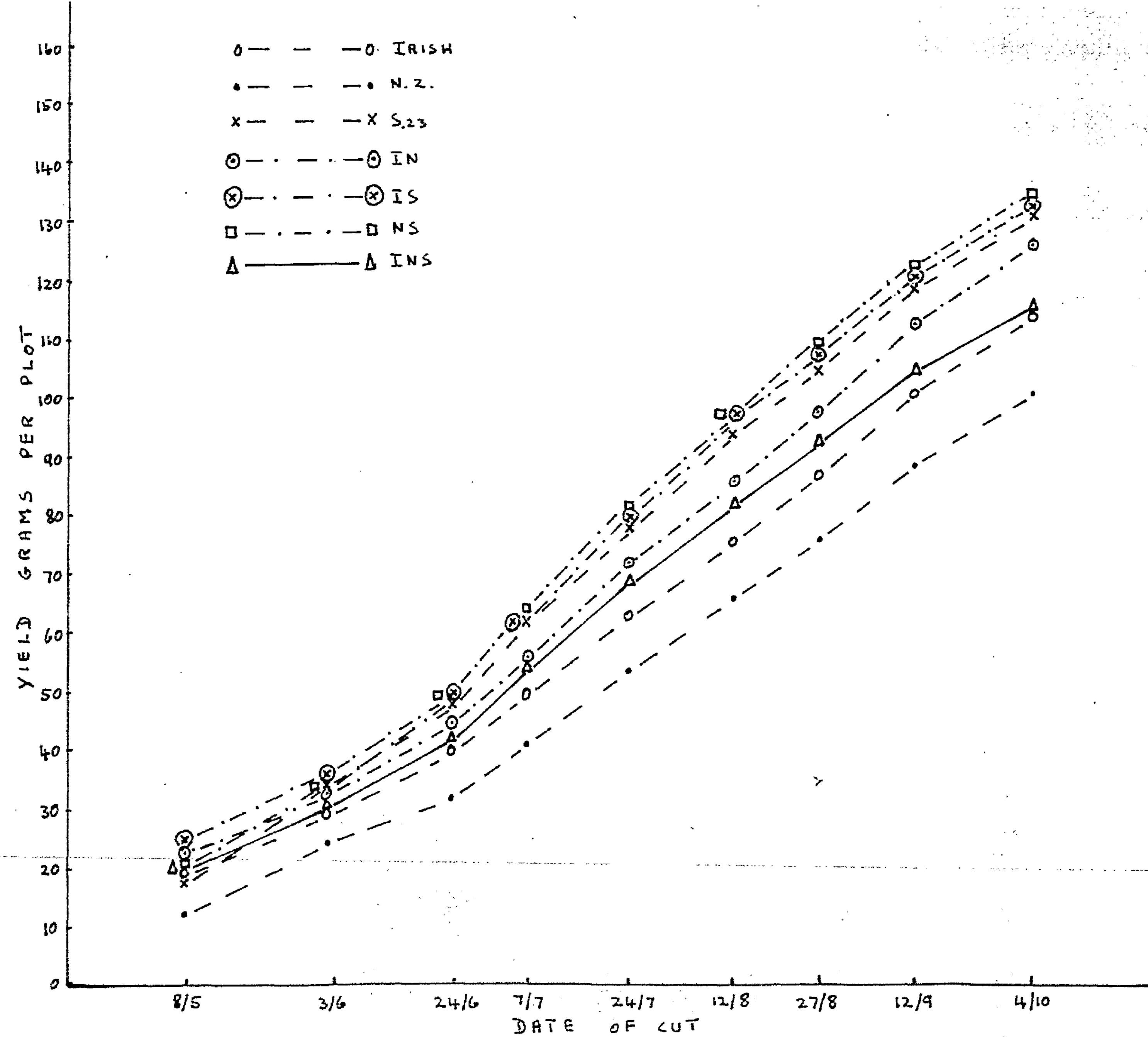


Figure 1.15 . Accumulative dry matter yield of cultivars growing alone and in mixtures in section 2 during 1958.

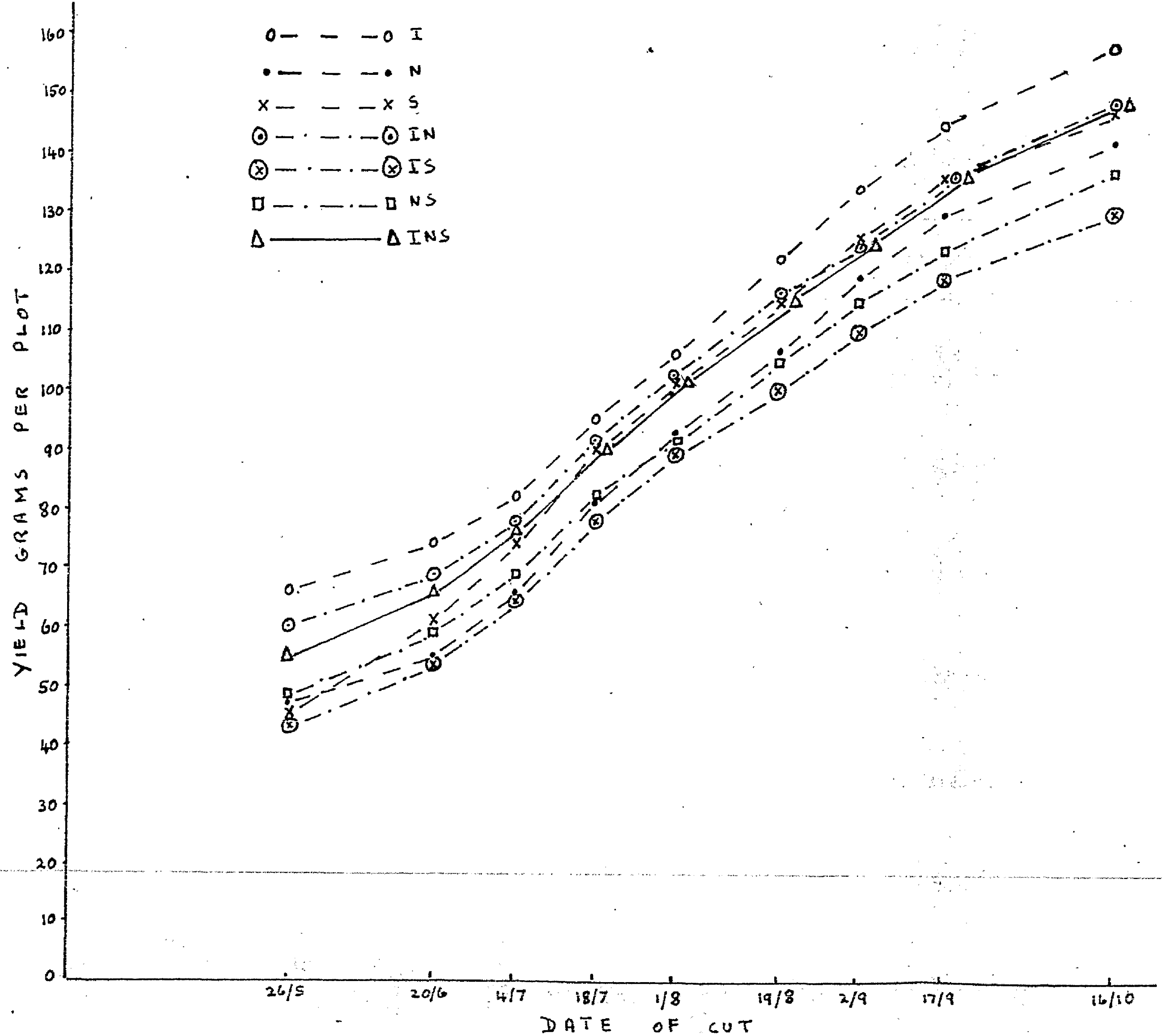


Figure 1.16 Accumulative dry matter yield of cultivars growing alone and in mixtures in section 3 during 1958.

Considering first the cultivars growing alone, Irish commenced the year above New Zealand and S.23; but, due to a lower growth rate, it was overtaken by S.23 by the beginning of June. Subsequently, the rate of growth of Irish was less than that of either S.23 or New Zealand, being closer to the latter than the former. It finished with a similar yield to that of New Zealand but well below that of S.23. S.23, as has been stated, displayed a very rapid growth rate during May and June and by the second cut had produced more than any other treatment. This high rate of production was maintained and gradually put S.23 well above Irish or New Zealand. New Zealand was the lowest yielder at cut 1 and, although its subsequent growth rate was equivalent to that of Irish, did not make up for the initial deficiency and was the lowest at every cut.

The IN combination proved rather more productive than either of its components from mid-season onwards when its growth curve began to diverge from those of Irish and New Zealand. Although rather better in total than its components, it still ranked below all other treatments. The IS mixture benefited at the first cut by the presence of the slightly higher yielding Irish and thereafter, followed the S.23 curve when the Irish growth rate was falling off. The NS mixture behaved in a somewhat similar manner in that it followed more closely the S.23 pattern and was more productive than New Zealand. The combination of all 3 cultivars did not reflect the higher early growth of Irish and thereafter occupied an intermediate position between the high yielding S.23 and the lower Irish and New Zealand. The INS curve was almost identical to that of the NS mixture.

<u>Section 2</u> As sections 1 and 2 were cut on the same days for the first 4 cuts the general form of both graphs was similar. New Zealand and

Irish still ranked below all others although the Irish growth rate was noticably better over the latter part of the season in section 2.

S.23 and its mixtures with Irish and New Zealand formed a very close group which established its superiority over the other treatments by its greater rate of growth in late spring and early summer. The IN mixture was again rather more productive than either of its components. Its yield was similar to Irish up to the end of June, then its rate of growth increased slightly while Irish and New Zealand remained steady. The INS mixture again displayed an intermediate rate of growth which, if anything, placed it nearer to its lower yielding Irish and New Zealand components.

Section 3 This section presented a quite different, and very interesting, picture from sections 1 and 2. The later first cut had put Irish well ahead initially, but it was able to retain this position despite a period, following the first cut, of reduced growth rate. Evidently the cutting sequence had favoured Irish as instead of showing a fall off in productivity in the second half of the season, as was the tendency in section 1, it actually slightly widened the gap between it and the next most productive treatment. New Zealand growth was slow up to June 20th then rapidly picked up and in the August-September period displayed a relatively high rate of increase. The late maturing S.23 had a typical growth curve, low in early spring, rising sharply in May, June and July, then holding a fairly constant rate till the end of the season.

Unlike sections 1 and 2 the mixtures of S.23 with Irish and New Zealand did not follow the S.23 pattern and were both obviously influenced by their early maturing components in the June-July period. This meant that, although S.23 was growing rapidly at this time, the IS and NS mixtures were held back and their accumulated yields fell below that of S.23. It is of particular interest that, at cut 1, the IS yield was low and similar to S.23, while Irish showed a markedly greater yield.

The growth of the IN mixture closely resembled that of Irish but was also influenced by New Zealand as when that cultivar's growth rate increased in early July so did the IN mixture. The INS treatment yielded more than S.23 or New Zealand at the first cut, due to its Irish component, and subsequently benefited by the higher growth rate of S.23 and was almost identical with it for the rest of the season.

The management of section 3 resulted in a smaller spread of ultimate yields than did sections 1 and 2. In section 3, the ultimate yield and, except for S.23, the ranking of yields was largely determined by the yields obtained at the late first cut.

The Effect on Yield of Combining Cultivars

The yields of cultivar mixtures, relative to their components, are given in figure 1.17 as percentage increases, or decreases, compared to either Irish, New Zealand or S.23 growing alone.

It is not intended that a close scrutiny should be made of the individual differences since these have already been dealt with in table 1.1. The intention in including figure 1.17 is to present the results in a slightly different form which, it is hoped, helps to clarify the cultivar mixture/yield relationships by giving a general picture of what had occurred.

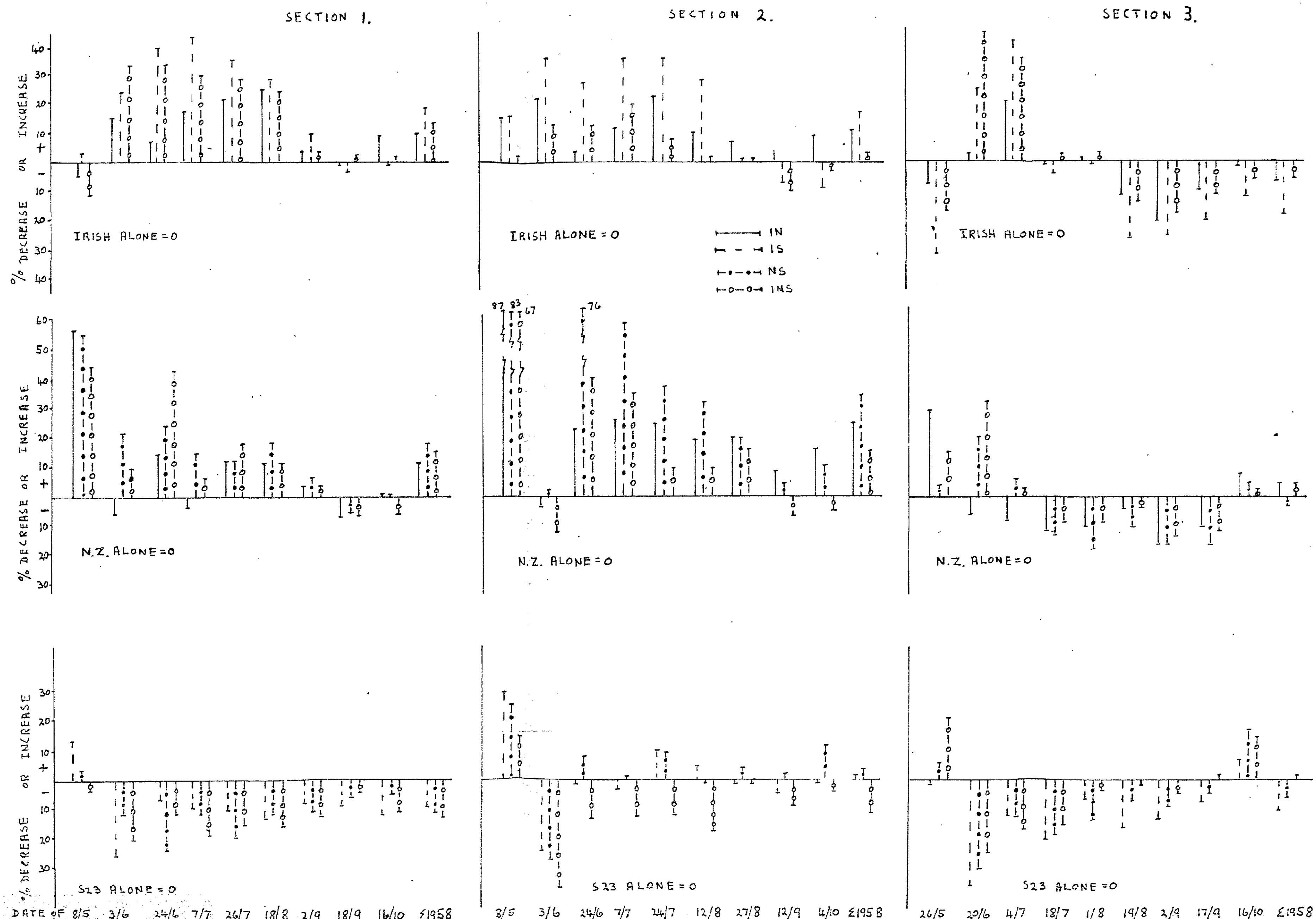
Yields of Mixtures Containing Irish Relative to Irish Growing Alone

The top 3 graphs in figure 1.17 show Irish alone as zero and the combinations of Irish with the other cultivars relative to this. Thus in the first cut of section 1 the IN, INS and IS treatments gave respective yields 5% and 12% below and 3% above Irish alone. The yields of all mixtures were subsequently greater than Irish until September 18th when there were virtually no differences. On the total for the year IN, IS and INS all showed to advantage compared to Irish.

In section 2 the pattern was similar and on total growth IN and IS exceeded Irish by over 10% while INS showed a very small increase.

The cutting sequence of section 3 altered the yield pattern and, apart from the cuts taken on June 20th and July 4th, all mixtures were less, or little better than Irish. The accumulated growth for the year, of the mixtures, was less than Irish.

Figure 1.17 Yields of cultivar mixtures relative to the components of the mixtures growing alone.



SECTION 1.
SECTION 2.
SECTION 3.
% DECREASE OR INCREASE
IRISH ALONE = 0
N.Z. ALONE = 0
S23 ALONE = 0
IN
IS
NS
INS
87
83
67
76
DATE OF CUT
8/5
3/6
24/6
7/7
26/7
18/8
2/9
18/9
16/10
£1958
24/7
12/8
27/8
12/9
4/10
26/5
20/6
4/7
18/7
1/8
19/8
17/9

Yields of Mixtures Containing New Zealand Relative to New Zealand Growing Alone

The middle three graphs in figure 1.17 show New Zealand alone as zero and the combinations of New Zealand with the other cultivars relative to this.

In section 1 the yields of the mixtures were considerably higher than New Zealand at the first cut. The increases gradually lessened over the season until at the second last cut all mixtures were producing slightly less than New Zealand. On the total for the year, however, the mixtures of New Zealand with the other cultivars were better than New Zealand alone.

The increases over New Zealand were much more marked in section 2 and all mixtures performed better than New Zealand, especially NS.

The taking of a late spring cut showed New Zealand to better advantage and, in section 3, the increases over New Zealand alone were mostly confined to the early part of the season. Only small deviations from the New Zealand total yield were recorded.

Yields of Mixtures Containing S.23 Relative to S.23 Growing Alone

The bottom three graphs in figure 1.17 show S.23 alone as zero and its combinations with the other cultivars relative to this.

In all sections a similar pattern appeared as, apart from the first cut, the yields of the mixtures were, in general, lower than S.23. This was especially noticable in section 1.

Percentage Distribution of Seasonal Production

One of the advantages claimed for mixing cultivars of varying growth cycles is that a more level seasonal production results. Table 1.3 shows the seasonal production of the various treatments expressed as percentages of total yield.

Section 1 The largest differences in percentage distribution of yield occurred at the first cut where the Irish alone was considerably higher than the New Zealand or S.23 alone. Combining New Zealand and/or S.23 with Irish gave a percentage distribution intermediate between the contrasting cultivars. The NS treatment resulted in a slightly higher percentage than either New Zealand or S.23 alone. Over the rest of the year the differences between cultivar combinations seldom exceeded 1 or 2% and it would be difficult to draw any conclusions. It was noticable that the large percentage given by Irish in the first cut was balanced by slightly lower percentages at the next three cuts and more markedly by a lower production at the second flush in the July-August period. It did, however, appear that in spring there was some slight advantage in smoothing out seasonal production by combining Irish and S.23 or Irish and New Zealand or all three.

Section 2 Compared to section 1 the more frequent cutting in the middle and later part of the season caused a slight shift in the distribution of yield. The July-August flush was reduced and a greater proportion of the yield occurred in the late summer and autumn. Within this general pattern there were still the differences due to the cultivars.

New Zealand and S.23 growing alone again gave a smaller percentage of their total yield at the first cut than Irish. Also, as in section 1,

Table 1.3 Percentage distribution of total yield during 1958.

Section 1. Date of Cut

	8/5	3/6	24/6	7/7	26/7	18/8	2/9	18/9	16/10
Cut	1	2	3	4	5	6	7	8	9
I	20	8	9	8	12	14	10	9	9
N	13	9	9	10	14	16	10	9	10
S	14	10	11	10	14	16	9	7	8
IN	18	8	9	9	14	16	10	8	9
IS	18	8	11	10	14	15	9	7	8
NS	17	10	10	10	13	15	9	8	9
INS	16	9	11	9	14	15	9	8	8

Section 2.

	8/5	3/6	24/6	7/7	24/7	12/8	27/8	12/9	4/10
I	17	8	10	9	12	11	10	12	11
N	12	11	9	9	13	12	10	14	12
S	14	12	11	11	12	12	9	11	9
IN	18	9	9	9	13	11	9	12	11
IS	17	9	11	10	13	12	8	10	8
NS	16	9	11	10	13	11	9	10	9
INS	17	9	11	10	12	11	10	11	10

Section 3.

	26/5	20/9	4/7	18/7	1/8	19/8	2/9	17/9	16/10
I	42	5	5	8	7	10	8	7	8
N	33	6	7	10	9	10	8	8	8
S	31	11	8	11	8	9	7	7	7
IN	41	6	6	9	7	9	6	7	8
IS	34	8	8	10	8	9	7	7	9
NS	35	8	8	9	7	9	7	7	9
INS	37	8	7	9	8	9	7	7	8

the NS treatment gave slightly more than New Zealand or S.23 separately. Mixtures containing Irish were similar to Irish grown alone.

At the second cut the pure sown New Zealand and S.23 percentages were higher than all other treatments and compensated their lower proportion in the first cut. The proportions of total yield given by mixtures of the cultivars were nearer the Irish value than the higher New Zealand and S.23. Taking the first and second cuts together the proportions of total yield produced by all treatments were very similar. In the third and fourth cuts S.23 and mixtures containing it gave a slightly higher percentage than the others. During the next two cuts there was little variation in percentage distribution and in the latter part of the season Irish and New Zealand cultivars tended to give a greater percentage than S.23. The IS and NS mixtures followed the S.23 pattern and the INS that of the early cultivars.

Section 3 A completely different growth pattern was obtained in section 3 by delaying the first cut until May 26th, 18 days after the other sections. During this period growth was very rapid and the percentage of total yield obtained was more than double that in the other sections. The greatest increase was from New Zealand and expressed as a percentage over the mean of the other sections it amounted to 164%, while the Irish and S.23 showed respective increases of 127 and 121%. Yield was very evenly distributed throughout the remainder of the season and the autumn flush was much less marked than in the other sections.

The IN mixture at the first cut tended towards the figure for Irish alone and the IS mixture was nearer to S.23. The INS treatment was about intermediate between the early and late groups, and the NS combination exceeded the average of New Zealand and S.23 by 3%.

At the second cut the percentage of Irish and New Zealand was markedly lower than that of S.23, and treatments containing S.23 were intermediate to these groups. At subsequent cuts the variation between treatments was small.

Actual Percentage, and Potential Percentage, Contribution to Yield by the Components of Cultivar Mixtures at Each Cut and to Annual Yield

Actual Contribution

Irish ryegrass

The percentage contribution to total yield made by Irish ryegrass when growing with New Zealand and/or S.23 is shown in table 1.4 and figures 1.11, 1.12 and 1.13.

First cuts Growing with New Zealand or S.23 the amounts contributed by Irish were not significantly different and were what could be expected from a combination of 50% of each cultivar, if both were equally productive. The fact that there was no increase in Irish contribution in the IS treatment in section 3 when Irish growing alone showed a marked increase in yield over S.23 alone reflects the competitive influence of S.23 on Irish. The effect of both New Zealand and S.23 on Irish was similar to either alone as, it will be remembered, only $\frac{1}{3}$ of the area was planted to Irish in the INS mixture and therefore the 35% contribution by Irish in the INS mixture was approximately the figure that could have been expected.

Second cuts Even at these second cuts the more aggressive nature of S.23 was evident and the contribution of Irish was reduced to 32% compared to 41% with New Zealand. The effect of both together on Irish was of course to reduce its contribution which was only 23% of the total yield.

Third cuts The position established at the previous cuts was maintained with Irish contributing less when in combination with S.23 than with New Zealand.

Table 1.4 Actual percentage contribution to yield by Irish during 1958. Significant differences calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Cut	Section	Date	Irish With N.Z.	Irish With S.23	Irish With N.Z.+S.23	$\bar{x}$	Cut	Date	Irish With N.Z.	Irish With S.23	Irish With N.Z.+S.23	$\bar{x}$
	1	8/5	47	52	32	44		3/6	42	33	20	32
1	2	8/5	46	53	34	44	2	3/6	40	32	20	31
	3	26/5	44	46	38	43		20/6	42	31	30	34
	x		46(42.4)	50(45.4)	35(35.9)	44			41(39.7)	32(34.2)	23(28.5)	32
	L.S.D.	1=N.S.	2=4.3	3&4=N.S.	C.V.=12.1%			1=N.S.	2=5.0	3&4=N.S.	C.V.=17.1%	
	1	24/6	41	30	18	30		7/7	42	24	20	29
3	2	24/6	40	28	20	29	4	7/7	36	23	20	26
	3	4/7	44	34	25	34		18/7	46	28	26	33
	x		42(40.2)	31(33.2)	21(27.2)	31			41(40.0)	25(29.7)	22(27.8)	29
	L.S.D.	1=N.S.	2=2.8	3&4=N.S.	C.V.=9.9%			1=N.S.	2=3.7	3&4=N.S.	C.V.=13.4%	
	1	26/7	40	23	20	28		18/8	40	22	19	27(30.8)
5	2	24/7	36	26	17	26	6	12/8	34	22	19	25(29.7)
	3	1/8	47	30	23	33		19/8	52	32	27	37(37.0)
	x		41(39.6)	26(30.5)	20(26.0)	29			42(40.2)	25(29.7)	22(27.7)	30
	L.S.D.	1=N.S.	2=3.6	3&4=N.S.	C.V.=13.2%			1=5.6	2=2.6	3&4=N.S.	C.V.=9.2%	
	1	2/9	39	22	19	27		18/9	40	22	21	28(31.1)
7	2	27/8	39	26	20	28	8	12/9	37	26	19	27(30.6)
	3	2/9	44	30	20	34		17/9	50	32	34	39(38.1)
	x		41(39.4)	26(29.3)	22(28.1)	30			42(40.5)	27(30.5)	25(29.0)	31
	L.S.D.	1=N.S.	2=5.0	3&4=N.S.	C.V.=17.9%			1=6.2	2=4.0	3&4=N.S.	C.V.=14.1%	
	1	16/10	42	26	22	30(32.9)	Total		42	30	22	31
9	2	4/10	33	22	24	26(30.3)	for		38	30	23	30
	3	16/10	50	33	34	39(38.5)	1958		46	36	32	38
	x		42(39.8)	27(30.8)	27(31.1)	32			42(38.6)	32(34.2)	26(30.1)	33
	L.S.D.	1=5.4	2=4.5	3&4=N.S.	C.V.=15.6%			1=N.S.	2=3.0	3&4=N.S.	C.V.=9.9%	

Fourth cuts The aggressiveness of S.23 towards Irish was even more marked at these cuts and the contribution of Irish fell to an average figure of 25% over the 3 sections. With New Zealand and New Zealand plus S.23 Irish held its previously established place but still showed a reduction. There was a tendency for a higher contribution from Irish in section 3.

Fifth cuts The results obtained at these cuts were very similar to the previous ones and still showed a greater reduction due to S.23.

Sixth cuts The Irish contribution was as before with regard to companion cultivar but, with all combinations, the contribution was significantly higher in section 3, a trend which had been noted in the two previous cuts.

Seventh, eighth and ninth cuts A higher contribution in section 3 was apparent at these cuts although not significant at the 7th cuts. The contribution with New Zealand and/or S.23 remained steady showing little difference from the position obtained at the second cuts in June. Irish made its greatest contribution in association with New Zealand and its least with S.23. With both together the contribution was intermediate.

Total for 1958 Considering the year as a whole there were no significant differences between cutting sections but the contribution of Irish was reduced when it was grown with any of the other cultivars. With New Zealand, S.23 and New Zealand + S.23 the average percentage contributions were respectively 42, 32 and 26.

New Zealand ryegrass

The percentage contributions to total yield by New Zealand when in association with Irish and/or S.23 are given in table 1.5 and figures 1.11, 1.12 and 1.13.

First cuts The yield from the IN treatment was composed of slightly more New Zealand than Irish while with S.23 the New Zealand had a decided advantage and provided 61% of the growth. In combination with Irish and S.23 New Zealand contributed one third of the total. It is interesting to note that, in sections 1 and 2, the actual yield of New Zealand when in association with Irish or S.23 was practically as great as from New Zealand growing alone (Figures 1.11 and 1.12) despite the fact that there were twice the number of New Zealand plants in the plots containing only one cultivar.

Second cuts By the second cuts the contribution of New Zealand with Irish had risen to 59% which was significantly greater than with S.23 which had fallen from 61% in the first cuts to 45%. In combination with both cultivars the influence of S.23 was the stronger and caused a slight reduction in the New Zealand contribution.

Third - ninth cuts These seven cuts can be considered together since the contribution of New Zealand was fairly constant throughout.

With Irish the percentage of New Zealand only varied between 58 and 59 averaged over the 3 sections. The percentage was always lower in section 3 but not sufficiently to give statistical significance.

After its initial flush of growth, New Zealand with S.23 was suppressed and varied between a maximum of 42% at the 8th and 9th cuts to a minimum of 36% at the 5th and 7th cuts. In this association, the trend was for a higher New Zealand contribution in the section 2.

Table 1.5 Actual percentage contribution to yield by New Zealand during 1958. Significant differences calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

			N.Z. With						N.Z. With			
Cut	Section	Date	Irish	S.23	Irish+S.23	$\bar{x}$	Cut	Date	Irish	S.23	Irish+S.23	$\bar{x}$
	1	8/5	54	54	31	46		3/6	58	38	26	41
1	2	8/5	54	63	34	50	2	3/6	60	49	31	47
	3	26/5	56	66	37	53		20/6	58	47	25	43
	$\bar{x}$		55(47.7)	61(51.6)	34(35.6)	50			59(50.3)	45(41.4)	27(31.1)	44
	L.S.D.	1=N.S.	2=6.3	3&4=N.S.	C.V.=16.4%			1=N.S.	2=5.7	3&4=N.S.	C.V.=16.2%	
	1	24/6	59	38	25	41		7/7	58	33	22	38
3	2	24/6	60	47	28	45	4	7/7	64	41	22	42
	3	4/7	56	40	24	40		18/7	54	38	24	39
	$\bar{x}$		58(49.8)	41(40.1)	26(30.2)	42			59(50.0)	37(37.2)	23(27.9)	40
	L.S.D.	1=N.S.	2=4.4	3&4=N.S.	C.V.=13.0%			1=N.S.	2=5.2	3&4=N.S.	C.V.=15.6%	
	1	26/7	60	35	22	39		18/8	60	33	21	38
5	2	24/7	64	42	22	43	6	12/8	66	43	20	43
	3	1/8	53	32	28	38		19/8	48	36	27	37
	$\bar{x}$		59(50.4)	36(36.6)	24(29.1)	40			58(53.2)	37(37.3)	23(28.3)	39
	L.S.D.	1=N.S.	2=4.1	3&4=N.S.	C.V.=12.4%			1=N.S.	2=4.3	3&4=N.S.	C.V.=13.0%	
	1	2/9	61	34	22	39		18/9	60	38	21	40
7	2	27/8	61	40	21	41	8	12/9	63	48	23	45
	3	2/9	56	35	30	40		17/9	50	39	26	38
	$\bar{x}$		59(50.4)	36(36.7)	24(29.3)	40			58(49.5)	42(39.9)	23(28.7)	41
	L.S.D.	1=N.S.	2=4.0	3&4=N.S.	C.V.=12.1%			1=N.S.	2=4.5	3&4=N.S.	C.V.=13.4%	
	1	16/10	58	37	24	40	Total		58	40	24	41
9	2	4/10	67	51	26	48	for		62	48	26	45
	3	16/10	50	39	27	39	1958		54	48	30	44
	$\bar{x}$		58(50.2)	42(40.2)	26(30.3)	42			58(49.8)	45(42.2)	27(30.8)	43
	L.S.D.	1=N.S.	2=4.7	3&4=N.S.	C.V.=13.6%			1=N.S.	2=4.3	3&4=N.S.	C.V.=12.2%	

When all 3 cultivars were growing together the New Zealand contribution never fell below 23% or exceeded 26% averaged over the 3 sections; but there was a trend towards a higher percentage in section 3.

Total for 1958 Within the annual total yield, the New Zealand share was significantly higher when in association with Irish than with S.23. In combination with both cultivars, 27% of the yield was produced by New Zealand. The differences in contribution between the sections were not significant.

S.23 ryegrass

The percentage contributions to total yield by S.23 when in association with Irish and/or New Zealand are given in table 1.6 and figures 1.11, 1.12 and 1.13.

First cuts S.23 supplied half the yield of the IS treatment and the timing of the first cut had little effect on this figure. With New Zealand the S.23 contribution was significantly less at 39% and tended to be lower at the later cut. This trend was more marked when S.23 was growing with Irish plus New Zealand but on average the S.23 held its own and contributed 32% of the yield.

Second and third cuts By this time the S.23 was growing strongly and had considerably increased its percentage contribution to 68 and 69% in the IS mixture for the second and third cuts respectively. There was a nearly proportional increase in the IN and INS treatments. The effect of time of cutting was not significant.

Fourth - ninth cuts During the remainder of the year the contribution of S.23 with Irish remained around the 75% level. The New Zealand, however, was not suppressed to such a degree and the S.23 percentage never rose above 64. With Irish plus New Zealand there was a greater

Table 1.6 Actual percentage contribution to yield by S.23 during 1958. Significant differences calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Cut	Section	Date	S.23 With Irish	S.23 With N.Z.	S.23 With Irish+N.Z.	x̄	Cut	Date	S.23 With Irish	S.23 With N.Z.	S.23 With Irish+N.Z.	x̄
	1	6/5	50	46	40	45		3/6	67	62	53	61
1	2	8/5	47	37	31	38	2	3/6	68	51	49	56
	3	26/5	54	34	25	38		20/6	69	53	45	56
	x̄		50(44.9)	39(38.3)	32(34.2)	40			68(55.8)	55(48.5)	49(44.4)	58
	L.S.D. 1=N.S. 2=5.2 3&4=N.S. C.V.=15.3%							1=N.S. 2=5.5 3&4=N.S. C.V.=12.9%				
	1	24/6	70	62	57	63		7/7	76	67	58	67
3	2	24/6	72	53	52	59	4	7/7	77	59	58	65
	3	4/7	66	60	51	59		18/7	72	62	51	62
	x̄		69(56.7)	58(49.8)	53(47.0)	60			75(60.2)	63(52.7)	56(48.3)	65
	L.S.D. 1=N.S. 2=4.4 3&4=N.S. C.V.=10.2%							1=N.S. 2=4.9 3&4=N.S. C.V.=10.7%				
	1	26/7	77	65	58	67		18/8	78	67	60	68
5	2	24/7	74	58	61	64	6	12/8	78	57	60	65
	3	1/8	70	68	50	63		19/8	68	64	46	59
	x̄		74(59.4)	64(53.0)	56(48.8)	65			75(60.2)	63(52.7)	55(48.0)	64
	L.S.D. 1=N.S. 2=5.0 3&4=N.S. C.V.=10.8%							1=N.S. 2=4.1 3&4=N.S. C.V.=9.0%				
	1	2/9	78	66	58	67		18/9	78	62	56	65
7	2	27/8	74	60	59	64	8	12/9	74	52	58	61
	3	2/9	70	65	42	59		17/9	68	61	41	57
	x̄		76(59.8)	64(53.2)	53(46.8)	63			73(59.4)	58(50.1)	52(45.8)	61
	L.S.D. 1=N.S. 2=6.2 3&4=N.S. C.V.=13.5%							1=N.S. 2=5.6 3&4=N.S. C.V.=12.5%				
	1	16/10	74	63	54	64	Total		70	60	54	62
9	2	4/10	78	49	50	59	for		70	52	52	58
	3	16/10	67	61	38	55	1958		64	52	38	51
	x̄		73(59.0)	58(49.8)	47(43.2)	59			68(55.8)	55(47.9)	48(43.8)	57
	L.S.D. 1=N.S. 2=6.1 3&4=N.S. C.V.=14.0%							1=N.S. 2=4.3 3&4=N.S. C.V.=10.3%				

proportional rise in the percentage of S.23 and in the 4th, 5th and 8th cuts there was no significant difference between the NS and INS treatments.

The effect of date of cutting was never significant but the tendency was for a lower percentage of S.23 in section 3.

Total for 1958 S.23 made its greatest average contribution (68%) when in association with Irish and the results for the NS and INS mixtures were not significantly different at 55 and 48% respectively.

Potential Contribution

The percentage contribution to the total yields of the mixtures given in tables 1.4, 1.5 and 1.6 are important in that they show the actual contribution made by each cultivar when competing with an associated cultivar or cultivars. They do, in addition, reflect in some degree these competitive relationships but take no account of the varying yields of the cultivars when growing alone, free from competition. In order to measure the increases or decreases caused by associated cultivars it is necessary to construct a table showing what the potential contribution of any cultivar would have been if there had been no competition. By comparing this with the actual contribution an estimate of the competitive influence can be made.

This comparison can be made visually in figures 1.11, 1.12 and 1.13 by comparing the actual yield of a cultivar in a mixture with that of a cultivar growing alone. Thus, if the height of the histogram representing the yield of a cultivar, in a mixture of 2 cultivars, is less than half of the height of the column representing that cultivar alone a suppression in the mixture would be indicated. Where the 3 cultivars are growing together a column height greater or less than

$\frac{1}{5}$ of the respective cultivars growing alone would form the basis for comparison. Since these comparisons are difficult to make by eye and in any case are not precise, tables 1.7, 1.8 and 1.9 have been constructed and show the numerical results of these comparisons.

The calculations involved in the construction of table 1.7 are as follows. In the first cut, the figure of 62 is shown as being the percentage contribution of Irish when growing with New Zealand in section 1. This was arrived at by expressing the yields of Irish and New Zealand growing alone as a percentage of their combined yield. The figure of 62 was produced (see table 1.1) by the following calculation:-

$$(26.0 + 15.9) = 41.9$$

$$\therefore \text{\% contribution of Irish} = \frac{26.0}{41.9} \times \frac{100}{1} = 62$$

The remainder of table 1.7 and tables 1.8 and 1.9 were produced in a similar manner. The comparisons of these potential, or hypothetical, contributions with the actual contributions are shown as deviations from the potential contributions. In this manner a measure of the effects of inter-cultivar competition on yield can be obtained. It is possible to express the deviations as percentage depressions or increases from the potential contribution as follows:-

(a) mean depression due to presence of N.Z. $= \frac{14}{60} \times \frac{100}{1} = 23\%$

(b) mean depression due to presence of S.23 $= \frac{6}{56} \times \frac{100}{1} = 11\%$

(c) mean depression due to presence of N.Z. + S.23 $= \frac{6}{41} \times \frac{100}{1} = 15\%$

Irish ryegrass

Table 1.7 presents this data for Irish ryegrass during 1958 and the overall picture is of depression from its potential contribution as, in only one instance in cut 2 and in cut 3, were positive deviations recorded.

First cuts In all combinations, the growth of Irish was suppressed and the influence of New Zealand was greather than S.23. With all 3 cultivars together the effect on Irish was intermediate.

An interesting aspect of the association with S.23 was the deviation of -13 in section 3 which took place at a time when Irish was growing strongly and S.23 just entering the stem elongation phase.

Second cuts In this cut the suppression of Irish was not so severe and of a similar magnitude in all combinations with a slight trend towards a smaller depression in the section 3 except in combination with New Zealand.

Third cuts The more aggressive nature of S.23 compared to New Zealand was displayed in this cut but the greatest depression of Irish was in combination with both New Zealand and S.23. Irish performed markedly better in section 3 and in the presence of New Zealand displayed its only positive deviation which was a complete reversal from cut 2.

Fourth - ninth cuts During the remainder of the year the effect of New Zealand on Irish did not alter appreciably and averaged around a 16% depression. The suppressive influence was, however, always least in section 3 and greatest in section 2.

The suppression due to S.23 became progressively greater from cut to cut and averaged, in the last two cuts, 47%. This was, more or less, evenly expressed in all sections.

Table 1.7 Potential percentage contribution of Irish ryegrass to yield during 1958 related to yield of Irish growing alone and assuming no competition between cultivars. The deviations of actual contribution (table 1.4), from potential, are given alongside each result and, in parenthesis, the deviations are given as a percentage of potential.

			Irish With						Irish With			
Cut	Section	Date	N.Z.	S.23	N.Z.+S.23	x̄	Cut	Date	N.Z.	S.23	N.Z.+S.23	x̄
1	1	8/5	62-15(24)	52 0(-)	40 -8(20)	51 -7(14)	2	3/6	45 -3(7)	37 -4(11)	26 -6(23)	36 -4(11)
	2	8/5	62-16(26)	53 0(-)	40 -6(15)	52 -8(15)		3/6	44 -4(9)	36 -4(11)	24 -4(17)	35 -4(11)
	3	26/5	58-14(24)	59-13(22)	42 -4(10)	53-10(19)		20/6	48 -6(12)	34 -3(9)	24 +6(25)	35 -1(3)
	x		60-14(23)	56 -6(11)	41 -6(15)	52 -8(15)			45 -4(9)	35 -3(8)	25 -2(8)	37 -5(14)
3	1	24/6	52-11(21)	40-10(25)	29-11(38)	40-10(25)	4	7/7	45 -3(7)	38-14(37)	26 -6(23)	36 -7(19)
	2	24/6	56-16(28)	43-15(35)	32-12(38)	44-15(34)		7/7	53-17(32)	42-19(45)	31-11(35)	42-16(38)
	3	4/7	43 +1(2)	38 -4(10)	25 0(-)	35 -1(3)		18/7	47 -1(2)	45-17(38)	30 -4(13)	41 -8(20)
	x		50 -8(16)	40 -9(22)	29 -8(28)	40 -9(22)			48 -7(14)	42-17(40)	29 -7(24)	40-11(28)
5	1	26/7	48 -8(17)	40-17(42)	28 -8(28)	39-11(28)	6	18/8	47 -7(15)	40-18(45)	28 -9(32)	38-11(29)
	2	24/7	50-14(28)	45-19(42)	31-14(45)	42-16(38)		12/8	52-18(35)	45-23(51)	32-13(41)	43-18(42)
	3	1/8	47 0(-)	48-18(38)	31 -8(26)	42 -9(21)		19/8	53 -1(18)	53-21(40)	36 -9(25)	47-10(21)
	x		48 -7(14)	44-18(41)	30-10(33)	41-12(29)			50 -8(16)	45-20(44)	31 -9(29)	42-12(28)
7	1	2/9	50-11(22)	46-24(52)	31-12(39)	42-15(36)	8	18/9	49 -9(18)	48-26(54)	32-11(34)	43-15(35)
	2	27/8	54-15(28)	50-24(48)	35-15(43)	46-18(39)		12/9	51-14(27)	51-25(49)	34-15(44)	45-18(40)
	3	2/9	51 -7(14)	54-24(44)	35 -7(20)	47-13(28)		17/9	50 0(-)	53-21(40)	35 -1(3)	46 -7(15)
	x		52-11(21)	49-23(47)	34-12(35)	45-15(33)			50 -8(16)	51-24(47)	34 -9(26)	45-14(31)
9	1	16/10	48 -6(12)	47-21(45)	31 -9(29)	42-12(28)	Total for 1958		50 -8(16)	44-14(32)	31 -9(29)	42-11(26)
	2	4/10	52-19(36)	52-30(58)	35-11(31)	46-20(43)			53-15(28)	46-16(35)	33-10(30)	44-14(32)
	3	16/10	52 -2(4)	55-22(40)	36 -2(6)	48 -9(19)			53 -7(13)	52-16(31)	35-3 (8)	47 -9(19)
	x		51 -9(18)	51-24(47)	34 -7(20)	45-13(29)			52-10(19)	48-16(33)	33 -7(21)	44-11(25)

With both New Zealand and S.23 competing with Irish, the depression was intermediate between those resulting from either one singly, varied around 30% and was always highest in section 2.

Total for 1958 In the total for the year the same general influences as mentioned above were apparent, S.23 being more aggressive than New Zealand and their combined effect intermediate.

New Zealand ryegrass

Table 1.8 shows the potential percentage contributions of New Zealand and the deviations of the actual contributions. The general impression of the results was of an increase in New Zealand growth in association with Irish and an approximately equal share of production with S.23. With both acting together New Zealand appeared to be slightly depressed.

First cuts New Zealand was the major contributor in association with both Irish and S.23, the contribution with S.23 being slightly higher but as a percentage over potential slightly less. New Zealand also exceeded its potential yield in combination with Irish plus S.23 but to a smaller extent than with either singly. The differences between sections were not large.

Second cuts At this period New Zealand was still dominating associated Irish and on average was also exceeding its potential with S.23. It should, however, be noticed that although in fact S.23 was being slightly suppressed it was still contributing over 50% of the yield. The mean effect of Irish plus S.23 was to slightly depress the New Zealand percentage relative to its potential. New Zealand tended to do rather better in the sections 2 and 3 but the differences were not large.

Table 1.8 Potential percentage contribution of New Zealand ryegrass to yield during 1958 related to yield of Irish growing alone and assuming no competition between cultivars. The deviations of actual contribution (table 1.5) from potential are given alongside each result and, in parenthesis, the deviations are given as a percentage of potential.

			N.Z. With						N.Z. With			
Cut	Section	Date	Irish	S.23	Irish+S.23	x̄	Cut	Date	Irish	S.23	Irish+S.23	x̄
	1	8/5	38+16(42)	40+14(35)	24 +7(29)	34+12(35)		3/6	55 +3(5)	42 -4(10)	31 -5(16)	43 -2(5)
1	2	8/5	38+16(42)	41+22(54)	24+10(42)	34+16(47)	2	3/6	56 +4(7)	41 +8(20)	31 0(-)	43 +4(9)
	3	26/5	42+14(33)	50+16(32)	30 +7(23)	41+12(29)		20/6	52 +6(12)	36+11(30)	26 -1(4)	38 +5(13)
	x̄		40+15(38)	46+15(33)	27 +7(26)	38+12(32)			55 +4(7)	40 +5(12)	30 -3(10)	42 +2(5)
	1	24/6	48+11(23)	38 0(-)	27 -2(7)	38 +3(8)		7/7	55 +3(5)	43-10(23)	32-10(31)	43 -5(12)
3	2	24/6	44+16(36)	38 +9(24)	26 +2(8)	36 +9(25)	4	7/7	47+17(36)	39 +2(5)	27 -5(18)	38 +4(10)
	3	4/7	57 -1(2)	46 -6(13)	34-10(29)	46 -6(13)		18/7	53 +1(2)	48-10(21)	34-10(29)	45 -6(13)
	x̄		50 +8(16)	40 +1(2)	28 -2(7)	39 +3(8)			52 +7(13)	44 -7(16)	31 -[illegible](26)	42 -2(5)
	1	26/7	52 +8(15)	42 -7(17)	30 -8(27)	41 -2(5)		14/8	53 +7(13)	43-10(23)	31-10(32)	42 -4(10)
5	2	24/7	50+14(28)	44 -2(4)	30 -8(27)	41 +2(5)	6	12/8	48+18(38)	43 0(-)	29 -9(31)	40 +3(8)
	3	1/8	53 0(-)	51-19(37)	35 -7(20)	46 -8(17)		19/8	47 +1(2)	50-14(28)	32 -5(16)	43 -6(14)
	x̄		52 +7(13)	45 -9(20)	32 -8(25)	43 -3(7)			50 +8(16)	45 -8(18)	31 -8(26)	42 -3(7)
	1	2/9	50+11(22)	45-11(24)	31 -9(29)	42 -3(7)		18/9	51 +9(18)	50-12(24)	34-13(38)	45 -5(11)
7	2	27/8	46+15(33)	46 -6(13)	30 -9(30)	41 0(-)	8	12/9	49+14(28)	49 -1(2)	32 -9(28)	43 +2(5)
	3	2/9	49 +7(14)	52-17(33)	34 -4(12)	45 -5(11)		17/9	50 0(-)	53-14(26)	35 -9(26)	46 -8(17)
	x̄		48+11(23)	47-11(23)	31 -7(22)	42 -2(5)			50 +8(16)	51 -9(18)	34-11(32)	45 -4(9)
	1	16/10	52 +6(12)	49-12(24)	33 -9(27)	45 -5(11)	Total		50 +8(16)	43 -3(7)	30 -6(20)	41 0(-)
9	2	4/10	48+19(40)	50 +1(2)	33 -7(21)	44 +4(9)	for		47+15(32)	44 +4(9)	29 -3(10)	40 +5(12)
	3	16/10	40+2 (4)	53-14(26)	34 -7(20)	45 -6(13)	1958		47 +7(15)	49 -1(2)	32 -2(6)	43 +1(2)
	x̄		49 +9(18)	50 -8(16)	33 -7(21)	44 -2(4)			48+10(21)	45 0(-)	30 -3(10)	41 +2(5)

Third cuts New Zealand again showed an average positive deviation in combination with Irish but this was composed of fairly substantial increases in the sections 1 and 2 and a small depression in section 3. The influence of S.23 was also variable over the cutting sections being nil in section 1, +9 in section 2 and -6 in section 3. With the 3 cultivars together the average effect was depressive and was most evident in section 3. The average effects of sections showed that New Zealand was suppressing its companions in sections 1 and 2 but was being suppressed in section 3.

Fourth - ninth cuts The competitive effects over the remaining cuts were relatively constant.

New Zealand suppressed Irish growth at all cuts and in all sections except section 3 where its effect was very much less or non-existent. With S.23 the results were quite different and New Zealand was suppressed in both sections 1 and 3, but held its own against the S.23 in section 2. The most consistent effect resulted when Irish plus S.23 were competing with New Zealand which was suppressed on all occasions and, to a greater degree than it was when only competing with S.23.

Total for 1958 On total yield New Zealand had increased its contribution, relative to its potential, by over 10% when in association with Irish; the increase being slightly lower in section 3.

On average, the competitive effect of S.23 was zero but varied slightly between sections; section 2 again showing a slight gain for New Zealand.

The combined effect of both Irish and S.23 was to suppress New Zealand slightly and was highest in section 1 and lowest in section 3.

S.23 ryegrass

Table 1.9 shows the potential percentage contributions of S.23 and the deviations of the actual contributions. The main points in this table were the suppression of Irish by S.23 and the fairly even balance achieved in combination with New Zealand.

First cuts Irish was suppressed by S.23 right from the first cut especially when this was delayed until May 26th. New Zealand on the other hand suppressed the S.23 production to a greater degree than the Irish was suppressed by S.23. With both Irish and New Zealand acting together the S.23 was able to offset its suppression by New Zealand against its gain in company with Irish, with the result that, averaged over the sections, the contribution of S.23 was unaffected by competition.

Second cuts S.23 showed a small gain in association with Irish and a small depression with New Zealand derived from sections 2 and 3. New Zealand plus Irish depressed S.23 in section 3 but allowed an increase in the other sections.

Third cuts S.23 had increased its suppression of Irish and was practically unaffected by New Zealand except in section 2. S.23 also suppressed both Irish and New Zealand when all 3 were together but, as would be expected, the most suppressed was Irish. This fact can be verified by reference to tables 1.6 and 1.7 where it will be seen that at the third cuts the average effect of the INS mixture on Irish was to give a -8 deviation and on New Zealand a -2 deviation.

Fourth - ninth cuts During this period the increase of S.23 at the expense of Irish continued progressively and balanced the diminution of Irish contribution seen in table 1.6 which finally amounted to a suppression of 47% of its potential.

Table 1.9 Potential percentage contribution of S.23 ryegrass to yield during 1958 related to yield of Irish growing alone and assuming no competition between cultivars. The deviations of actual contribution (table 1.6) from potential are given alongside each result and, in parenthesis, the deviations expressed as a percentage of potential.

			S.23 With						S.23 With			
Cut	Section	Date	Irish	N.Z.	Irish+N.Z.	x̄	Cut	Date	Irish	N.Z.	Irish+N.Z.	x̄
1	1	8/5	48 +2(4)	60-14(23)	36 +4(11)	48 -3(6)	2	3/6	63 +4(6)	58 +4(7)	43+10(23)	55 +6(11)
	2	8/5	47 0(-)	59-22(37)	36 -5(14)	47 -9(19)		3/6	64 +4(6)	59 -8(14)	45 +4(9)	56 0(-)
	3	26/5	41+13(32)	50-16(32)	28 -3(11)	40 -2(5)		20/6	66 +3(4)	64-11(17)	50 -5(10)	60 -4(7)
	x̄		44 +6(14)	54-15(28)	32 0(-)	43 -3(7)			65 +3(5)	60 -5(8)	45 +4(9)	57 +1(2)
3	1	24/6	60+10(17)	62 0(-)	44+13(30)	55 +8(14)	4	7/7	62+14(22)	57+10(18)	42+16(38)	54+13(24)
	2	24/6	57+15(26)	62 -9(14)	42+10(24)	54 +5(9)		7/7	58+19(33)	61 -2(3)	42+16(38)	54+11(20)
	3	4/7	62 +4(6)	54 +6(11)	41+10(24)	52 +7(13)		18/7	55+17(31)	52+10(19)	36+15(42)	48+14(29)
	x̄		60 +9(15)	60 -1(2)	43+10(23)	54 +6(11)			58+17(29)	56 +7(12)	40+16(40)	51+14(27)
5	1	26/7	60+17(28)	58 +7(12)	42+16(38)	53+14(26)	6	18/8	60+18(30)	57+10(18)	41+19(46)	53+15(28)
	2	24/7	55+19(34)	56 +2(4)	39+22(56)	50+14(28)		12/8	55+23(42)	57 0(-)	39+21(54)	50+15(30)
	3	1/8	52+18(35)	49+19(39)	34+16(47)	45+18(40)		19/8	47+21(45)	50+14(28)	32+14(44)	43+16(37)
	x̄		56+18(32)	55 +9(16)	38+18(47)	50+15(30)			55+20(36)	55 +8(14)	38+17(45)	49+15(31)
7	1	2/9	54+24(44)	55+11(20)	38+20(53)	49+18(37)	8	18/9	52+26(50)	50+12(24)	34+22(65)	45+20(44)
	2	27/8	50+24(48)	54 +6(11)	35+24(68)	46+18(39)		12/9	49+25(51)	51 +1(2)	34+24(70)	45+16(36)
	3	2/9	46+24(52)	48+17(35)	31+11(35)	42+17(40)		17/9	47+21(45)	47+14(30)	30+11(37)	41+16(39)
	x̄		51+23(45)	53+11(21)	35+18(51)	46+17(37)			49+24(49)	49 +9(18)	32+20(62)	43+18(42)
9	1	16/10	53+21(40)	51+12(24)	36+18(50)	47+17(36)	Total for 1958		56+14(25)	57 +3(5)	39+15(38)	51+11(21)
	2	4/10	48+30(62)	50 -1(2)	32+18(56)	43+16(37)			54+16(30)	56 -4(7)	38+14(37)	49 +9(18)
	3	16/10	45+22(49)	47+14(30)	30 +8(27)	41+14(34)			48+16(33)	51 +1(2)	33 +5(15)	44 +7(16)
	x̄		49+24(49)	50 +8(16)	33+14(42)	44+15(34)			52+16(31)	55 0(-)	37+11(30)	43 +9(19)

New Zealand, as was also previously seen, was slightly suppressed but not in section 2.

S.23 was the dominant cultivar in the INS combination producing, on average, more than the other two put together. Again this dominance was gained more at the expense of Irish than New Zealand.

Total for 1958 S.23 showed an average gain of 31% over its potential contribution when in association with Irish but could show no improvement with New Zealand as its partner and was in fact slightly depressed in section 2. In the INS mixture S.23 exhibited a 30% increase balancing the 10% and 20% decreases in New Zealand and Irish respectively. On average, cutting section had little effect.

8 cutting.
date of cutting ?

Plant and Tiller Numbers

Plant Survival

From the plant count made at the end of the first harvest year the percentage survival of each cultivar growing alone and in combination with the others was calculated. Table 1.10 gives these results within, and averaged over, each section. There were no significant differences between any treatments, but comparing the cultivars growing alone their survivals were respectively 92%, 88% and 96% for Irish, New Zealand and S.23. It was noticable that the combination of Irish with New Zealand and/or S.23 lowered its survival in all cutting sections. Similarly the survival of New Zealand was slightly less when it was associated with S.23. The survival of S.23 was very constant and little affected by cultivar combinations.

Tiller Numbers

Mean tiller number per plant The first tiller count was made on plots of pure sown cultivars shortly after establishment and gave a reference for initial tiller numbers applicable to all sowings since it was assumed that interactions between cultivars had not had time to function. These results are given in table 1.11 and show no significant difference between cultivars.

The mean tiller numbers per plant at the end of the first harvest year are recorded in table 1.12.

Irish growing with New Zealand and/or S.23 suffered a significant reduction in tiller numbers compared to Irish growing alone. The reduction due to the presence of S.23 was greater than that due to New Zealand and amounted to an average of 15 tillers per plant. With both New Zealand and S.23 present the Irish plants had 14 fewer tillers

Table 1.10 Percentage survival at November 1958.

Irish ryegrass

Section	Alone	With N.Z.	With S.23	With N.Z.+S.23	$\bar{x}$	L.S.D.
1	90	88	74	82	83	1,2,3,4=N.S.
2	92	78	82	77	81	
3	93	86	88	85	88	C.V.=14.3%
$\bar{x}$	92	84	81	81	84	

N.Z. ryegrass

	Alone	With Irish	With S.23	With Irish+S.23	$\bar{x}$	
1	88	92	79	73	83	1,2,3,4=N.S.
2	88	84	87	88	87	
3	90	86	78	88	85	C.V.=13.1%
$\bar{x}$	88	87	81	83	85	

S.23 ryegrass

	Alone	With Irish	With N.Z.	With Irish+N.Z.	$\bar{x}$	
1	94	98	95	98	96	1,2,3,4=N.S.
2	98	93	97	100	97	
3	97	96	90	92	94	C.V.=11.8%
$\bar{x}$	96	96	94	97	96	

Table 1.11 Mean tiller number per plant of Irish, New Zealand and S.23 when growing alone at 11th July, 1957.

Cultivar			
Irish	N.Z.	S.23	
13.9	13.4	14.0	C.V. = 38.3%

Differences between means = N.S.

Table 1.12 Mean tiller number per plant at November 1958.

Irish ryegrass

Section	Alone	With N.Z.	With S.23	With N.Z.+S.23	$\bar{x}$	L.S.D.
1	40	35	25	25	31	1=N.S.
2	43	30	24	26	31	2=7
3	36	31	26	28	30	3,4=N.S.
$\bar{x}$	40	32	25	26	31	C.V.=28.0%

N.Z. ryegrass

Section	Alone	With Irish	With S.23	With Irish+S.23	$\bar{x}$	L.S.D.
1	27	43	27	27	31	1=5
2	41	42	28	28	34	2=7
3	20	34	28	30	28	3,4=N.S.
$\bar{x}$	29	40	28	28	31	C.V.=28.5%

S.23 ryegrass

Section	Alone	With Irish	With N.Z.	With Irish+N.Z.	$\bar{x}$	L.S.D.
1	42	41	44	39	42	1,2,3,4=N.S.
2	38	41	34	40	38	C.V.=26.4%
3	28	37	41	38	36	
$\bar{x}$	36	40	39	39	39	

than Irish alone. The effect of cutting section was non-significant and showed little effect on tiller production.

Considering the effects on New Zealand tiller number it can be seen that in combination with Irish this was significantly increased from 29 to 40 per plant while with S.23 or Irish and S.23 it was similar to New Zealand alone.

The effect of cutting sections on New Zealand tillers per plant was significant. New Zealand had only 28 tillers under the management of section 3 and 34 in section 2. This was especially noticable where New Zealand was growing alone.

The tiller numbers of S.23 plants were not significantly affected by combining with other cultivars although in each case the average figures were slightly higher than S.23 alone.

The average figures for the cultivars growing alone showed Irish to have 40 tillers per plant and S.23 slightly less at 36 while New Zealand was markedly lower at 29.

Tillers per Unit Area The total number of tillers per sq. ft. for each treatment, shown in table 1.13 and figure 1.18 were calculated by adding the products of the mean tillers per plant and the number of plants surviving for each cultivar present in a treatment. Thus in figure 1.18 the contribution to the total tillers produced by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total tillers that it represents is quoted. Irish alone had, on average, the highest number of tillers per sq. ft. but not significantly more than S.23. New Zealand alone was the lowest and the other treatments did not differ significantly from each other but were all significantly lower than Irish alone. Only the INS mixture and New Zealand alone were significantly lower than S.23. There were no significant differences between the section means.

Table 1.13 Total tillers per sq. ft. at November 1958.

Section	I	N	S	IN	IS	NS	INS	$\bar{x}$	L.S.D.
	Cultivar Combinations								
1	1295	862	1422	1185	1040	1145	940	1127	1=N.S.
2	1428	1312	1355	1058	1022	1018	1042	1176	2=210
3	1205	650	968	1008	1105	952	1020	987	3&4=N.S.
$\bar{x}$	1309	942	1248	1083	1056	1038	1001	1097	C.V.=23.2%

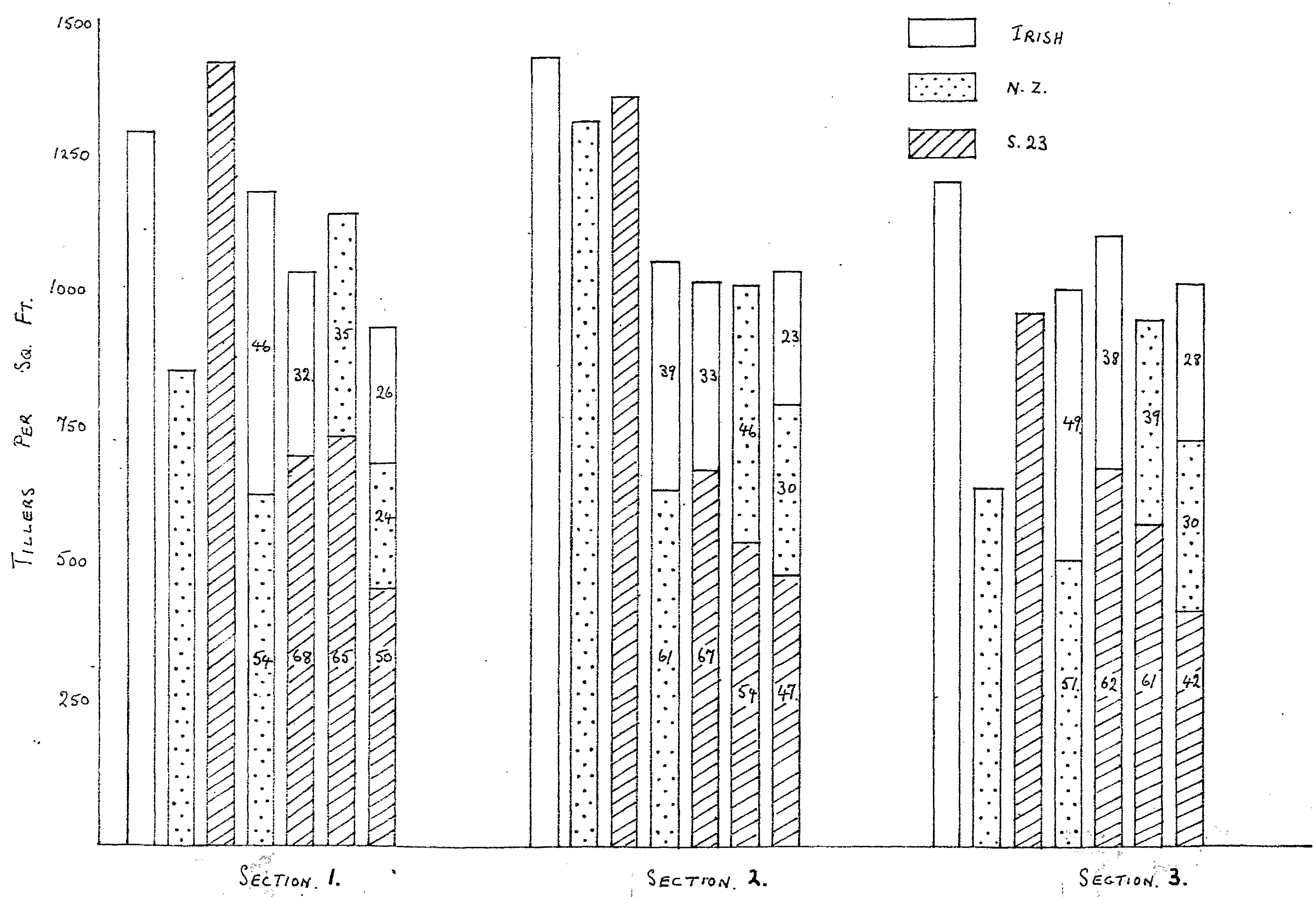


Figure 1.18 Tiller production per sq. ft. and contribution of the components of the mixtures at November 1958.

Actual Percentage, and Potential Percentage, Contribution to Tiller Production by the Components of Cultivar Mixtures

Actual Contribution

The contributions to total tiller number per sq. ft. made by the various components of the mixtures are presented in table 1.14 and figure 1.18. On average Irish, in mixtures, made the least contribution in terms of tiller numbers and S.23 the greatest. The effects of competition were apparent as Irish growing with S.23 had contributed significantly less than when in association with New Zealand.

The New Zealand contribution was also significantly affected by companion cultivars and was 15% greater in the presence of Irish than S.23. New Zealand in the INS mixture produced 28% of the tillers which was slightly more than Irish.

S.23 contributed the bulk of the tillers in all combinations. The 6% higher contribution with Irish compared to New Zealand was not significant.

The effects of the cutting sections were not significant for any of the cultivars.

Potential Contribution

As with the yield data it was considered desirable to construct a table of hypothetical, potential contributions to tiller production and the deviations of the actual contributions from the potential. The calculations were done in a similar manner to that used for the yield data. The figures used in calculating the potential contributions were obtained from table 1.13.

Table 1.15 shows these potential contributions and the effects of competition as reflected in the deviations from the actual values (table 1.14).

Table 1.14. Actual percentage of total tillers per sq. ft. contributed by the components of the mixtures at November 1958. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Irish With

Section	N.Z.	S.23	N.Z.+S.23	$\bar{x}$	L.S.D.
1	46	32	26	35	1=N.S.
2	39	33	23	32	2=5
3	49	38	28	38	3,4=N.S.
$\bar{x}$	45(42)	34(35)	26(30)	35	C.V.=16.7%

N.Z. With

	Irish	S.23	Irish+S.23	$\bar{x}$	
1	54	35	24	38	1=N.S.
2	61	46	30	46	2=6
3	51	39	30	40	3,4=N.S.
$\bar{x}$	55(48)	40(39)	28(32)	41	C.V.=16.4%

S.23 With

	Irish	N.Z.	Irish+N.Z.	$\bar{x}$	
1	68	65	49 50	61	1=N.S.
2	67	54	46 47	56	2=5
3	62	61	41 42	55	3,4=N.S.
$\bar{x}$	66(54)	60(51)	46(42)	57	C.V.=12.0%

Table 1.15 Potential percentage contributions of cultivars to total tiller production in 1958 related to tiller production of cultivars growing alone and assuming no competition between them. The deviations, of actual contributions (table 1.14), from potential are given alongside each result and, in parenthesis, the deviations expressed as a percentage of potential.

Irish With

Section	N.Z.	S.23	N.Z.+S.23	$\bar{x}$
1	60-14(23)	48-16(33)	36-10(28)	48-13(27)
2	52-13(25)	51-18(35)	35-12(34)	46-14(30)
3	65-16(25)	55-17(31)	43-15(35)	54-16(30)
$\bar{x}$	58-13(22)	51-17(33)	37-11(30)	49-14(29)

N.Z. With

	Irish	S.23	Irish+S.23	$\bar{x}$
1	40+14(35)	38 -3(8)	24 0(-)	34 +4(12)
2	48+13(27)	49 -3(6)	32 -2(6)	43 +3(7)
3	35+16(46)	40 -1(2)	23 +7(30)	33 +7(21)
$\bar{x}$	42+13(31)	43 -3(7)	27 +1(4)	37 +4(11)

S.23 With

	Irish	N.Z.	Irish+N.Z.	$\bar{x}$
1	52+16(31)	62 +3(5)	40 +9(22)	51+10(20)
2	49+18(37)	51 +3(6)	33+13(39)	44+12(27)
3	45+17(38)	60 +1(2)	34 +7(20)	46 +9(20)
$\bar{x}$	49+17(35)	57 +3(5)	36+10(28)	47+10(21)

Irish ryegrass   The tillering capacity of Irish was depressed in all combinations and all sections. With New Zealand or S.23 it produced less than half the total and was depressed by 22 and 33% respectively from its potential. With all cultivars together the depression was 30% of potential indicating a compensating effect.

The suppression of Irish was not markedly affected by cutting section.

New Zealand ryegrass   New Zealand tillered more freely in the presence of Irish than it did when S.23 was present and in the latter association it was actually slightly suppressed. The two effects balanced each other so that in combination with both Irish and S.23 the average New Zealand contribution to total tiller production was little different from its potential.

These results were somewhat modified by cutting section as with Irish or Irish + S.23 the New Zealand gain was greater in section 3. With S.23, the suppression was rather greater in section 1 and least in section 3.

S.23 ryegrass   S.23 made substantial gains against Irish which were not noticably affected by cutting section and averaged a 35% increase over the potential. The gain against New Zealand was very much less and averaged only 5%.

The 28% increase of S.23 in the INS mixture was balanced by a large depression in Irish tillers and not, as would be expected, by suppression of New Zealand.

SECOND HARVEST YEAR

Dry Matter Yield of Cultivars Growing Alone and in Mixtures at Each Cut and Accumulatively

Yield per Cut

The yields of dried herbage for the 9 cuts taken in 1959 and the total for the year are given in table 1.16 and diagramatically in figures 1.19, 1.20 and 1.21.

Cutting frequencies The dates of cutting and intervals between cuts are summarised in table 1.17. During this second year section 2 again reached the required 18 cm. height on 9 occasions and sections 1 and 3 were cut only 8 times.

New Zealand ryegrass growing alone was first to reach 18 cm. and section 2 was cut three days before section 1. S.23 growing alone was again the last in spring to reach cutting height and its section (No. 3) was not defoliated until 17 days and 14 days after sections 2 and 1 respectively.

Until the last cut section 2 was cut at fairly regular intervals throughout the year but section 1 regrowth intervals lengthened to 40 and 45 days between the sixth and seventh and between the seventh and eighth cuts. Section 3 after its late start was quite regular in frequency until the autumn period when, like the others, the rate of growth slowed down.

The average yield for all treatments was 20.4 g. per plot for the first cuts and slightly lower and fairly constant for all subsequent cuts. Section 2 gave the most regular yield with a range from 11.4 g. to 19.1 g. per plot.

Table 1.16 Yield of dry matter (grams per plot) during 1959 and total for the year.

Cut	Section	Date	I	N	S	IN	IS	NS	INS	$\bar{x}$	L.S.D.
			Cultivar Treatments								
1	1	21/4	16.5	22.2	16.5	20.0	17.0	17.4	21.3	18.7	1. = 1.5
	2	18/4	11.3	14.4	15.0	17.0	10.7	16.6	14.0	14.1	2. = 3.6
	3	5/5	37.8	25.1	19.8	37.0	23.2	28.2	27.7	28.4	3. = 6.2
	x		21.9	20.6	17.1	24.7	17.0	20.8	21.0	20.4	4. = 5.9
											C.V. = 25.3%
2											1. = 1.6
	1	12/5	14.9	14.0	14.8	14.6	15.0	14.5	14.6	14.6	2. = N.S.
	2	7/5	10.3	13.6	12.4	14.2	9.8	11.5	10.4	11.7	3. = 3.7
	3	23/5	12.4	11.5	16.6	11.6	15.4	17.7	12.8	14.0	4. = 3.8
	x		12.5	13.0	14.6	13.4	13.4	14.6	12.6	13.4	C.V. = 19.4%
3											1. = 3.3
	1	30/5	10.3	14.8	18.4	13.4	16.7	17.0	16.9	15.3	2. = 2.7
	2	20/5	11.7	14.6	15.2	13.8	12.1	13.6	13.0	13.4	3. = N.S.
	3	16/6	19.9	14.9	19.0	18.7	19.6	23.5	21.6	19.6	4. = N.S.
	x		14.0	14.8	17.5	15.3	16.2	18.0	17.1	16.1	C.V. = 20.5%
4											1. = N.S.
	1	19/6	10.7	16.4	20.8	13.9	16.6	17.6	16.3	16.0	2. = 1.8
	2	12/6	10.1	12.8	17.0	13.6	14.8	15.6	15.8	14.2	3. = 3.1
	3	7/7	13.2	13.1	15.4	15.8	15.4	19.4	17.3	15.6	4. = 3.7
	x		11.3	14.1	17.7	14.4	15.6	17.5	16.4	15.3	C.V. = 14.2%
5											1. = 2.4
	1	13/7	14.6	23.8	26.0	20.6	23.3	25.6	22.4	22.3	2. = 1.9
	2	2/7	7.8	11.8	13.3	11.2	10.8	13.4	11.7	11.4	3. = 3.3
	3	24/7	12.7	12.1	13.4	14.5	13.5	16.4	14.7	13.9	4. = 3.8
	x		11.7	15.9	17.6	15.4	15.9	18.5	16.3	15.9	C.V. = 14.2%
6											1. = 2.2
	1	31/7	11.0	17.4	18.4	14.8	17.2	17.2	16.2	16.0	2. = 2.0
	2	22/7	13.8	19.5	22.5	20.0	18.3	20.8	18.9	19.1	3. = N.S.
	3	12/8	13.7	14.4	14.2	14.7	14.8	17.5	15.3	14.9	4. = N.S.
	x		12.8	17.1	18.4	16.5	16.8	18.5	16.8	16.7	C.V. = 14.2%
7											1. = 2.6
	1	9/9	15.8	28.8	30.8	26.8	29.7	32.0	27.1	27.3	2. = 2.5
	2	7/8	10.2	15.0	16.1	15.9	13.4	15.0	14.1	14.2	3. = 4.4
	3	10/9	11.9	15.6	14.0	14.2	14.5	18.4	16.3	15.0	4. = 4.8
	$\bar{x}$		12.6	19.8	20.3	18.9	19.2	21.8	19.2	18.8	C.V. = 16.3%
8											1. = 6.4
	1	24/10	11.6	23.4	26.2	22.4	29.6	28.8	23.1	23.6	2. = 3.1
	2	2/9	9.6	16.6	17.0	15.7	13.2	15.8	14.6	14.6	3. = 5.3
	3	16/10	11.2	16.0	13.9	14.6	14.6	18.0	14.7	14.7	4. = 8.2
	x		10.8	18.6	19.0	17.6	19.1	20.9	17.4	17.6	C.V. = 21.0%
9	2	15/10	10.0	17.0	18.8	17.4	15.1	18.6	17.0	16.3	2. = 4.2
											C.V. = 17.3%

continued overleaf

Table 1.16 (continued).

Cut	Section	I	N	S	IN	IS	NS	INS	$\bar{x}$		
Total	1	106	161	172	146	165	170	158	154	1.	= 11
for	2	95	136	148	139	118	141	130	129	2.	= 15
1959	3	133	123	126	141	131	159	140	136	3.	= 26
										4.	= 27
	$\bar{x}$	111	140	148	142	138	156	143	140	C.V.	= 13.1%

Table 1.17 Dates on which the sections were cut during 1959 and intervals between cuts.

Section		Cut 1.	2.	3.	4.	5.	6.	7.	8.	9.
1	Date of cut	21/4	12/5	30/5	19/6	13/7	31/7	9/9	24/10	
	Interval between cuts	0	21	18	20	24	18	40	45	
2	Date of cut	18/4	7/5	20/5	12/6	2/7	22/7	7/8	2/9	15/10
	Interval between cuts	0	19	13	23	20	20	16	26	43
3	Date of cut	5/5	23/5	16/6	7/7	24/7	12/8	10/9	16/10	
	Interval between cuts	0	18	24	21	17	19	29	36	

Figure 1.19 Yields of dry matter in section 1 at each cut in 1959 and total for 1959. The contribution to the total yield by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total yield that it represents is quoted.

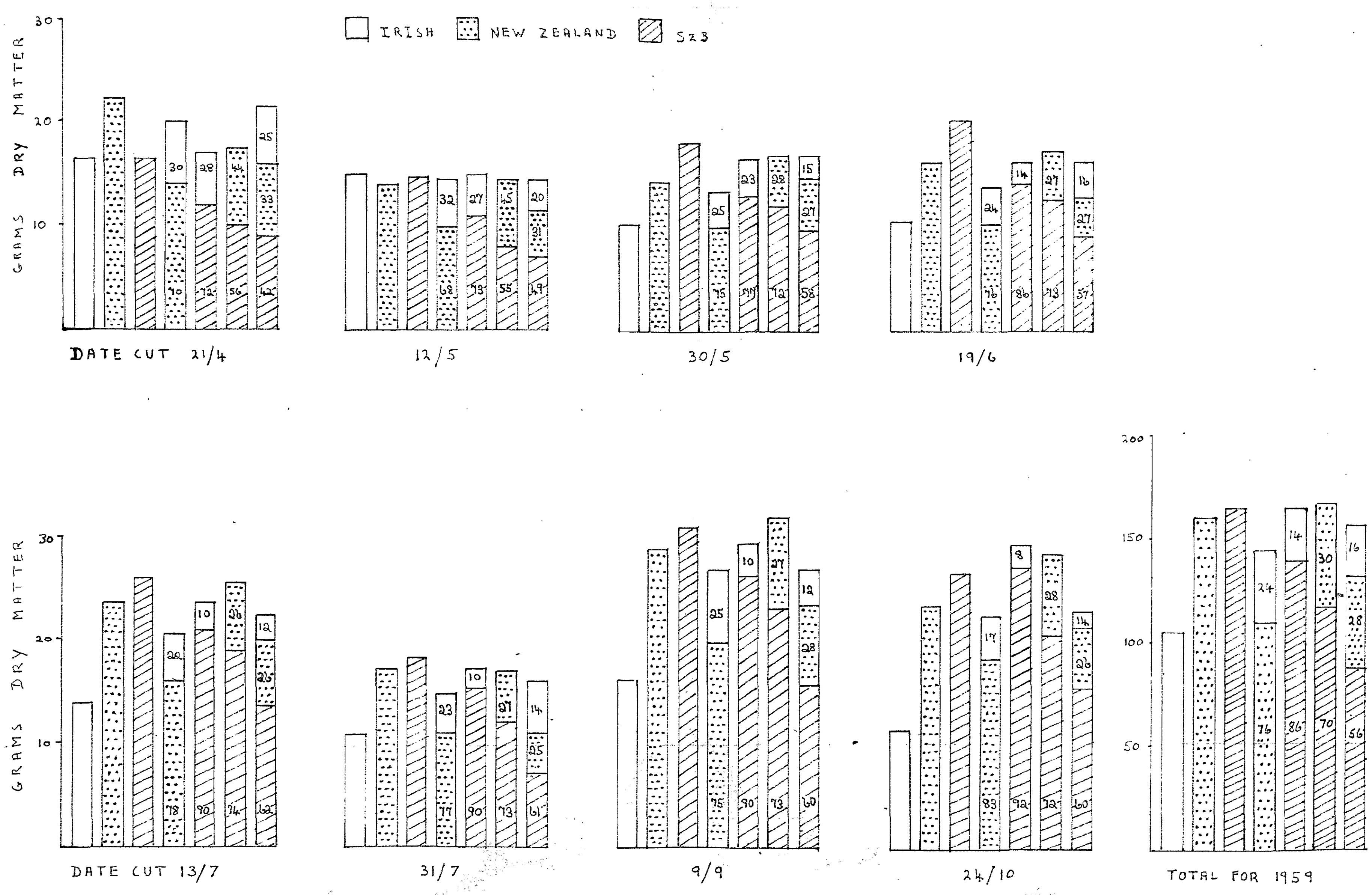

IRISH
NEW ZEALAND
S23
GRAMS DRY MATTER
10
20
30
DATE CUT 21/4
12/5
30/5
19/6
GRAMS DRY MATTER
10
20
30
DATE CUT 13/7
31/7
9/9
24/10
50
100
150
200
TOTAL FOR 1959

Figure 1.20 Yield of dry matter in section 2 at each cut in 1959 and total for 1959. The contribution to the total yield by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total yield that it represents is quoted.

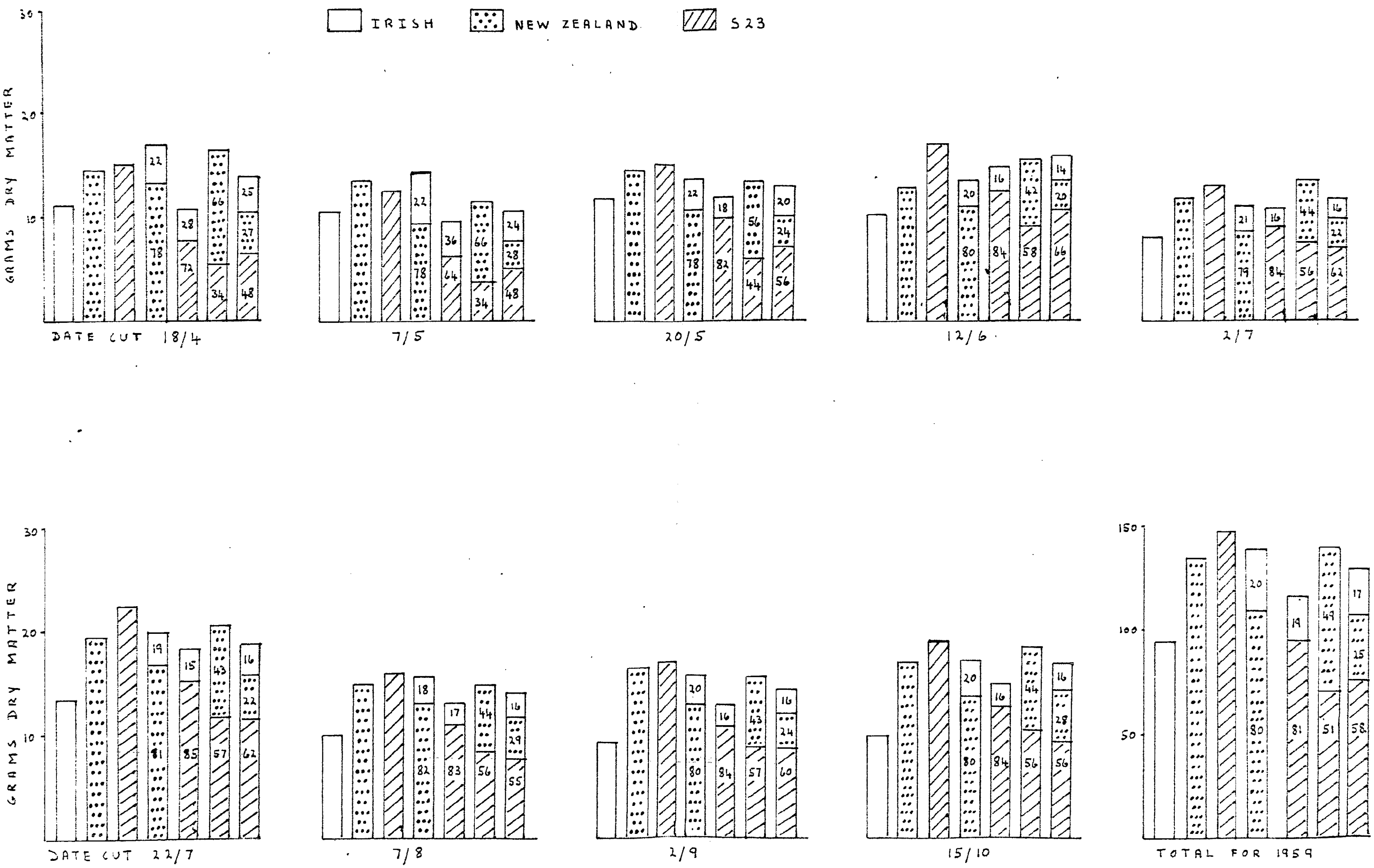
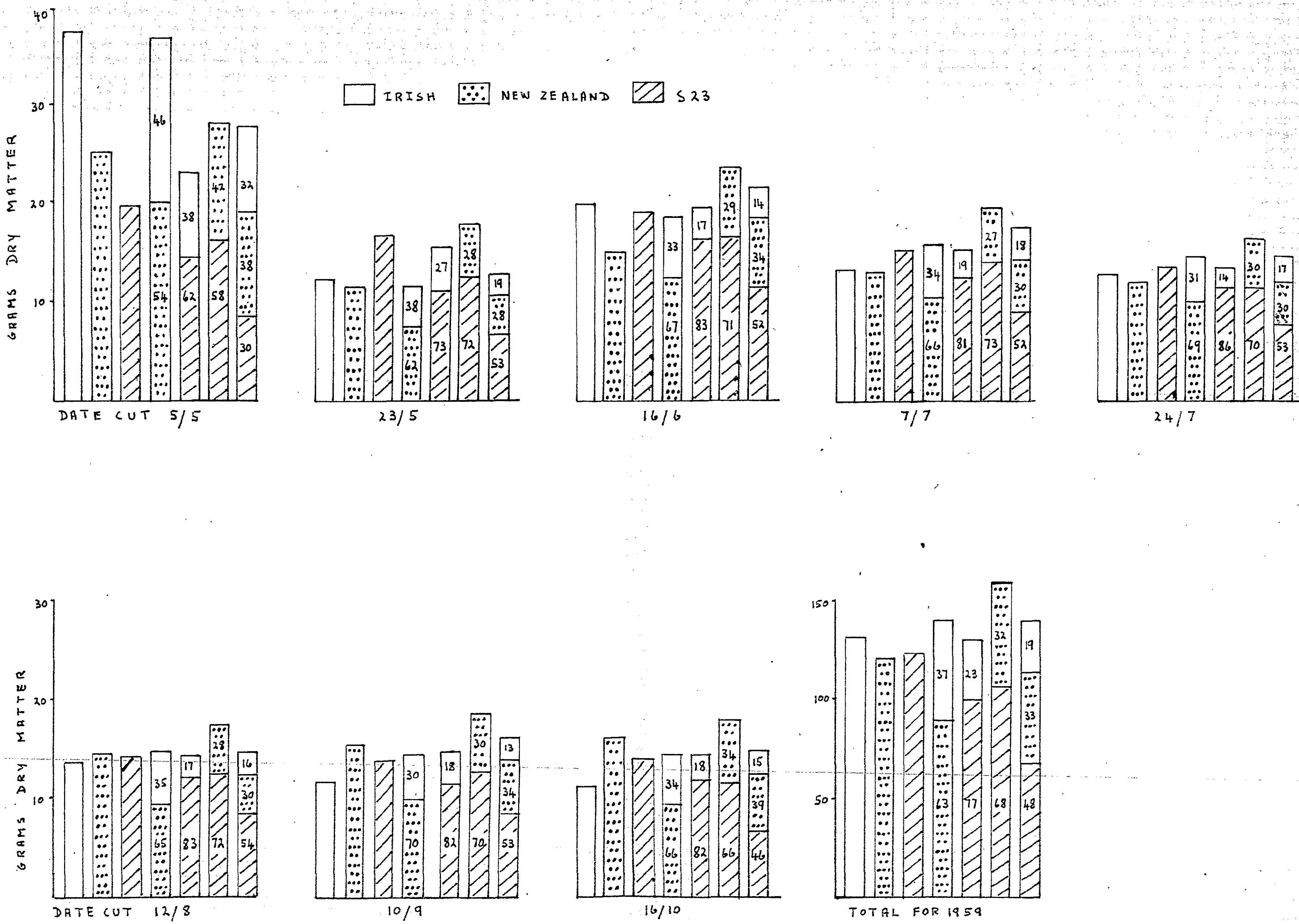

IRISH
NEW ZEALAND
S23
GRAMS DRY MATTER
10
20
30
DATE CUT 18/4
7/5
20/5
12/6
2/7
GRAMS DRY MATTER
10
20
30
DATE CUT 22/7
7/8
2/9
15/10
50
100
150
TOTAL FOR 1959

Figure 1.21 Yield of dry matter in section 3 at each cut in 1959 and total for 1959. The contribution to the total yield by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total yield that it represents is quoted.



GRAMS DRY MATTER
IRISH
NEW ZEALAND
S23
DATE CUT 5/5
23/5
16/6
7/7
24/7
DATE CUT 12/8
10/9
16/10
TOTAL FOR 1959

Significant differences between the main plot section means were recorded at all cuts except the fourth, and between sub plot cultivar treatment means at all cuts except the second. The interaction between cutting sections and cultivar treatments was significant at all cuts except the third and sixth and in these cuts it was not far from significant (table A2.1).

First cuts The effects of the different cutting times on the yields of the cultivar treatments was very noticable, there being no significant differences between the yields in either sections 1 or 2. There were, however, some very marked differences in section 3. For example, the late cultivar S.23 gave a yield not significantly different from the two early types in sections 1 and 2 but by delaying the first cut until May 5th the Irish yield was more than doubled and was significantly greater than New Zealand or S.23. The higher yield of New Zealand over S.23 in this section was not statistically significant. Of the mixed sown cultivars, the IN combination was the only one containing Irish which markedly responded to the increased Irish growth rate exhibited in section 3 and its yield was only just less than Irish alone. The IS mixture yield while higher than S.23 was not significantly so and lay much closer to the S.23 than the higher Irish value. The INS mixture significantly outyielded S.23 alone but not New Zealand and was considerably below the Irish yield. The yield of the NS mixture was greater than either of its components growing alone but was not significantly different from New Zealand.

Second cuts In section 1 all yields were extremely close and ranged from 14.0 g. for New Zealand to 15.0 g. for IS.

The section 2 yields were more variable and the only significant difference was between the highest (IN) and the lowest (IS). The yield of Irish alone was lower than New Zealand or S.23 but the difference just failed to reach statistical significance. Considering the mixtures, the IS yield has already been referred to, and was significantly less than IN, which was the highest of the mixtures. The NS and INS yields were not greatly different and fell between those of their components.

In section 3 the yield of S.23 alone was higher than Irish or New Zealand which was a reversal of the position at the first cut. The IS and NS combinations were evidently influenced by the higher yield of S.23 and both showed yields closer to this cultivar than to the lower yielding component. The NS yield was, as at the first cut, higher than New Zealand or S.23 alone. The IN and INS yields were in the low group and similar to Irish and New Zealand growing alone.

Third cuts Of the cultivars growing alone S.23 was again highest in yield and was only exceeded (averaged over all cutting sections) by the NS mixture.

Although the sections x cultivar interaction was not significant, a study of the differences within sections revealed some important facts which were later substantiated. In sections 1 and 2 the yield of the NS mixture was never as great as its higher yielding component. In section 3 an increase which amounted to 58% and 24% over New Zealand and S.23 alone respectively was recorded. It is also of interest to note that in this section the yield of Irish was slightly higher than S.23. The INS yield was also above that of its components separately, but was less than NS.

Fourth cuts S.23 growing alone gave higher yields than Irish or New Zealand alone in all sections but in section 3 the difference was not significant. New Zealand significantly outyielded Irish in the section 1.

S.23 alone was higher yielding than all other treatments in section 1 and mixtures with S.23 were higher than the one without. In section 2 S.23 was still the top yielder but not significantly more than those mixtures containing S.23. The IN yield was greater than Irish or New Zealand separately but not significantly higher than New Zealand.

Section 3 displayed an interesting result in that the NS yield was significantly higher than New Zealand or S.23 growing alone. This result had been suggested in the first three cuts but lacked statistical confirmation. The INS yield was also above that of its components but not sufficiently to be significant.

Fifth cuts The longer interval between cuts of section 1 resulted in increased yields of all treatments in that section. The yield of Irish alone, however, showed the poorest response and was in fact not significantly greater than the yield in section 3. Irish was also the lowest yielder of the three cultivars growing alone in section 2 but was equal with New Zealand and S.23 in the section 3.

S.23 was again the highest yielder in sections 1 and 2 but in section 3 was exceeded by the IN, IS, NS and INS mixtures. These differences were, however, small apart from the NS mixture which narrowly failed to show the significant positive interaction seen at the previous cut. The IN mixture was also higher than Irish or New Zealand but again not significant.

<u>Sixth cuts</u> The cutting sections x cultivar interaction was not quite significant at these cuts but it should be noted that in section 3 the NS yield was again greater than either of the components and was 22% above the mean yield of New Zealand and S.23. Irish was on average the poorest yielder but the difference between it and the other treatments was much less in section 3. The New Zealand and S.23 yields were not significantly different and, as has been noted, were only exceeded by the NS mixture. The other mixtures were not significantly less than NS.

<u>Seventh cuts</u> The much longer period allowed for the regrowth of section 1 resulted in considerably increased yields of all treatments except Irish alone which apparently lacked the vigour to take advantage of the longer growing interval. There were no significant differences between any of the other treatments in this section but the NS yield was greater, by 7%, than the mean of New Zealand and S.23 alone.

In section 2 Irish was again the lowest yielder but not significantly less than IS or INS. Apart from this there were no real differences between the treatments.

The management of section 3 again seemed to favour Irish as here its yield, although lower, was not significantly less than New Zealand or S.23 and was only really exceeded by the NS mixture which was once more higher than New Zealand or S.23 alone. The INS combination gave a small increase over its components growing alone.

<u>Eighth cuts</u> The pattern of yields was very similar to that seen in the seventh cuts and the main features were again the low yield of Irish and the positive interaction between New Zealand and S.23 which showed itself in sections 1 and 3. The yield of Irish alone although

always the lowest was closer to the others in section 3, and New Zealand and S.23 alone were not significantly different in any section.

Ninth cut As New Zealand growing alone had had shorter intervals between cuts than Irish and since S.23 commenced the season 17 days after New Zealand it was the only cultivar (and its section) which was cut for a ninth time.

The main feature in this cut was the low yield from Irish. There were no significant differences between any of the other treatments.

Total for 1959 The mean yields over the three cutting sections showed Irish as the lowest yielder, but whereas all treatments gave their highest yield in section 1 Irish alone was best in section 3 where its yield was higher (not significantly) than New Zealand or S.23.

The IN mixture was not significantly higher than Irish or New Zealand in any section and had very similar yields in all sections.

The IS mixture showed no advantage over S.23 alone and was in fact significantly lower in section 2. The NS mixture, however, gave a 28% increase over the mean of New Zealand and S.23 in section 3 and was never significantly less than S.23 or greater than New Zealand in the other sections.

The combination of all three cultivars gave no yield advantage over New Zealand or S.23 alone but was significantly better than Irish in sections 1 and 2.

Accumulative Yield

The accumulative yield of all cultivar treatments during 1959 are presented in figures 1.22, 1.23 and 1.24 for sections 1, 2 and 3 respectively.

Section 1 Excluding Irish, differences in growth rate were small and the range in yields not wide. Irish started as lowest yielder then had a brief period of rapid growth followed by a lower growth rate than any other treatment. New Zealand had the highest accumulated yield of the cultivars growing alone at cuts 1, 2 and 3 but S.23 was growing faster and ranked first from June 19th onwards. From August the S.23 and New Zealand growth rates were similar and their final yields not far apart.

The growth curves of all mixtures tended to follow those of the more productive cultivars, New Zealand and S.23. IN was most influenced by Irish and showed a rather lower rate of production than the other mixed sowings. Between IS, NS and INS there was little to differentiate. INS commenced at the top then fell off slightly and NS took its place and maintained it until the end of the season. IS closely followed the S.23 growth pattern in spring and not until June, when S.23 displayed its most rapid growth, did their lines diverge.

Section 2 In this section which was cut earlier and once oftener than sections 1 and 3 the final yields were lower but in general the shape of the curves and the ranking of the cultivar treatments were similar to section 1.

The Irish growth rate dropped off markedly after the cut on May 20th and, despite its rise in July, was again far below all other

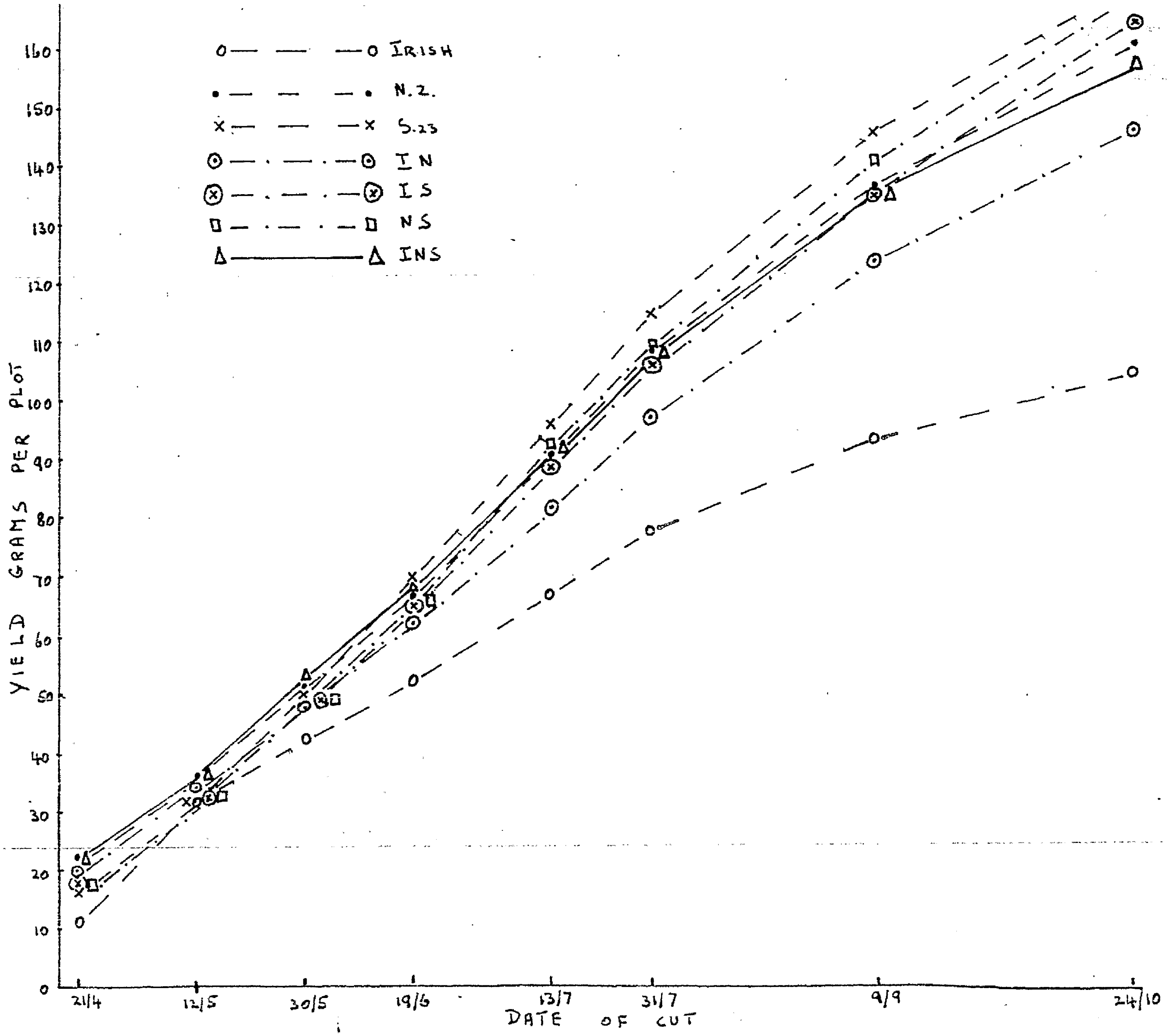


Figure 1.22 Accumulative dry matter yield of cultivars growing alone and in mixtures in section 1 during 1959.

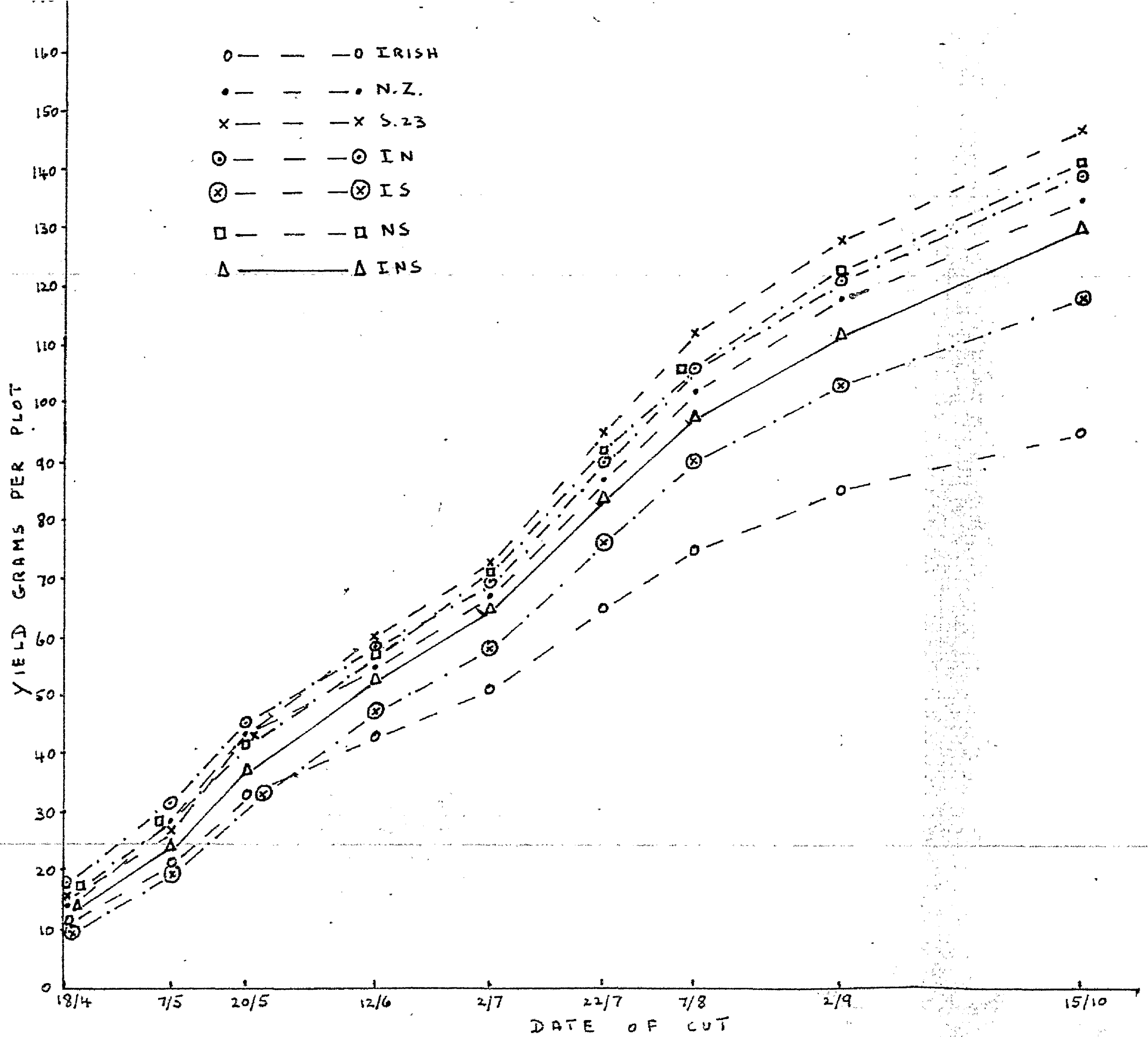


Figure 1.23 Accumulative dry matter yield of cultivars growing alone and in mixtures in section 2 during 1959.

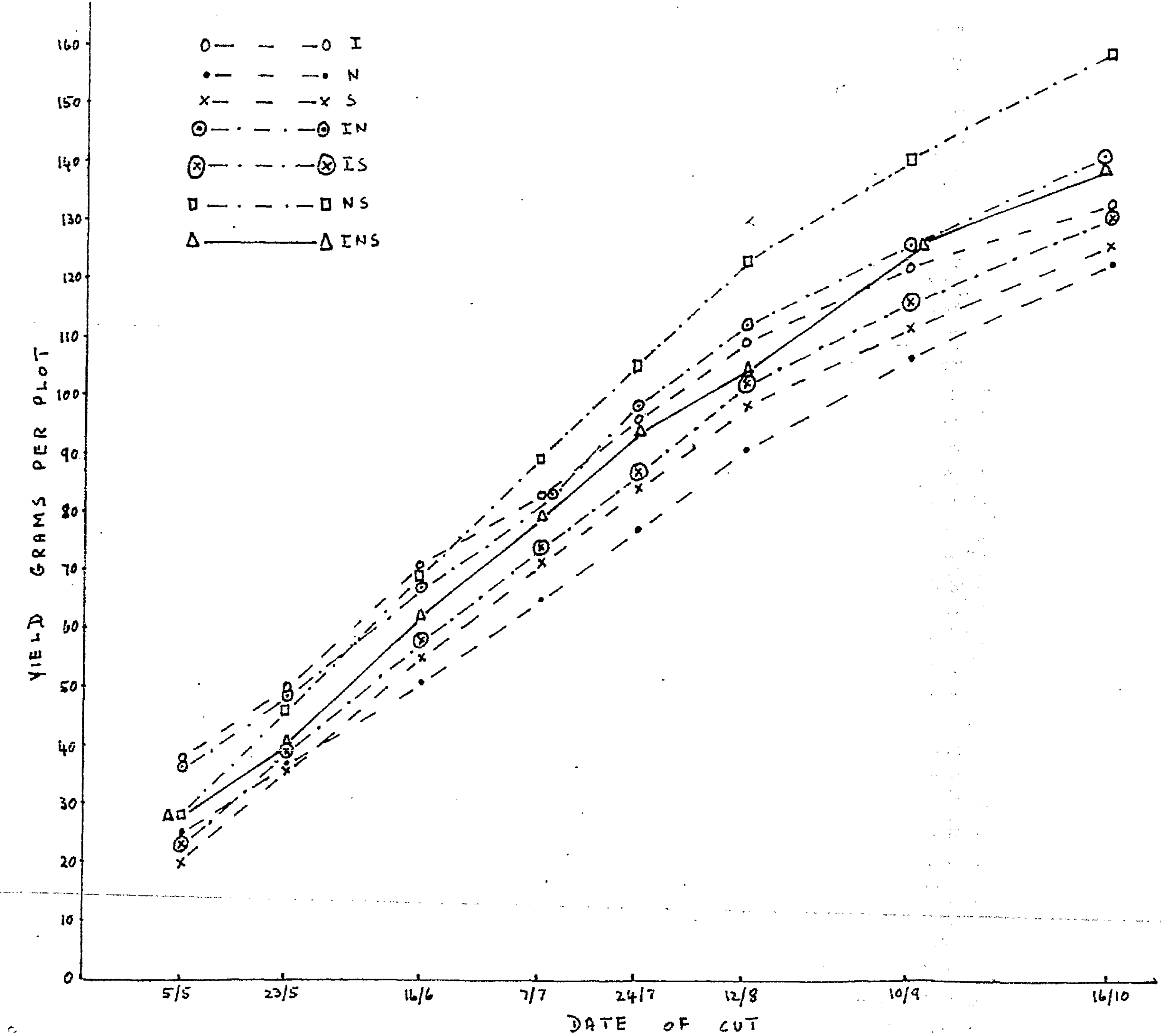


Figure 1.24 Accumulative dry matter yield of cultivars growing alone and in mixtures in section 3 during 1959.

treatments. New Zealand and S.23 were almost identical up to May 20th, S.23 then showed its characteristic increase and moved into the top position. Subsequently S.23 gained a little on New Zealand but their final yields were not markedly different.

The main difference between sections 1 and 2 was in the reversal of positions by the IN and IS mixtures. In section 1 IN, while higher than Irish, came below all other treatments and IS followed the more productive S.23 pattern. In section 2 IS appeared to be greatly influenced by Irish in the early part of the season and, although its growth rate was greater than Irish in mid-season, it ranked below the other treatments at every cut. IN, on the other hand, took the form of the New Zealand curve and at no time appeared affected by Irish.

The INS growth curve bore a greater resemblance to New Zealand than to Irish and S.23. In so doing it could be judged to be reflecting the productivity of all 3 cultivars as New Zealand itself occupied an intermediate position between the high placed S.23 and the lowest placed Irish.

<u>Section 3</u> As in 1958 the change in management of section 3 caused some very marked alterations in relative production of the cultivar mixtures.

Irish was top yielder in the first cut and by maintaining a relatively good rate of growth held this position until the beginning of July. New Zealand displayed none of the characteristics of an early maturing ryegrass, its initial yield being relatively low and its growth until mid-June lower than the other treatments. Although the rate of production subsequently increased the initial setback kept it in bottom position. S.23 did, however, improve its position, after commencing the year as lowest yielder, but it did not display such a marked increase in June growth as characterised it in sections 1 and 2.

The IN, IS and INS mixtures had little outstanding in their performance. IN followed the Irish pattern and IS the S.23. INS reflected the higher early growth of Irish then followed the more productive S.23. During August a sharp rise in the INS productivity occurred which was not evident in the curves of any of its components.

The obviously important mixture was NS which displayed an extremely rapid growth rate, much higher than either of its components. This carried its yield well above all other treatments. The steeper angle of its curve, compared to New Zealand or S.23, was noticable from the first to the last cuts.

The Effect on Yield of Combining Cultivars

The yields of cultivar mixtures, relative to their components, are given in figure 1.25 as percentage increases or decreases compared to either Irish, New Zealand or S.23 growing alone.

Only the general trends of these results are outlined since individual differences have already been dealt with in table 1.16.

Yields of Mixtures Containing Irish Relative to Irish Growing Alone

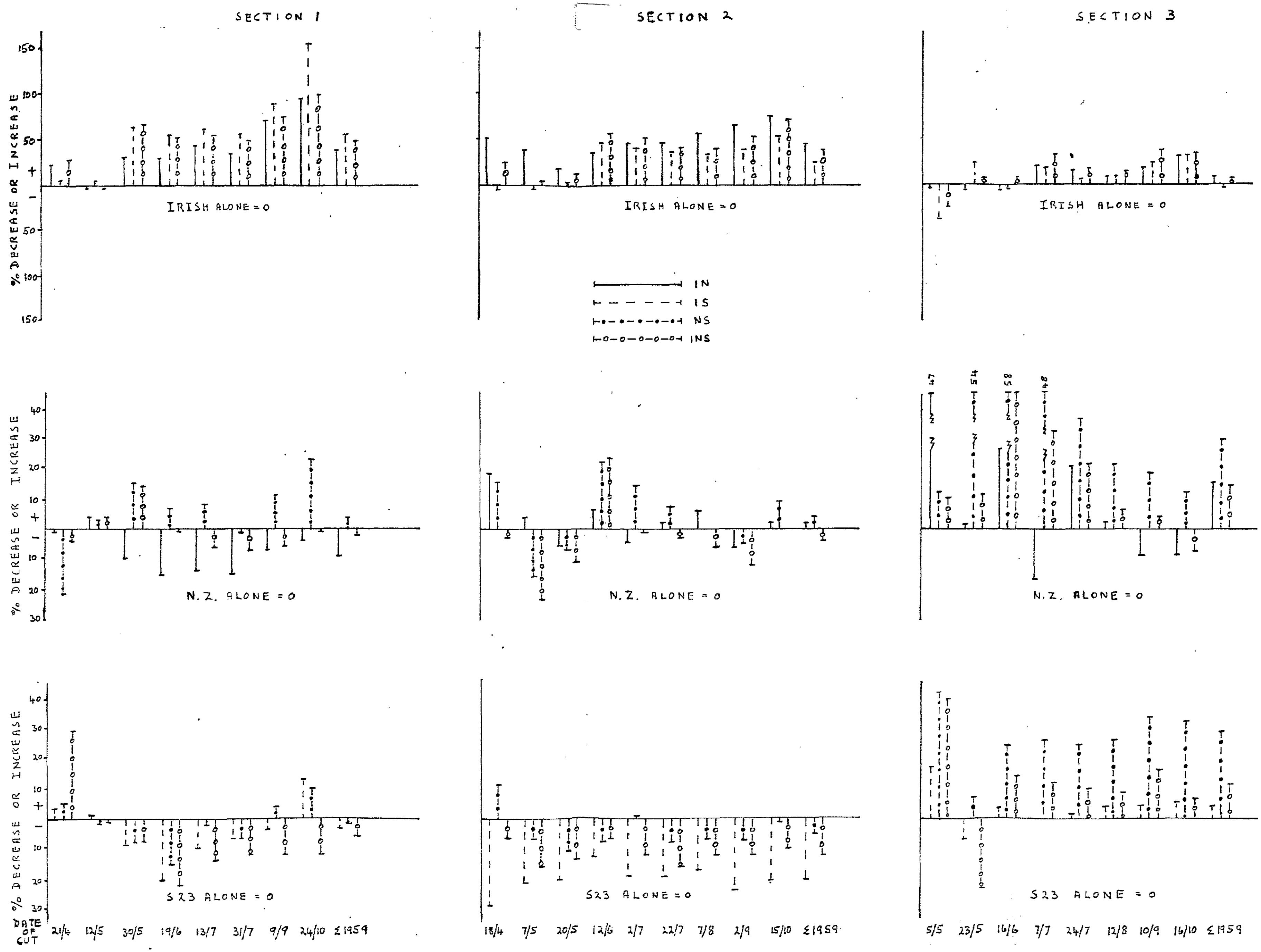
It should be noted that the top 3 graphs of figure 1.25, which show Irish alone as zero, are in a smaller scale than the other graphs. In sections 1 and 2 the yield of Irish was exceeded by its mixtures at nearly every cut. The trend was for larger increases as the season advanced. On the annual total all mixtures showed considerable increases compared to Irish growing alone. In section 3 the increases made by the mixtures were smaller and, in the beginning of the year, decreases were recorded. On the total yield only the mixtures with New Zealand and New Zealand plus S.23 showed small improvements compared to Irish.

Yields of Mixtures Containing New Zealand Relative to New Zealand Growing Alone

In section 1 the results were rather variable. The mixture with Irish did, however, give a lower yield than New Zealand at most cuts and its total yield was 10% below New Zealand's. The combination with S.23 was higher yielding than New Zealand except at the first cut when a substantial decrease occurred. The INS mixture varied little from New Zealand alone.

In section 2 the results were again variable and no trends were distinguishable; increases at one cut being balanced by decreases at another.

Figure 1.25 Yields of cultivar mixtures relative to the components of the mixtures growing alone.


SECTION 1
SECTION 2
SECTION 3
% DECREASE OR INCREASE
150
100
50
+
–
IRISH ALONE = 0
IN
IS
NS
INS
40
30
20
10
N.Z. ALONE = 0
S23 ALONE = 0
47
54
58
48
DATE OF CUT
21/4
12/5
30/5
19/6
13/7
31/7
9/9
24/10
Σ1959
18/4
7/5
20/5
12/6
2/7
22/7
7/8
2/9
15/10
5/5
23/5
16/6
7/7
24/7
12/8
10/9
16/10

Section 3, however, showed a different picture as here large increases over New Zealand took place at almost every cut by all mixtures. The mixture with S.23 exhibited the greatest increases from the second cut onwards.

Yields of Mixtures Containing S.23 Relative to S.23 Growing Alone

In both sections 1 and 2 there were few occasions when the yield of mixtures containing S.23 exceeded the yield of S.23 growing alone. The mixture with Irish was noticably poorer than all others in section 2.

The change in management of section 3 caused a marked alteration in the relative yields; the yield of S.23 being exceeded at all but one cut. The increase due to the association with New Zealand was most outstanding and amounted to over 20% on the annual total.

Percentage Distribution of Seasonal Production

Table 1.18 shows the seasonal production of the various treatments expressed as percentages of total yield.

Section 1 At the first cut the early cultivars, Irish and New Zealand, gave a higher percentage of their total yield than did S.23. The influence of S.23 was most marked in the IS and NS combinations where the percentages were similar to S.23 alone. The INS treatment moved nearer to the early group but was still considerably influenced by S.23. The IN treatment was similar to New Zealand alone.

At the second cut the Irish again gave the highest percentage while New Zealand and S.23 were similar. Treatments containing more than one cultivar conformed to the New Zealand and S.23 pattern. The effect of Irish was not evident.

At the third and fourth cuts S.23 gave slightly more of its total yield than Irish or New Zealand. The treatments combining Irish and New Zealand did not, however, appear to reflect this, apart from INS in the third cut. The percentages for all treatments were similar at the fifth or sixth cuts while the seventh and eighth cuts showed a fall off in the percentage of Irish. The IS and NS combinations in the last cut had higher percentages than any of the cultivars growing alone.

Section 2 This section was cut earlier and more frequently than the others and showed remarkably little variation in seasonal production among the treatments. S.23 was slightly lower than Irish or New Zealand at the first three cuts and combining S.23 with Irish did not change the position. The NS treatment, however, did give a higher proportion in the first cut than S.23 or New Zealand alone. The INS treatment slightly raised the percentage, compared to S.23, but only in the first cut.

Table 1.18 Percentage distribution of total yield during 1959.

Section 1. Date of Cut

	21/4	12/5	30/5	19/6	13/7	31/7	9/9	24/10	
Cut	1	2	3	4	5	6	7	8	9
I	16	14	10	10	14	10	15	11	
N	14	9	9	10	15	11	18	14	
S	10	9	11	12	15	11	18	15	
IN	14	10	9	9	14	10	18	15	
IS	10	9	10	10	14	10	18	18	
NS	10	8	10	10	15	10	19	17	
INS	13	9	11	10	14	10	17	15	

Section 2.

	18/4	7/5	20/5	12/6	2/7	22/7	7/8	2/9	15/10
I	12	11	12	11	8	14	11	10	11
N	11	10	11	10	9	14	11	12	13
S	10	8	10	12	9	15	11	12	13
IN	12	10	10	10	8	14	11	11	12
IS	10	8	10	12	9	15	11	11	13
NS	12	8	10	11	10	15	11	11	13
INS	11	8	10	12	9	14	11	11	13

Section 3.

	5/5	23/5	16/6	7/7	24/7	12/8	10/9	16/10
I	28	9	15	10	10	10	9	8
N	20	9	12	11	10	12	13	13
S	16	13	15	12	11	11	11	11
IN	26	8	13	11	10	10	10	10
IS	18	12	15	12	10	11	11	11
NS	18	11	15	12	10	11	12	11
INS	20	9	15	12	10	11	12	10

Throughout the remainder of the year the IN combination showed little variation from the pattern of Irish or New Zealand alone while the IS treatment followed the S.23 pattern where it differed from Irish. NS and New Zealand and S.23 alone were practically the same and INS gave a similar result as the cultivars alone, except in the last cut when a low percentage from Irish was not reflected in the mixture.

Section 3 By delaying the first cut until May 5th the greater capacity of Irish and New Zealand for early growth became obvious. The Irish and New Zealand cultivars gave 28 and 20% of their total yield respectively compared to 16% from S.23. The IS and NS combinations were more influenced by the S.23 component and consequently gave a lower percentage than the early cultivars. The INS mixture was affected by both groups and occupied an intermediate position.

At the second cut S.23 gave the highest proportion and the IS and NS mixtures came between S.23 and Irish and New Zealand. The INS treatment, however, was similar to Irish and New Zealand alone.

From the third to the sixth cut there was little variation between cultivar combinations. During the last two cuts the New Zealand alone gave a higher proportion than the other cultivars.

Actual Percentage, and Potential Percentage, Contribution to Yield by the Components of Cultivar Mixtures at Each Cut and to Annual Yield

Actual Contribution

Irish ryegrass

The percentage contribution to total yield made by Irish ryegrass when growing with New Zealand and/or S.23 is shown in table 1.19 and figures 1.19, 1.20 and 1.21.

First cuts   Although the statistical analysis failed to show any significant differences Irish appeared to have made a greater contribution at the latest spring cut. This was most noticeable when it was combined with New Zealand.

Second cuts   The slightly higher contribution of Irish in section 3 suggested by the first cut was not maintained except when Irish was growing with New Zealand.

Third cuts   The third cuts showed a further reduction in the contribution of Irish. The contribution with S.23 was 19%; significantly less than the 27% achieved with New Zealand. Where all three cultivars were together the depression of Irish yield fell between that experienced when Irish was growing with either one separately.

Fourth cuts   There was another slight depression in Irish contribution except in section 3. S.23 again exerted the greatest depressing influence.

Fifth cuts   The downward trend in the percentage contribution of Irish continued. With S.23 the Irish only contributed an average of 13% of the total yield. The highest contribution made by Irish was with New Zealand in section 3.

Table 1.19 Percentage contribution to yield by Irish during 1959. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Cut	Section	Date	Irish With N.Z.	Irish With S.23	Irish With N.Z.+S.23	$\bar{x}$	Cut	Date	Irish With N.Z.	Irish With S.23	Irish With N.Z.+S.23	$\bar{x}$
1	1	21/4	30	28	24	27	2	12/5	32	27	20	26
	2	18/4	22	28	25	25		7/5	22	36	24	27
	3	5/5	46	38	32	39		23/5	38	27	20	28
	$\bar{x}$		33	31	27	30			31	30	21	27
	L.S.D. 1,2,3 and 4 = N.S. C.V. = 23.2%							1,2,3 and 4 = N.S. C.V. = 26.8%				
3	1	30/5	25	23	15	21	4	19/6	24	14	16	18
	2	20/5	22	18	21	21		12/6	20	16	14	17
	3	16/6	33	17	14	21		7/7	33	19	18	24
	$\bar{x}$		27(31.0)	19(25.2)	17(23.7)	21			26(30.2)	16(22.9)	16(23.2)	20
	L.S.D. 1=N.S. 2=5.3 3&4=N.S. C.V.=23.3%							1=N.S. 2=5.4 3&4=N.S. C.V.=24.6%				
5	1	13/7	22	10	12	15	6	31/7	23	10	14	16
	2	2/7	21	16	16	18		22/7	19	15	16	16
	3	24/7	31	14	17	21		12/8	35	17	17	23
	$\bar{x}$		24(29.1)	13(20.6)	15(22.3)	18			26(30.0)	14(21.2)	16(22.8)	18
	L.S.D. 1=N.S. 2=4.7 3&4=N.S. C.V.=23.0%							1=N.S. 2=4.9 3&4=N.S. C.V.=23.3%				
7	1	9/9	25	10	13	16	8	24/10	17	8	13	13
	2	7/8	18	17	16	17		2/9	20	16	16	17
	3	10/9	30	18	14	20		16/10	34	18	15	23
	$\bar{x}$		24(29.0)	15(21.8)	14(21.6)	18			24(28.7)	14(20.8)	15(22.1)	18
	L.S.D. 1=N.S. 2=4.9 3&4=N.S. C.V.=23.8%							1=N.S. 2=4.4 3&4=N.S. C.V.=21.5%				
9	1	-	-	-	-	-	Total for 1959		24	14	16	18
	2	15/10	20	16	16	17			20	19	17	19
	3	-	-	-	-	-			37	23	19	26
									27(30.8)	19(25.2)	17(24.4)	21
	L.S.D. 2=N.S. C.V.=19.2%							1=N.S. 2=3.9 3&4=N.S. C.V.=17.1%				

Sixth - eighth cuts During the remainder of the season the contributions of Irish did not vary greatly from the position established at the fifth cuts. With New Zealand, Irish gave around 25% of the yield but it was always slightly higher in section 3. The presence of S.23 held the Irish contribution down to 14 - 15%; the lowest contribution of 8% occurred in the eighth cut of section 1. With 3 cultivars together the Irish contribution averaged 15%.

Ninth cut Section 2 was the only one cut 9 times and there were no significant differences between treatments.

Total for 1959 The average percentage of the total yield given by Irish was greatest (27%) in combination with New Zealand. In section 3 this rose to 37% and in general the management of section 3 resulted in higher contributions from Irish than in the other sections.

The depressing effect of S.23 was significantly greater than that of New Zealand and with both together the effect was intermediate.

New Zealand ryegrass

The percentage contribution made to total yield by New Zealand ryegrass when growing with Irish and/or S.23 is shown in table 1.20 and figures 1.19, 1.20 and 1.21.

First cuts With Irish, New Zealand was the dominant partner in the cuts taken on the 18th and 21st of May but, when cutting was delayed until May 5th, the percentage was reduced to 54. In association with S.23 New Zealand contributed an average of 51% of the yield. The highest contribution of 66% was recorded in section 2. Where New Zealand was competing with both Irish and S.23 its gain over Irish was balanced by the suppressing influence of S.23 so that its contribution was approximately $\frac{1}{3}$ of the total.

Table 1.20 Percentage contribution to yield by N.Z. during 1959. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Cut	Section	Date	N.Z. With Irish	N.Z. With S.23	N.Z. With Irish+S.23	x̄	Cut	Date	N.Z. With Irish	N.Z. With S.23	N.Z. With Irish+S.23	x̄
1	1	21/4	70(56.8)	44(40.2)	33(34.0)	49	2	12/5	68	45	31	48
	2	18/4	78(62.0)	66(54.5)	27(31.2)	57		7/5	78	66	28	57
	3	5/5	54(47.2)	42(41.5)	38(38.2)	45		23/5	62	28	28	39
	x̄		67(55.3)	51(45.6)	33(34.5)	50			67(56.6)	46(42.8)	29(32.3)	44
	L.S.D.	1=N.S.	2=5.1	3=8.8	4=12.8	C.V.=13.2%		1=N.S.	2=6.1	3&4=N.S.	C.V.=16.1%	
3	1	30/5	75(60.0)	28(31.0)	27(30.8)	43	4	19/6	76	27	27	43
	2	20/5	78(62.0)	56(48.2)	24(28.5)	53		12/6	80	42	19	47
	3	16/6	67(55.0)	29(32.0)	34(35.0)	43		7/7	66	27	30	41
	x̄		73(59.0)	38(37.1)	28(31.4)	46			74(59.7)	32(33.6)	25(29.7)	44
	L.S.D.	1=N.S.	2=5.2	3=8.9	4=12.3	C.V.=14.1%		1=N.S.	2=5.3	3&4=N.S.	C.V.=15.0%	
5	1	13/7	78	26	26	43	6	31/7	77	27	25	43
	2	2/7	79	44	22	48		22/7	81	43	23	49
	3	24/7	69	30	30	43		12/8	65	28	30	41
	x̄		75(60.7)	33(34.4)	26(30.1)	45			74(59.8)	33(34.4)	26(30.1)	44
	L.S.D.	1=N.S.	2=5.1	3&4=N.S.	C.V.=14.4%			1=N.S.	2=5.9	3&4=N.S.	C.V.=16.6%	
7	1	9/9	75	27	28	43	8	24/10	83(66.2)	28(30.5)	26(30.5)	46
	2	7/8	82	44	29	52		2/9	80(63.5)	43(41.0)	24(29.0)	49
	3	10/9	70	30	34	45		16/10	66(54.2)	34(35.2)	39(38.2)	46
	x̄		76(60.9)	34(36.8)	30(32.9)	47			76(61.3)	35(35.6)	30(32.6)	47
	L.S.D.	1=N.S.	2=6.4	3&4=N.S.	C.V.=17.2%			1=N.S.	2=4.9	3=8.5	4=10.9	C.V.=13.3%
9	1	-	-	-	-	-	Total for 1959		76(60.8)	30(32.5)	28(31.2)	45
	2	15/10	80(64.2)	44(41.5)	29(32.2)	51			80(63.8)	49(44.2)	25(29.8)	51
	3	-	-	-	-	-			63(52.8)	32(34.2)	33(35.0)	43
									73(58.9)	37(37.0)	29(32.0)	46
	L.S.D.	2=12.9	C.V.=16.3%					1=N.S.	2=4.6	3=8.0	4=10.6	C.V.=12.6%

<u>Second cuts</u> The interaction between sections and cultivar combinations was not quite significant but there were differences of importance. With Irish, in section 3, the contribution had risen from 54% in the first cut to 62% and with S.23 the contribution had gone down from 42% to 28%. In the other sections the percentages of New Zealand with Irish or S.23 were as before. Where both Irish and S.23 were present the New Zealand contribution had fallen slightly to 29%.

<u>Third cuts</u> The picture here was very similar to that at the second cuts. The only marked change was a fall in contribution with S.23 in section 1.

<u>Fourth - ninth cuts</u> In the remaining cuts of the season the contribution of New Zealand with the other cultivars did not alter appreciably. In combination with Irish the average contribution varied around 75% and, within the sections, the percentages did not differ significantly except at the eighth cuts when only 66% was contributed to the yield in section 3 compared to 83% in section 1.

With S.23 the percentages were very constant with section 2 always slightly, but not significantly, higher. Although suppressed by S.23 the New Zealand held its position much better than did Irish. Where all 3 cultivars were together the compensating influence of Irish and S.23 maintained the average New Zealand contribution just below, or at, 30%. There was a tendency for a higher contribution in section 3.

<u>Total for 1959</u> As a percentage of the annual total New Zealand with Irish was highest in section 2 and lowest in section 3. With S.23 section 2 also resulted in the highest percentage of 49 for New Zealand contribution. This figure was made up of contributions of over 50% in the first 3 cuts followed by percentages of under 50 for the remaining

6 cuts. In the other sections New Zealand with S.23 only averaged 31% of the yields.

In association with both Irish and S.23 there were no significant differences among the sections and the mean contribution was 29%.

S.23 ryegrass

The percentage contribution made to total yield by S.23 ryegrass when growing with Irish and/or New Zealand is shown in table 1.21 and figures 1.19, 1.20 and 1.21.

First cuts Averaged over the 3 sections S.23 contributed significantly more when growing with Irish than with New Zealand. Growing with both cultivars S.23 gave an average of 40% of the yield.

Second cuts The contribution with Irish remained at 70% while, with New Zealand and Irish plus New Zealand there was a slight increase.

Third cuts The percentage of S.23 in all mixtures was considerably greater than at the second cuts. With Irish the mean was 81% and there were no significant differences between sections. Combined with New Zealand the contribution was significantly lower at 62% and, in section 2, the percentage was only 44. Where all 3 cultivars were combined the contribution averaged 55% and did not vary significantly over the sections.

Fourth - ninth cuts The contribution of S.23 remained very steady in the last 6 cuts of the season averaging around 85% with Irish, 67% with New Zealand and 57% with Irish plus New Zealand. In section 1 the contribution of S.23 with Irish was always highest but never significantly so. With New Zealand, the contribution in section 2 was always low but the only time this was significant was, as already seen, at the third cuts. Combined with Irish and New Zealand S.23 was again the dominant partner.

Table 1.21 Percentage contribution to yield by S.23 during 1959. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

			S.23 With						S.23 With			
Cut	Section	Date	Irish	N.Z.	Irish+N.Z.	$\bar{x}$	Cut	Date	Irish	N.Z.	Irish+N.Z.	$\bar{x}$
	1	21/4	72	56	42	57		12/5	73	55	49	59
1	2	18/4	72	34	48	51	2	7/5	64	34	48	49
	3	5/5	62	58	30	50		23/5	73	72	53	66
	$\bar{x}$		69(56.4)	49(44.7)	40(39.1)	53			70(57.5)	54(47.2)	50(45.0)	58
	L.S.D.	1=N.S. 2=7.1 3&4=N.S. C.V.=17.8%						1=N.S. 2=7.4 3&4=N.S. C.V.=17.4%				
	1	30/5	77(62.2)	72(59.0)	58(49.5)	69		19/6	86	73	57	72
3	2	20/5	82(65.2)	44(41.5)	56(48.2)	61	4	12/6	84	58	66	69
	3	16/6	83(66.2)	71(58.0)	52(46.2)	69		7/7	81	73	52	69
	$\bar{x}$		81(64.6)	62(52.8)	55(48.2)	66			84(67.0)	68(56.3)	58(50.2)	70
	L.S.D.	1=N.S. 2=5.8 3=10.1 4=13.6 C.V.=12.3%						1=N.S. 2=5.3 3&4=N.S. C.V.=10.6%				
	1	13/7	90	74	62	75		31/7	90	73	61	75
5	2	2/7	84	56	62	67	6	22/7	85	57	62	68
	3	24/7	86	70	53	70		12/8	83	72	54	70
	$\bar{x}$		87(67.8)	67(55.6)	59(50.2)	71			86(67.2)	67(55.5)	59(50.0)	71
	L.S.D.	1=N.S. 2=5.2 3&4=N.S. C.V.=10.3%						1=N.S. 2=5.9 3&4=N.S. C.V.=11.8%				
	1	9/9	90	73	60	74		24/10	92	72	60	75
7	2	7/8	83	56	55	65	8	2/9	84	57	60	67
	3	10/9	82	70	53	68		16/10	82	66	46	65
	$\bar{x}$		85(68.2)	66(54.8)	56(48.5)	69			86(69.1)	65(54.3)	55(48.4)	69
	L.S.D.	1=N.S. 2=5.9 3&4=N.S. C.V.=12.1%						1=N.S. 2=5.7 3&4=N.S. C.V.=11.6%				
	1	-	-	-	-	-	Total		86	70	56	71
9	2	15/10	84(67.2)	56(48.5)	56(48.2)	65	for		81	51	58	63
	3	-	-	-	-	-	1959		77	68	48	64
									81(64.8)	63(53.0)	54(47.4)	66
	L.S.D.	2=12.2 C.V.=12.9%						1=N.S. 2=5.1 3&4=N.S. C.V.=10.8%				

Total for 1959 Comparing the contributions in the totals for the year S.23 gave a significantly greater yield when combined with Irish than with New Zealand and the contribution with Irish plus New Zealand was only just significantly less than with New Zealand alone.

Potential Contribution

Tables 1.22, 1.23 and 1.24 which show the potential contributions of cultivars when growing in mixtures were constructed in the same manner, and for the same reasons, as tables 1.7, 1.8 and 1.9 which gave this information for the first harvest year. As before, the deviations of the actual contributions from the potential figures have been calculated and are shown alongside each result. These deviations are also expressed as percentage, gains or losses of the potential contribution.

Irish ryegrass

Table 1.22 presents this data for Irish ryegrass during 1959 and a casual perusal of the results shows that Irish was suppressed at all cuts, in all sections and under all combinations.

First cuts Overall, Irish suffered a mean depression of its potential by 38%. The competitive influence of S.23 was greater than New Zealand while both together apparently had a lesser influence than either separately.

With New Zealand as a companion the greatest depression occurred in section 2 and with S.23 in section 1. With New Zealand plus S.23 present the Irish contribution was down by a maximum of 30% in section 3.

Second cuts The average suppression of Irish was similar to the first cuts but did not vary significantly between the different combinations.

Table 1.22 Potential percentage contribution of Irish ryegrass to yield during 1959 related to yield of Irish growing alone and assuming no competition between cultivars. The deviations of actual contribution (table 1.19) from potential are given alongside each result and, in parenthesis, the deviations are expressed as a percentage of potential.

Cut	Section	Date	Irish With N.Z.	S.23	NZ+S.23	x̄	Cut	Date	Irish With N.Z.	S.23	NZ+S.23	x̄
1	1	21/4	43-13(30)	50-22(44)	30 -6(20)	41-14(34)	2	12/5	52-20(38)	50-23(46)	34-14(41)	45-19(42)
	2	18/4	44-22(50)	43-15(35)	28 -3(11)	38-13(34)		7/5	43-21(49)	45-9(20)	28-4(14)	39-12(31)
	3	5/5	60-14(23)	66-28(42)	46-14(30)	57-18(32)		23/5	52-14(27)	43-16(37)	31-11(35)	42-14(33)
	x̄		52-19(36)	56-25(45)	37-10(27)	48-18(38)			49-18(37)	46-16(35)	31-10(32)	42-15(36)
3	1	30/5	41-16(39)	36-13(36)	24 -9(38)	34-13(38)	4	19/6	39-15(38)	34-20(59)	22 -6(27)	32-14(44)
	2	20/5	44-22(50)	43-25(58)	28 -7(25)	38-17(45)		12/6	44-24(54)	37-21(57)	25 -9(36)	35-18(51)
	3	16/6	57-24(42)	51-34(67)	37-23(62)	48-27(56)		7/7	50-17(34)	46-27(59)	32-14(44)	43-19(44)
	x̄		49-22(45)	44-25(57)	30-13(43)	41-20(49)			44-18(41)	39-23(59)	26-10(38)	36-16(44)
5	1	13/7	38-16(42)	36-26(72)	23-11(48)	32-17(53)	6	31/7	39-16(41)	37-27(73)	24-10(42)	33-17(52)
	2	2/7	40-19(48)	37-21(57)	27 -9(33)	35-17(48)		22/7	41-22(54)	38-23(60)	25 -9(36)	35-19(54)
	3	24/7	51-20(39)	49-35(71)	33-16(48)	44-23(52)		12/8	49-14(28)	49-32(65)	32-15(47)	43-20(46)
	x̄		42-18(43)	40-27(68)	26-11(42)	36-18(50)			43-17(40)	41-27(66)	26-10(38)	37-19(51)
7	1	9/9	35-10(28)	34-24(70)	21 -8(38)	30-14(47)	8	24/10	33-16(48)	31-23(74)	19 -6(32)	28-15(54)
	2	7/8	40-22(55)	39-22(56)	25 -9(36)	35-18(51)		2/9	37-17(46)	36-20(56)	22 -6(27)	32-15(47)
	3	10/9	43-13(30)	46-28(61)	29-15(52)	39-19(49)		16/10	41 -7(17)	45-27(60)	27-12(44)	38-15(39)
	x̄		39-15(38)	38-23(60)	24-10(42)	34-16(47)			37-13(35)	36-22(61)	22 -7(32)	32-14(44)
9	1	-	-	-	-	-	Total for 1959		40-16(40)	38-24(63)	24 -8(33)	34-16(47)
	2	15/10	37-17(46)	35-19(54)	22 -6(27)	31-14(45)			41-21(51)	39-20(51)	25 -8(32)	35-16(46)
	3	-	-	-	-	-			52-15(29)	51-28(55)	35-16(46)	46-20(43)
	x̄								44-17(39)	43-24(56)	28-11(39)	38-17(45)

New Zealand again had its greatest effect in section 2 and S.23 in section 1 while with both together Irish suffered its least depression in section 2.

Third cuts By the third cuts the actual contribution of Irish was 20% below its potential, a fall of 49%, chiefly due to the competition from S.23. The influence of New Zealand and New Zealand plus S.23 were similar and also, of course, depressive. New Zealand, as before, was most aggressive in section 2 but S.23 caused the greatest reduction in Irish yield in section 3, amounting to 67% of potential. Irish was also most suppressed by New Zealand plus S.23 in section 3 and to only a slightly less degree than that caused by S.23 alone.

Fourth - ninth cuts The average actual contribution of Irish stabilized around 14 - 19% less than its potential over the remainder of the year. S.23 continued to exert the greatest influence reaching a maximum average figure of -27 in the fifth cut. The highest individual figure was in the eighth cut in section 1 when the actual yield was 74% less than the potential. In general S.23 was most aggressive under the conditions of section 1 which had longer intervals between cuts.

New Zealand also markedly reduced Irish yield and was fairly constant over all cuts, ranging from 35% at cut 8 to 46% at cut 9. Unlike S.23 the New Zealand influence was greatest in section 2.

The New Zealand plus S.23 effect was also similar in all cuts and reduced the Irish yield by approximately 39%; this was a similar amount to New Zealand alone but only 2/3 of the S.23 influence. Like S.23 alone the suppression due to New Zealand plus S.23 was greatest in section 3.

Total for 1959 The average reduction of Irish potential contribution amounted to 45% composed of a 56% suppression by S.23 and 39% each from New Zealand and New Zealand plus S.23.

The largest reduction of 63% due to S.23 occurred in section 1 while New Zealand's greatest effect was 51% in section 2 and the New Zealand plus S.23 maximum of 46% was recorded in section 3.

New Zealand ryegrass

Table 1.23 lists the potential contributions to yield of New Zealand ryegrass during 1959 and the deviations of its actual contributions from them. The general impression was that New Zealand almost held its own in competition with Irish and S.23 but on inspection this was seen to be due to the compensating effect of Irish suppression and S.23 aggression.

First cuts New Zealand showed a gain over Irish in all sections, averaging a 40% increase. With S.23, however, New Zealand only made a gain in section 2 and was suppressed in sections 1 and 3 so that, on average, a suppression of 7% resulted. In association with both Irish and S.23 the 27% increase of New Zealand in section 3 was nearly balanced by decreases of 18% and 23% in sections 1 and 2 respectively.

Second cuts The results from the second cuts were in the same general pattern as the first cuts with Irish being suppressed in all sections, S.23 only in the section 2 and Irish plus S.23 suppressing New Zealand in all sections except number 3. Overall New Zealand was still showing a slight gain from its various combinations.

Third cuts New Zealand increased its mean contribution with Irish to 43% over its potential. The increase was greatest at 56% in section 3; falling to 27% in section 1. S.23 depressed the New Zealand contribution by 36% in both sections 1 and 3 but was itself depressed by

Table 1.23 Potential percentage contribution of N.Z. ryegrass to yield during 1959 related to yield of N.Z. growing alone and assuming no competition between cultivars. The deviations of actual contribution (table 1.20) from potential are given alongside each result and, in parenthesis, the deviations are expressed as a percentage of potential.

			N.Z. With						N.Z. With			
Cut	Section	Date	Irish	S.23	Irish+S.23	$\bar{x}$	Cut	Date	Irish	S.23	Irish+S.23	$\bar{x}$
1	1	21/4	57+13(23)	57-13(23)	40 -7(18)	51 -2(4)	2	12/5	48+20(42)	48 -3(6)	32 -1(3)	43 +5(12)
	2	18/4	56+22(39)	49+17(35)	35 -8(23)	47+10(21)		7/5	57+21(37)	52+14(27)	37 -9(24)	49 +8(16)
	3	5/5	40+14(35)	56-14(25)	30 +8(27)	42 +3(7)		23/5	48+14(29)	41-13(32)	28 0(-)	39 0(-)
	$\bar{x}$		48+19(40)	55 -4(7)	34 -1(3)	46 +4(9)			51+18(35)	47 -1(2)	32 -3(9)	43 +1(2)
3	1	30/5	59+16(27)	44-16(36)	34 -7(20)	46 -3(6)	4	19/6	61+15(24)	44-17(39)	34 -7(20)	46 -3(6)
	2	20/5	56+22(39)	49 +7(14)	35-11(31)	47 +6(13)		12/6	56+24(43)	43 -1(2)	32-13(41)	44 +3(7)
	3	16/6	43+24(56)	44-15(34)	28 +6(21)	38 +5(13)		7/7	50+17(34)	46-19(41)	31 -1(3)	42 -1(2)
	$\bar{x}$		51+22(43)	44 -6(14)	32 -4(12)	42 +4(10)			56+18(32)	44-12(27)	33 -8(24)	44 0(-)
5	1	13/7	62+16(26)	48-22(46)	37-11(30)	49 -6(12)	6	31/7	61+16(26)	49-22(45)	37-12(32)	49 -6(12)
	2	2/7	60+19(32)	47 -3(6)	36-14(39)	48 0(-)		22/7	59+22(37)	46 -3(6)	36-13(36)	47 +2(4)
	3	24/7	49+20(41)	47-17(36)	32 -2(6)	43 0(-)		12/8	51+14(27)	50-22(44)	34 -4(12)	45 -4(9)
	$\bar{x}$		58+18(31)	47-14(30)	35 -9(26)	47 -2(4)			57+17(30)	48-15(31)	35 -9(26)	47 -3(6)
7	1	9/9	65+10(15)	48-21(44)	38-10(26)	50 -7(14)	8	24/10	67+16(24)	47-19(40)	38-12(32)	51 -5(10)
	2	7/8	60+22(37)	48 -4(8)	36 -7(19)	48 +4(8)		2/9	63+17(27)	49 -6(12)	38-14(37)	50 -1(2)
	3	10/9	57+13(23)	53-23(43)	38 -4(10)	49 -4(8)		16/10	59+7 (12)	54-20(37)	39 0(-)	51 -5(10)
	$\bar{x}$		61+15(24)	49-15(31)	38 -8(21)	49 -2(4)			63+13(21)	49-14(28)	38 -8(21)	50 -3(6)
9	1	-	-	-	-	-	Total for 1959		60+16(27)	48-18(38)	37 -9(24)	48 -3(6)
	2	15/10	63+17(27)	47 -3(6)	37 -8(22)	49 +2(4)			59+21(36)	48+1 (2)	36-11(30)	48 +3(6)
	3	-	-	-	-	-			48+15(31)	49+17(35)	32 +1(3)	43 0(-)
	$\bar{x}$								56+17(30)	49-12(24)	35 -6(17)	47 -1(2)

14% in section 2.

Irish plus S.23 reduced New Zealand contribution by 20% and 31% respectively in sections 1 and 2 but New Zealand showed an increase of 21% in section 3.

Fourth - ninth cuts In cut 4 the average gain in association with Irish was slightly down at 32% and continued to fall until at the eighth cut it was 21%. The effect within the sections was variable but tended to be greatest in section 2.

With S.23 the New Zealand contribution was suppressed in all sections with a mean of 27% at the fourth cut which remained fairly steady throughout the rest of the season; the suppression was always least in section 2.

With all 3 cultivars together New Zealand was suppressed in all sections and all cuts except the eighth cut of section 3 when the deviation was zero. This tendency for a rather smaller suppression of New Zealand in this section was noticable at every cut and was peculiar in that separately the effects of Irish and S.23 were least in section 2.

Total for 1959 On the annual total New Zealand showed a mean gain of 30% above its potential contribution by suppressing associated Irish plants and, as was seen at most cuts, the greatest gain came in section 2.

On average, New Zealand was suppressed by S.23 but actually made a gain of 2% in section 2 and a loss of 38% and 35% in sections 1 and 3 respectively.

The influence of Irish plus S.23 balanced to a degree, and New Zealand averaged a 17% suppression but this was made up of a 3% gain in section 3 and a loss of 24% and 30% respectively in sections 1 and 2.

S.23 ryegrass

Table 1.24 gives the potential contributions and deviations from it of actual contribution of S.23 ryegrass during 1959. S.23 made an overall gain in combination with all cultivars but there were a few instances in spring when it was suppressed by New Zealand.

Most of the interesting points of detial concerning the effect of S.23 on New Zealand and Irish have already been dealt with when the results for these two cultivars were presented, and the remarks relative to table 1.24 are confined to highlighting those points not already mentioned, and to any trends visible over the year.

The greatest mean gain by S.23 over Irish took place at the first cut when S.23 exceeded its potential by 57%. At the second cut this fell to 30% and never rose again above 46% achieved at the sixth cut. It is of interest to note that the greatest depression of Irish did not coincide with the highest actual contribution to yield by S.23. This occurred in the fifth cut when 87% of the yield was from S.23.

The important factor from the combination with New Zealand was the much smaller increase achieved by S.23 compared to that made in combination with Irish. Also, in the first 3 cuts of section 2 S.23 was itself suppressed and, thereafter, did not suppress New Zealand (in section 2) to the same degree as it did in the others.

In association with Irish plus New Zealand the S.23 was the dominant cultivar and by comparison of the results with those in tables 1.22 and 1.23 it can be seen that S.23 expanded mostly by suppression of Irish. Expressed on the total for the year S.23 showed a mean increase of 46% over potential while Irish and New Zealand respectively had decreases of 39% and 17%.

Table 1.24 Potential percentage contribution of S.23 ryegrass to yield during 1959 related to yield of S.23 growing alone and assuming no competition between cultivars. The deviations of actual contribution (table 1.2[illegible]) from potential are given alongside each result and, in parenthesis, the deviations are expressed as a percentage of potential.

Cut	Section	Date	S.23 With Irish	S.23 With N.Z.	S.23 With Irish+NZ	S.23 With $\bar{x}$	Cut	Date	S.23 With Irish	S.23 With N.Z.	S.23 With Irish+NZ	S.23 With $\bar{x}$
	1	21/4	50+22(44)	43+13(30)	30+12(40)	41+16(39)		12/5	50+23(46)	52 +3(6)	34+15(44)	45+14(31)
1	2	18/4	57+15(26)	51-17(33)	37+11(30)	48 +3(6)	2	7/5	55 +9(16)	48-14(29)	35+13(37)	46 +3(6)
	3	5/5	34+28(82)	44+14(32)	24 +6(25)	34+16(47)		23/5	57+16(28)	59+13(22)	41+12(29)	52+14(27)
	$\bar{x}$		44+25(57)	45 +4(9)	29+11(38)	39+14(36)			54+16(30)	53 +1(2)	37+13(35)	48+10(21)
	1	30/5	64+13(20)	56+16(28)	42+16(38)	54+15(28)		19/6	66+20(30)	56+17(30)	44+13(30)	55+17(31)
3	2	20/5	57+25(44)	51 -7(14)	37+19(51)	48+13(27)	4	12/6	63+21(33)	57 +1(2)	43+23(53)	54+15(28)
	3	16/6	49+34(69)	56+15(27)	35+17(48)	47+22(47)		7/7	54+27(50)	54+19(35)	37+15(40)	48+21(44)
	$\bar{x}$		56+25(45)	56 +6(11)	38+17(45)	50+16(32)			61+23(38)	56+12(21)	41+17(41)	53+17(32)
	1	13/7	64+26(41)	52+22(42)	40+22(55)	52+23(44)		31/7	63+27(43)	51+22(43)	39+22(56)	51+24(47)
5	2	2/7	63+21(33)	53 +3(6)	37+25(68)	51+16(31)	6	22/7	64+23(36)	54 +3(6)	39+23(59)	52+16(31)
	3	24/7	51+35(69)	53+17(32)	35+18(51)	46+24(52)		12/8	51+32(63)	50+22(44)	34+20(59)	45+25(56)
	$\bar{x}$		60+27(45)	53+14(26)	39+20(51)	51+20(39)			59+27(46)	52+15(29)	39+20(51)	50+21(42)
	1	9/9	66+24(36)	52+21(40)	41+19(46)	53+21(40)		24/10	69+23(33)	53+19(36)	43+17(40)	55+20(36)
7	2	7/8	61+22(36)	52 +4(8)	39+16(41)	51+14(27)	8	2/9	64+20(31)	51 +6(12)	40+20(50)	52+15(29)
	3	10/9	54+28(52)	47+23(49)	33+20(61)	45+23(51)		16/10	55+27(49)	46+20(43)	34+12(35)	45+20(44)
	$\bar{x}$		62+23(37)	51+15(29)	38+18(47)	50+19(38)			64+22(34)	51+14(27)	40+15(38)	52+17(33)
	1	-	-	-	-	-	Total		62+24(39)	52+18(35)	39+17(44)	51+20(39)
9	2	15/10	65+19(29)	53 +3(6)	41+15(36)	53+12(23)	for		61+20(33)	52 -1(2)	39+19(49)	51+12(24)
	3	-	-	-	-	-	1959		49+28(57)	51+17(33)	33+15(45)	44+20(45)
	$\bar{x}$								57+24(42)	51+12(24)	37+17(46)	48+18(38)

Plant and Tiller Numbers

Plant Survival

The survival of each cultivar growing alone and in mixtures in the spring and autumn of the second harvest year is given in table 1.25.

April 1959 Overall there had been an approximate 10% reduction in survival compared to the figures given in table 1.10 (survival at November 1958).

Irish had its lowest survival in section 2. The average effect of the presence of S.23 caused a significantly lower survival than the other cultivar treatments which were not significantly different. The competitive influence of S.23 seemed greatest in section 2.

New Zealand had a slightly higher general survival than Irish and was not affected by S.23. The analysis of the results showed no significant differences although there was a tendency for a higher survival in the presence of Irish.

S.23 had the highest survival rate and this was not significantly affected by associated cultivars.

November 1959 The percentage survival of Irish had fallen sharply to an average of 56% but, in section 3, the figure of 68% was significantly greater than those in the other sections. The aggressiveness of S.23 was clearly seen as only 44% of the Irish plants survived when Irish and S.23 were growing together. New Zealand did not significantly effect the Irish survival.

The mean survival of New Zealand was similar in all sections. In combination with Irish it was significantly higher than New Zealand alone and this was most marked in section 1. The effect of S.23 on New Zealand was slight and also not significant.

Table 1.25 Percentage survival in April and November 1959. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

April 1959

Irish ryegrass

Section	Alone	With N.Z.	With S.23	With NZ+S.23	$\bar{x}$	L.S.D.
1	82	81	68	75	76(62)	1=8
2	73	61	52	60	62(52)	2=7
3	87	82	70	81	80(64)	3,4=N.S.
$\bar{x}$	81(65)	75(62)	63(53)	72(59)	73	C.V.=13.4%

N.Z. ryegrass

Section	Alone	With Irish	With S.23	With Irish+S23	$\bar{x}$	
1	79	89	76	66	78	1,2,3,4=N.S.
2	76	82	78	75	78	C.V.=12.4%
3	76	79	67	77	75	
$\bar{x}$	77	83	74	73	77	

S.23 ryegrass

Section	Alone	With Irish	With N.Z.	With Irish+N.Z.	$\bar{x}$	
1	83	89	90	94	89	1,2,3,4=N.S.
2	86	81	85	86	84	C.V.=15.1%
3	88	94	88	88	89	
$\bar{x}$	86	88	88	89	87	

~~April~~ NOVEMBER 1959

Irish ryegrass

Section	Alone	With N.Z.	With S.23	With NZ+S.23	$\bar{x}$	L.S.D.
1	64	54	32	54	51(46)	1=8
2	54	46	44	54	49(45)	2=7
3	70	73	55	73	68(56)	3,4=N.S.
$\bar{x}$	63(52)	58(50)	44(41)	60(51)	56	

N.Z. ryegrass

Section	Alone	With Irish	With S.23	With Irish+S.23	$\bar{x}$	
1	73	90	62	60	71	1=N.S.
2	70	76	66	75	72	2=6
3	70	76	64	73	71	3,4=N.S.
$\bar{x}$	71(57)	81(65)	64(54)	69(57)	71	C.V.=12.6%

S.23 ryegrass

Section	Alone	With Irish	With N.Z.	With Irish+N.Z.	$\bar{x}$	
1	79	87	88	90	86	1,2,3,4=N.S.
2	79	78	83	79	80	C.V.=14.6%
3	83	87	86	83	85	
$\bar{x}$	80	84	86	84	84	

As at previous counts the survival of S.23 was not affected by cutting frequency or companion cultivar. S.23 again had the highest average survival of the cultivars.

Tiller Numbers

Mean tiller number per plant The mean tiller numbers per plant at the end of the second harvest year are shown in table 1.26. Compared to the previous year's count the Irish plants had fewer tillers while New Zealand and S.23 both had more.

The tiller numbers of Irish were not affected by frequency of cutting as evidenced by the closeness of the average figures for the section means but, by combining Irish with New Zealand and/or S.23 the tillers per plant were significantly reduced. In the case of S.23 the reduction was by more than half of the Irish alone figure.

The plants of New Zealand growing with Irish had a significantly greater number of tillers than in any of the other cultivar treatments. On average, New Zealand plants had 13 more tillers than Irish.

S.23 tiller numbers increased, compared to S.23 alone, when combined with Irish and Irish plus New Zealand. With only New Zealand present S.23 tillers remained unchanged. Comparing the results for the cultivars growing alone Irish and New Zealand were identical while S.23 was not significantly greater.

Tillers per Unit Area Table 1.27 and figure 1.26 show the total tillers per sq. ft. for each treatment. Statistical reduction of the data revealed no significant differences although S.23, and mixtures containing S.23, tended to have the largest number of tillers.

Table 1.26 Mean tiller numbers per plant at November 1959.

Irish ryegrass

Section	Alone	With N.Z.	With S.23	With NZ+S.23	$\bar{x}$	L.S.D.
						1=N.S.
1	36	20	12	17	22	2=6
2	37	20	21	23	25	3,4=N.S.
3	32	23	15	18	22	C.V.=32.2%
$\bar{x}$	35	21	16	19	23	

N.Z. ryegrass

	Alone	With Irish	With S.23	With Irish+S.23	$\bar{x}$	
						1=N.S.
1	33	42	30	34	35	2=6
2	41	53	38	30	40	3,4=N.S.
3	32	40	29	39	35	C.V.=21.7%
$\bar{x}$	35	45	32	35	36	

S.23 ryegrass

	Alone	With Irish	With N.Z.	With Irish+NZ	$\bar{x}$	
						1=N.S.
1	40	62	36	54	48	2=9
2	37	51	32	54	44	3,4=N.S.
3	35	58	40	41	44	C.V.=24.3%
$\bar{x}$	37	57	36	50	45	

Table 1.27 Total tillers per sq. ft. at November 1959.

Section	Treatments								
	I	N	S	IN	IS	NS	INS	$\bar{x}$	L.S.D.
1	815	875	1132	872	1058	900	952	944	1,2,3,4=N.S.
2	852	1018	1042	880	850	945	935	932	
3	802	800	1018	865	1068	940	910	915	C.V.=20.6%
$\bar{x}$	823	898	1064	872	992	928	932	930	

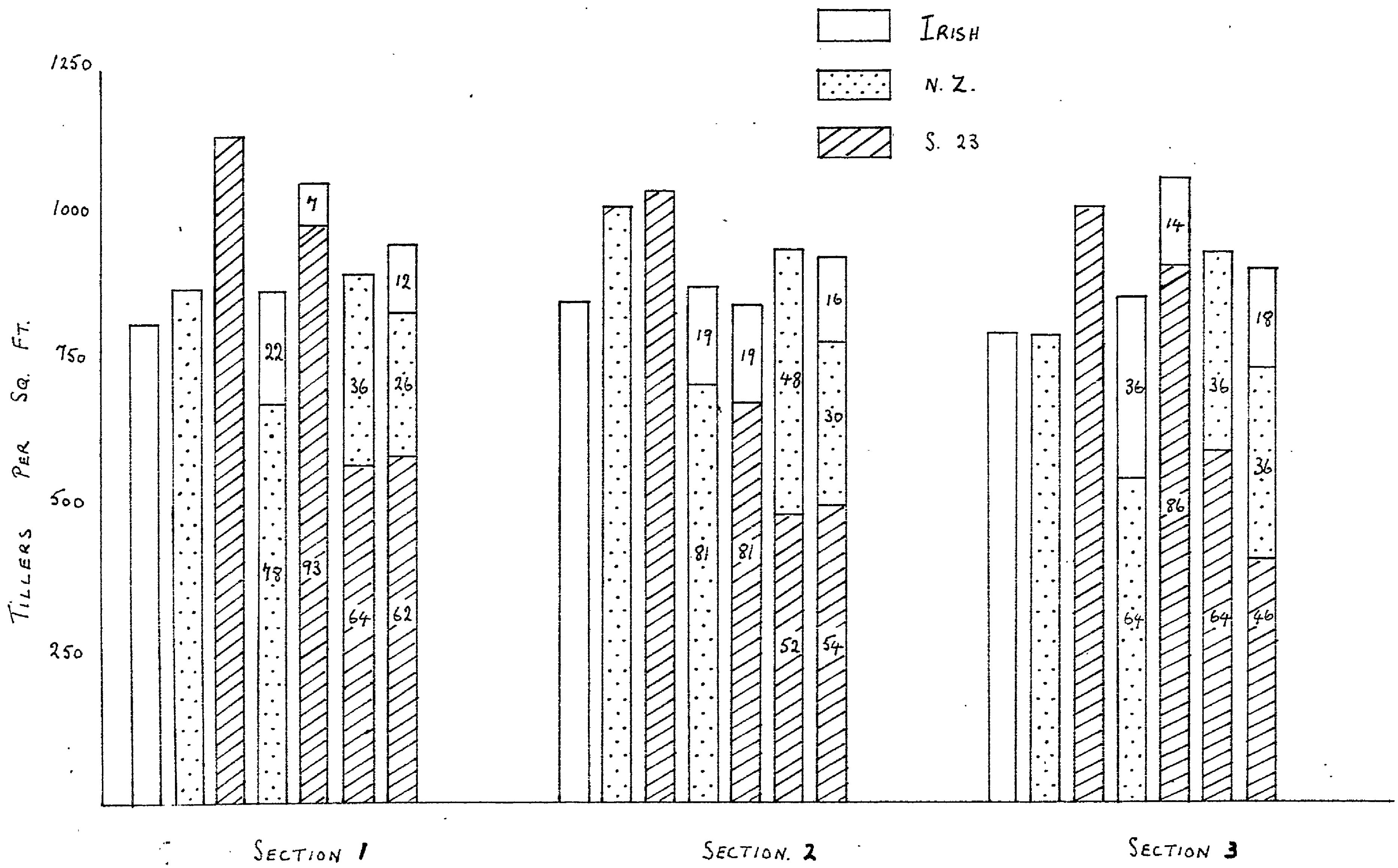


Figure 1.26 Tiller production per sq. ft. and contribution of the components of the mixtures at November 1959.

Actual Percentage, and Potential Percentage, Contribution to Tiller Production by the Components of Cultivar Mixtures

Actual Contribution

In table 1.28 and figure 1.26 the percentage contribution to total tillers made by the components of the mixtures are given.

The average contribution by Irish had nearly halved from the previous year (table 1.14) and was considerably below those of New Zealand and S.23 which had increased. The only significant differences for Irish were between the cultivar treatment means where the percentage with S.23 was half that achieved in combination with New Zealand. The Irish contribution appeared highest in section 3 when in combination with New Zealand and extremely low in section 1 with S.23 as a partner.

New Zealand dominated the association with Irish and produced an average of 74% of the tillers but was suppressed by S.23 and gave only 40% of their combined number. In combination with both Irish and S.23 approximately one third of the total tillers were produced by New Zealand, indicating a compensating influence between the effects of Irish and S.23.

Potential Contribution

In table 1.29 the potential percentage contributions of the cultivars based on their actual tiller production when growing alone (table 1.27) are given, as are the deviations from actual percentage contribution (table 1.28). Table 1.29 was constructed in a similar manner to table 1.15 which gives the equivalent data for the first harvest year.

Table 1.28 Percentage of total tillers per sq. ft. contributed by the components of the mixtures at November 1959. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Section	Irish with N.Z.	Irish with S.23	Irish with NZ+S.23	$\bar{x}$	L.S.D.
1	22	7	12	13	1=N.S.
2	19	19	16	18	2=5
3	36	14	18	23	3,4=N.S.
$\bar{x}$	26(30)	13(20)	15(22)	18	C.V.=23.9%

Section	N.Z. with Irish	N.Z. with S.23	N.Z. with Irish+S.23	$\bar{x}$	L.S.D.
					1=N.S.
1	78(63)	36(37)	26(30)	47	2=4
2	81(65)	48(44)	30(33)	53	3=8
3	64(53)	36(36)	36(37)	45	4=12
$\bar{x}$	74(60)	40(39)	31(33)	48	C.V.=11.8%

Section	S.23 with Irish	S.23 with N.Z.	S.23 with Irish+N.Z.	$\bar{x}$	L.S.D.
					1=N.S.
1	93	64	63 62	73	2=5
2	81	52	54	62	3,4=N.S.
3	86	64	46	65	C.V.=9.9%
$\bar{x}$	87(69)	60(51)	54(47)	67	

Table 1.29 Potential percentage contribution of cultivars to total tiller production in 1959 related to tiller production of cultivars growing alone and assuming no competition between them. The deviations, of actual contribution (table 1.28), from potential are given alongside each result and, in parenthesis, the deviations are expressed as a percentage of potential.

	Irish with			
Section	N.Z.	S.23	N.Z.+S.23	$\bar{x}$
1	48-26(54)	42-35(83)	29-17(59)	40-27(68)
2	46-27(59)	45-26(58)	29-13(45)	40-22(55)
3	50-14(28)	44-30(68)	31-13(42)	42-19(45)
$\bar{x}$	48-22(46)	44-31(70)	30-15(50)	41-23(56)

	N.Z. with			
	Irish	S.23	Irish+S.23	$\bar{x}$
1	52+26(50)	44-8(18)	31-5(16)	42+5(12)
2	54+27(50)	49-1(2)	35-5(14)	46+7(15)
3	50+14(28)	44-8(18)	30+6(20)	41+4(10)
$\bar{x}$	52+22(42)	46-6(13)	32-1(3)	43+5(12)

	S.23 with			
	Irish	N.Z.	Irish+N.Z.	$\bar{x}$
1	58+35(60)	56+8(14)	40+23(58)	51+22(43)
2	55+26(47)	57+1(2)	36+18(50)	47+15(32)
3	56+30(54)	56+8(14)	39 +7(18)	50+15(30)
$\bar{x}$	56+31(55)	54+6(11)	38+16(42)	49+18(37)

Irish ryegrass The tillering capacity of Irish was severly reduced in combination with New Zealand and/or S.23 and expressed as reductions of potential they amounted to 46%, 70% and 50% with New Zealand, S.23 and New Zealand plus S.23 respectively. The greatest suppression of Irish, by 83%, was in association with S.23 in section 1. On average Irish was least suppressed in section 3 and most in section 1.

New Zealand ryegrass New Zealand made its highest gains, with Irish as a partner, in section 1 and, on average, increased by 42%. S.23 suppressed New Zealand slightly in all sections and the New Zealand mean contribution was 13% below its potential. The smallest decrease of 2% was in section 2. In company with both Irish and S.23 the contribution of New Zealand was lowered in sections 1 and 2 but showed an increase in section 3. The average effect was a decrease of 3% showing that any tendence of New Zealand to tiller more freely in the presence of less vigorous Irish plants was overshadowed by the aggressiveness of S.23 except, as has been noted, under the management of section 3.

S.23 ryegrass S.23 was able to increase its tillering capacity in all combinations and most markedly with Irish where it rose to 55% above its potential. With New Zealand the increase only averaged 11% and, in section 2, was less than 2%.

With both Irish and New Zealand present the effect was intermediate and S.23 increased by a mean 42%. In section 3 only an 18% increase was recorded.

THIRD HARVEST YEAR

Dry Matter Yield of Cultivars Growing Alone and in Mixtures at Each Cut and Accumulatively

Yield per Cut

The yields of dried herbage for the 6 cuts taken in 1960, the total for the year and the total for 1958-59-60 are given in table 1.30 and diagramatically in figures 1.27, 1.28 and 1.29.

Cutting frequencies The dates of cutting and intervals between cuts are given in table 1.31. In the third harvest year the cultivars growing alone only reached the designated cutting height on 6 occasions. Section 1 did not actually reach this height at its last cut but, in order to conclude the experiment, a yield assessment was made.

Section 2 was again the first to be cut followed, 8 days later, by section 1. Section 3 was first cut 17 days after section 2.

The intervals between cuts were longer in 1960 than in 1958 and 1959. Section 1, as in previous years, began its cutting cycle before section 3 but, due to slower regrowth, finished after it. Section 2 also lost ground compared to section 3 and, at the final cut, was only 2 days ahead compared to 17 days in the spring.

The average yield for all treatments was 25.2 g. per plot for the first cuts but fell to average between 11.9 g. and 17.5 g. over the remainder of the season. The yield of section 1 was very low in the last cut due to the relatively short growth period.

Significant differences between the main plot cutting frequency section means were recorded at all cuts, except the second, and between sub plot cultivar treatment means at all cuts. The interaction between cutting frequency sections and cultivar treatments was significant at all cuts except the fourth and sixth and in the total for 1960.

Table 1.30 Yield of dry matter (grams per plot) during 1960, total for 1960 and total for 1958-59-60.

Cut	Section	Date	I	N	S	IN	IS	NS	INS	$\bar{x}$	L.S.D.
											1. = 3.5
1	1	10/5	13.4	21.6	16.6	21.4	16.0	19.0	21.6	18.5	2. = 4.2
	2	2/5	16.6	25.3	21.0	30.1	15.2	28.7	21.8	22.7	3. = 7.3
	3	19/5	29.9	49.2	24.0	41.3	28.9	34.0	33.1	34.3	4. = 7.4
	$\bar{x}$		20.0	32.0	20.6	30.9	20.0	27.2	25.5	25.2	C.V. = 20.3%
											1. = N.S.
2	1	7/6	7.0	10.7	16.1	9.8	13.0	15.1	11.0	11.8	2. = 2.0
	2	24/5	10.6	12.0	14.2	12.7	11.9	16.7	12.3	12.9	3. = 3.5
	3	17/6	5.4	6.6	11.6	7.4	17.6	15.2	13.4	11.0	4. = 3.4
	$\bar{x}$		7.7	9.8	14.0	10.0	14.2	15.7	12.2	11.9	C.V. = 20.5%
											1. = 3.0
3	1	2/7	5.7	11.8	10.7	9.5	11.2	11.0	9.9	10.0	2. = 2.6
	2	24/6	8.8	13.1	17.9	18.9	15.6	24.2	16.0	16.4	3. = 4.5
	3	22/7	12.0	21.5	18.7	19.7	23.8	22.8	21.8	20.0	4. = 4.8
	$\bar{x}$		8.8	15.4	15.8	16.0	16.9	19.4	15.9	15.5	C.V. = 20.6%
											1. = 4.3
4	1	9/8	11.1	20.4	23.8	19.6	23.9	28.2	18.9	20.8	2. = 2.8
	2	25/7	13.6	18.4	20.4	20.4	17.0	24.2	17.2	18.7	3. = N.S.
	3	16/8	7.9	12.8	11.0	13.2	15.4	15.8	14.6	13.0	4. = N.S.
	$\bar{x}$		10.9	17.2	18.4	17.8	18.7	22.7	16.9	17.5	C.V. = 19.8%
											1. = 2.4
5	1	19/9	12.0	21.7	22.8	20.2	20.8	21.0	18.8	19.6	2. = 2.9
	2	31/8	7.4	14.4	20.6	20.2	16.1	23.3	19.2	17.3	3. = 5.1
	3	8/9	9.6	14.2	12.8	13.6	15.4	14.8	14.0	13.5	4. = 5.1
	$\bar{x}$		9.7	16.8	18.7	18.0	17.4	19.7	17.3	16.8	C.V. = 21.5%
											1. = 2.2
6	1	14/10	6.5	9.6	9.2	7.5	8.8	9.1	7.9	8.4	2. = 2.2
	2	11/10	11.7	17.3	20.2	20.4	16.0	23.7	19.1	18.4	3. = N.S.
	3	13/10	12.3	16.1	16.4	16.6	17.8	19.7	16.0	16.4	4. = N.S.
	$\bar{x}$		10.2	14.3	15.3	14.8	14.2	17.5	14.3	14.4	C.V. = 18.7%
											1. = 12
Total for 1960	1		56	96	100	88	94	103	88	89	2. = 13
	2		69	100	114	123	92	139	106	106	3. = N.S.
	3		77	120	94	110	119	122	113	108	4. = N.S.
	$\bar{x}$		67	106	103	107	101	121	102	101	C.V. = 16.0%
											1. = 20
Total for 1958-59-60	1		228	380	432	370	410	398	388	381	2. = 32
	2		278	338	392	388	342	415	365	360	3. = 55
	3		368	385	365	402	378	420	400	388	4. = 59
	$\bar{x}$		311	368	397	387	377	411	384	376	C.V. = 10.3%

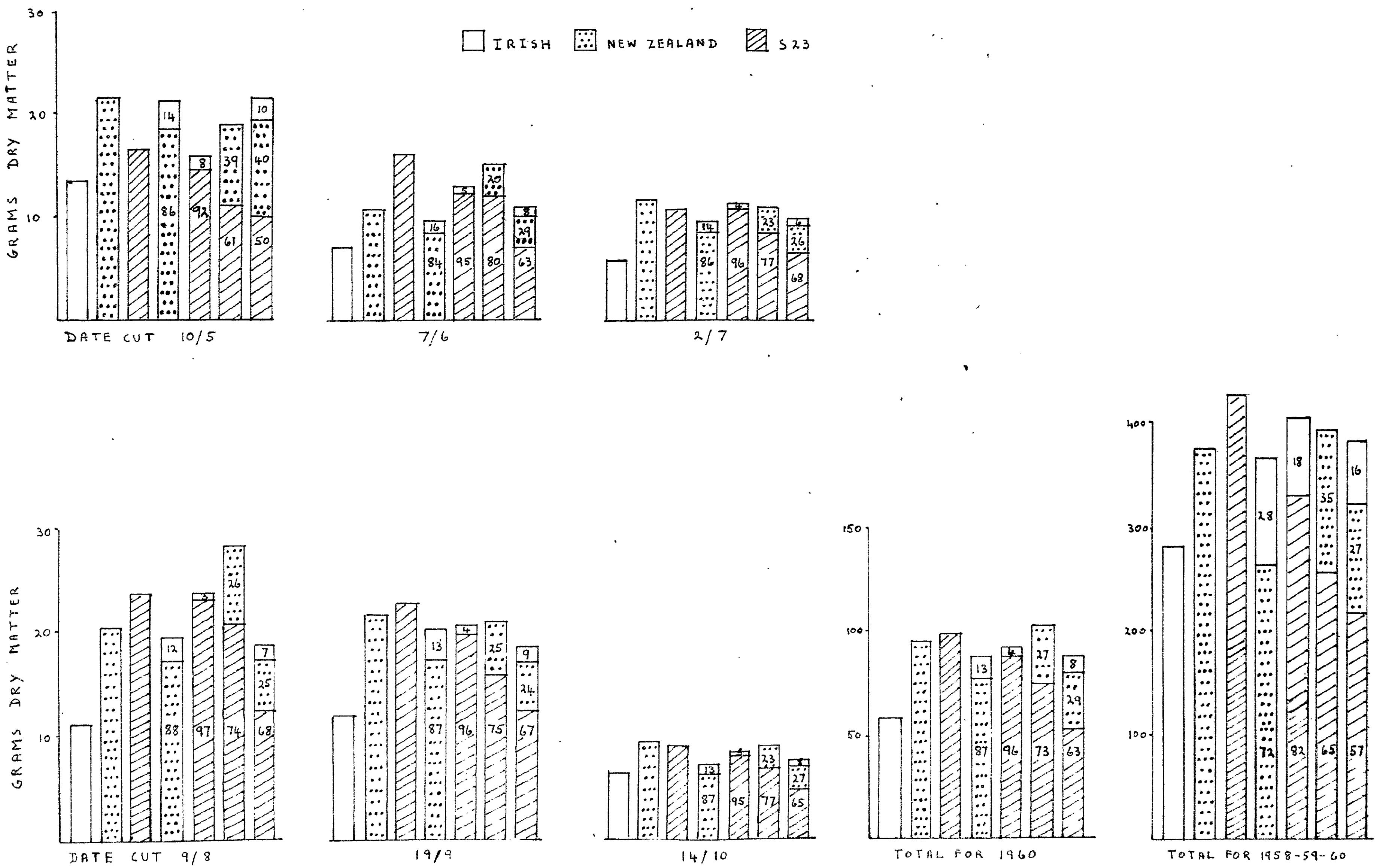

IRISH
NEW ZEALAND
S23
GRAMS DRY MATTER
DATE CUT 10/5
7/6
2/7
DATE CUT 9/8
19/9
14/10
TOTAL FOR 1960
TOTAL FOR 1958-59-60

Figure 1.27 Yield of dry matter in section 1 at each cut in 1960, total for 1960 and total for 1958-59-60. The contribution to the total yield by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total yield that it represents is quoted.

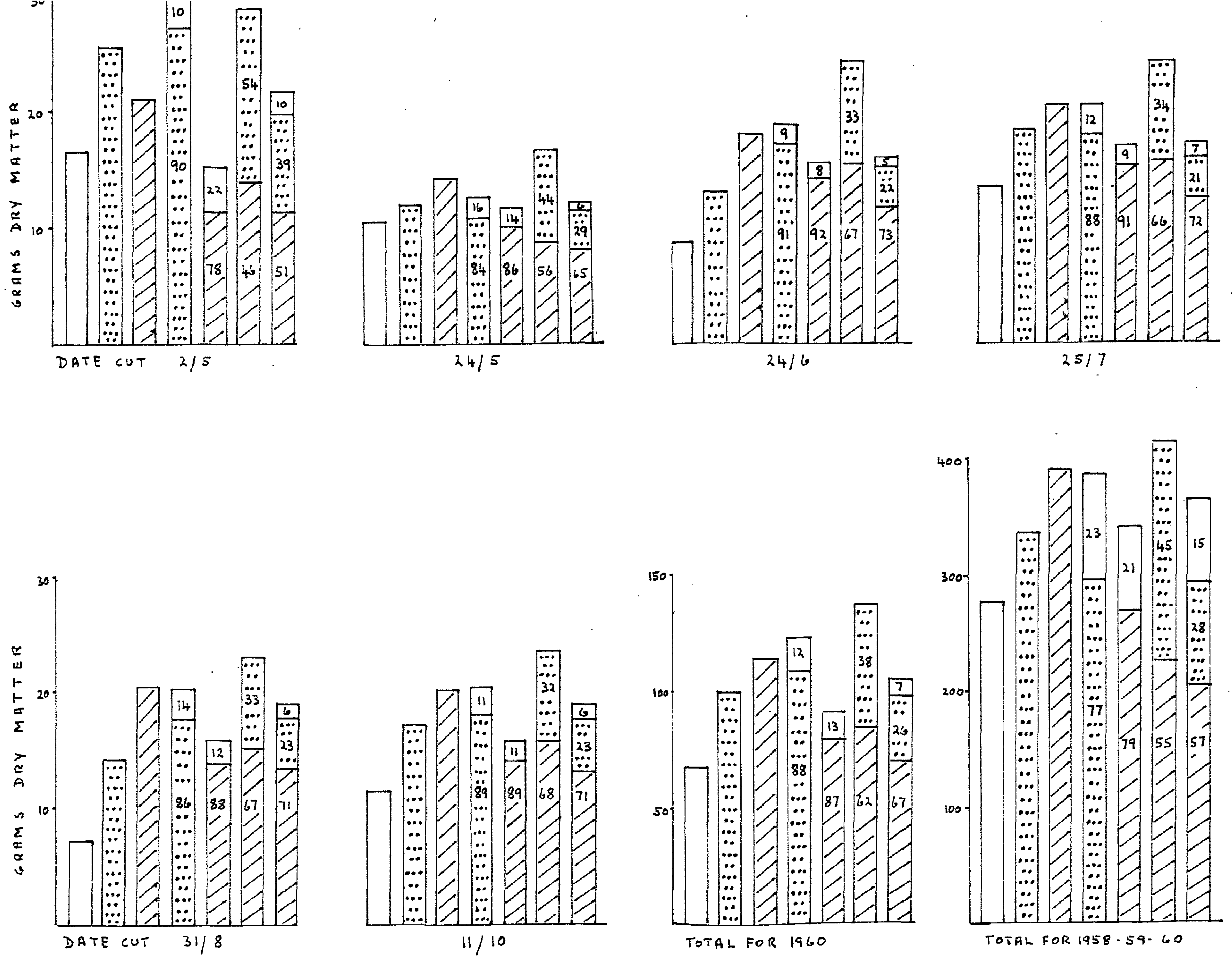
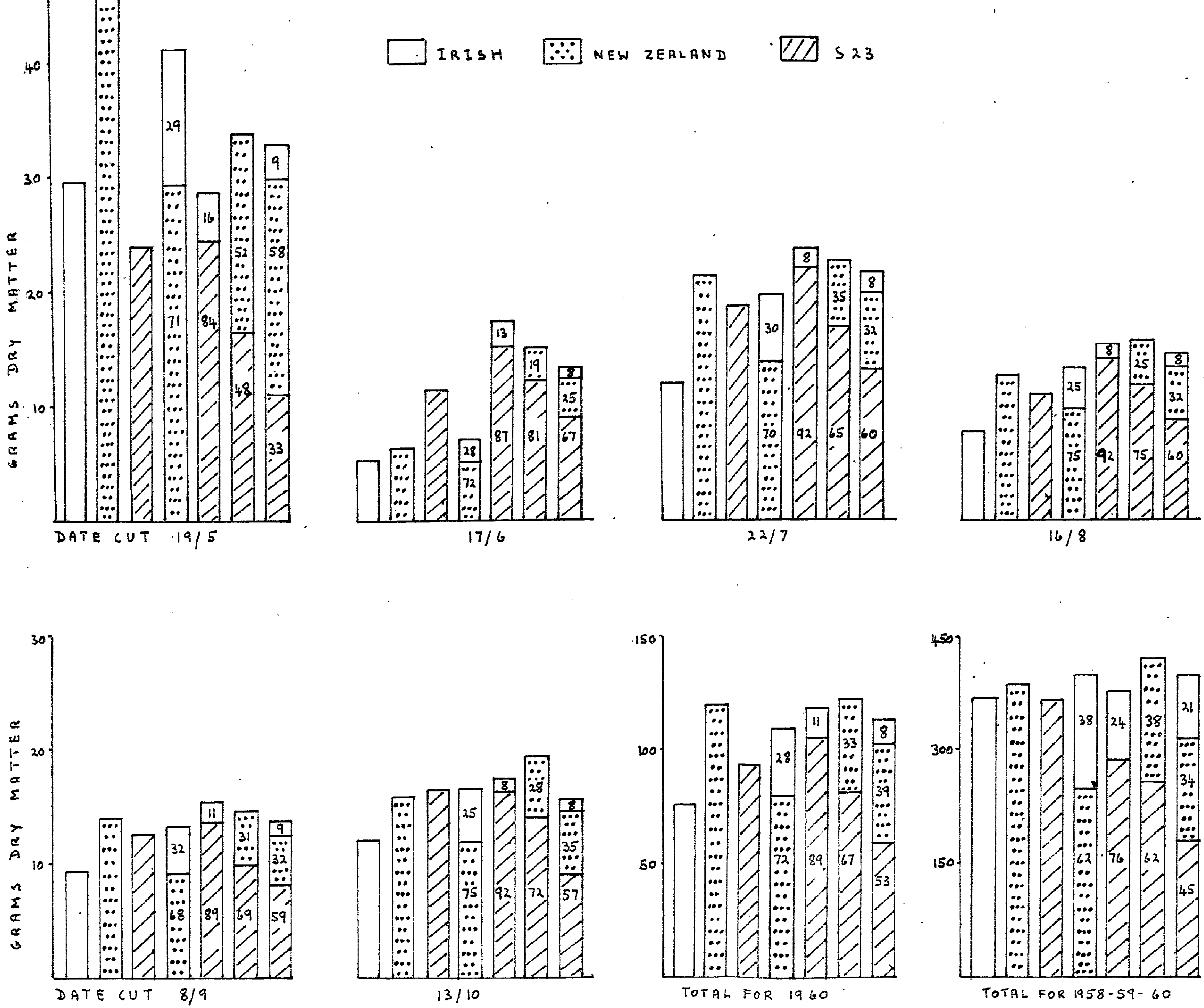

GRAMS DRY MATTER
10
20
DATE CUT 2/5
10
90
22
78
54
46
10
39
51
24/5
16
84
14
86
44
56
6
29
65
24/6
9
91
8
92
33
67
5
22
73
25/7
12
88
9
91
34
66
7
21
72
GRAMS DRY MATTER
10
20
30
DATE CUT 31/8
14
86
12
88
33
67
6
23
71
11/10
11
89
11
89
32
68
6
23
71
50
100
150
TOTAL FOR 1960
12
88
13
87
38
62
7
26
67
100
200
300
400
TOTAL FOR 1958-59-60
23
77
21
79
45
55
15
28
57

Figure 1.28 Yield of dry matter in section 2 at each cut in 1960, total for 1960 and total for 1958-59-60. The contribution to the total yield by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total yield that it represents is quoted.



IRISH
NEW ZEALAND
S23
GRAMS DRY MATTER
10
20
30
40
29
16
52
58
71
84
48
33
9
DATE CUT 19/5
13
19
8
28
25
72
87
81
67
17/6
8
8
35
30
32
70
92
65
60
22/7
8
8
25
25
32
75
92
75
60
16/8
GRAMS DRY MATTER
10
20
30
32
11
31
9
32
68
89
69
59
DATE CUT 8/9
8
25
28
8
35
75
92
72
57
13/10
50
100
150
11
28
33
8
39
72
89
67
53
TOTAL FOR 1960
150
300
450
38
24
38
21
34
62
76
62
45
TOTAL FOR 1958-59-60

Figure 1.29 Yields of dry matter in section 3 at each cut in 1960, total for 1960 and total for 1958-59-60. The contribution to the total yield by each component of the mixtures is shown by the sub-divisions of the histograms and, within each sub-division, the percentage of total yield that it represents is quoted.

Table 1.31 Dates on which the sections were cut during 1960 and intervals between cuts.

Section		Cut 1.	2.	3.	4.	5.	6.
1	Date of cut	10/5	7/6	2/7	9/8	19/9	14/10
	Interval between cuts	0	33	25	38	41	25
2	Date of cut	2/5	24/5	24/6	25/7	31/8	11/10
	Interval between cuts	0	22	31	31	37	41
3	Date of cut	19/5	17/6	22/7	16/8	8/9	13/10
	Interval between cuts	0	29	35	25	23	35

First cuts The cultivars growing alone showed different responses to the varying times of cutting. The yield of S.23 did not increase significantly from the earliest to the latest cut while both Irish and New Zealand gave increased yields at the latest cut. New Zealand increased by 27.6 g. and Irish by 16.5 g. Also important was the fact that, at the cut on May 2nd there were no significant differences between cultivars, while on May 10th Irish was apparently yielding less than New Zealand. By May 19th the position had changed and New Zealand considerably outyielded both of the others and Irish, although higher than S.23, was not significantly so.

In section 3 the mixture of Irish and New Zealand reflected the higher yield of New Zealand and was only just significantly less than it. The IS mixture came between the Irish and S.23 yields while the NS combination was significantly higher than S.23 alone and significantly lower than New Zealand alone. With Irish, New Zealand and S.23 together the yield was similar to that of the NS mixture.

It should be noted that, although non-significant, the NS yield in section 2 was higher than New Zealand or S.23 alone.

Second cuts Considering the cultivars growing alone S.23 gave a significantly higher yield than Irish in all 3 sections but was only significantly greater than New Zealand in sections 1 and 3. New Zealand outyielded Irish significantly in section 1.

The mixture of New Zealand and S.23 was the highest average yielder and was significantly greater than either of its components in section 3 but exceeded New Zealand significantly in all sections. The IS mixture also showed a positive interaction in section 3 but was intermediate to Irish and S.23 in the other sections. The combination of Irish and

New Zealand showed no significant advantage over its components. The INS mixture yield was significantly less than the best of its components (S.23) in section 1, and showed no material advantage or disadvantage over S.23 in the other sections.

Third cuts S.23 again outyielded Irish in all sections and was significantly greater than New Zealand in section 2, but produced slightly less than it in sections 1 and 3. New Zealand significantly outyielded Irish in all sections except 2.

The NS mixture again, on average, outyielded all other treatments and showed the same significant positive interaction recorded in section 2. Its yield in section 3 was also higher than New Zealand or S.23 alone, but not significantly.

The highest yield, as at the second cut, was given by the IS mixture in section 3 where there was a positive interaction. In the other sections IS gave slightly less than S.23 alone.

The IN mixture was higher than Irish but, only in section 2, outyielded New Zealand. INS never gave significantly more than the best of its components and in the sections 1 and 2 gave less.

Fourth cuts The mean yields over the cutting sections showed the NS mixture to be the most productive of all treatments; exceeding New Zealand and S.23 in all sections.

Irish alone was by far the poorest yielder while New Zealand and S.23 were not significantly different. The IN, IS and INS combinations were of a similar magnitude and not significantly different from New Zealand or S.23.

Fifth cuts The Irish yield was again considerably lower than New Zealand or S.23 in all sections. S.23 only significantly exceeded New

Zealand in section 2, otherwise these cultivars did not differ by a practical amount.

The NS mixture was still, on average, the most productive, but did not significantly exceed its components although it did give rather more than either in sections 2 and 3.

IS produced more than S.23 in section 3 (non-significant) but on average was no better or worse than S.23 alone. The IN mixture significantly exceeded both Irish and New Zealand in section 2 but in the other sections gave slightly less than New Zealand alone.

The INS combination was not significantly greater or less than its most productive components (New Zealand and S.23) in any section.

Sixth cuts All treatments produced less in section 1 due to the short regrowth period. Irish alone was once more significantly below New Zealand and S.23 which did not differ significantly.

The NS mixture did not, on average, significantly exceed S.23 but in sections 2 and 3 did give a noticably greater yield than either of its components. The IN mixture also outyielded its components in sections 2 and 3 although, on average, it was not significantly greater than New Zealand.

IS averaged less than S.23 alone although it did slightly exceed it in section 3. The INS mixture always gave a rather lower yield than S.23 alone.

Total for 1960 The extremely low production of Irish placed it well below the other cultivars both alone and in mixtures. New Zealand and S.23 were not significantly different but did show some interesting reversals of position between sections. In section 1 and, especially, section 2 S.23 outyielded New Zealand; in section 3 the roles were reversed.

The positive interaction between these 2 cultivars which had occurred at almost every cut was significant in the annual total. The largest increase over New Zealand and S.23 alone was in section 2 but, in section 1, only just exceeded the yields of its components. In section 3 the increase was only apparent relative to S.23.

IN was not statistically greater than New Zealand alone but in section 2 it did exceed it by 23%.

The same remark applies to the IS mixture which on average was similar to S.23 but did noticably outyield it in section 3.

INS was no better than New Zealand or S.23 in sections 2 and 3 and, in section 1, was rather worse.

Total for 1958-59-60 The grand total yield for the 3 years of the experiment showed Irish, averaged over the 3 sections, to be the lowest yielder but in section 3 there were no significant differences between any of the cultivars, either alone or in mixtures. New Zealand and S.23 were not significantly different although the S.23 yield was considerably higher in both sections 1 and 2.

The NS mixture was the highest yielder although never significantly exceeding the most productive of its components in any section. The lack of any positive interaction between New Zealand and S.23 in the first harvest year was undoubtedly the reason why it was not significant on the grand total. The trend was, however, present and in sections 2 and 3 NS gave respective increases of 14% and 12% over the mean yields of its components.

The IN mixture also outyielded its components in sections 2 and 3, but not significantly and, in section 1, produced slightly less than New Zealand.

The IS combination did not significantly exceed or fall below S.23 in any section but, on average, was slightly poorer.

The mixture of all 3 cultivars was no better or worse than New Zealand or S.23 in any section, but it did outyield Irish in sections 1 and 2.

Averaged over all cultivar treatments section 2 yielded significantly less than the other sections.

Accumulative Yield

The accumulative yield of all cultivar treatments during 1960 are presented in figures 1.30, 1.31 and 1.32 for sections 1, 2 and 3 respectively.

Section 1. All yields in 1960 were low compared to previous years and this was mainly due to the slow growth rate in the early part of the season.

Irish had the poorest growth rate of all treatments, the yield steadily dropping behind the others over the whole season. New Zealand outyielded S.23 at cut 1 then a more rapid growth rate put S.23 slightly ahead. The positions were changed again at the third cut and S.23 subsequently displayed a rather greater productivity than New Zealand but there was never any difference of practical importance between them.

The IN and IS mixtures followed the growth curves of their most productive components (New Zealand and S.23); the low production of Irish having no apparent effect. NS started the season with a yield intermediate to New Zealand and S.23. For the next two cuts there was little between these 3 treatments but after July 2nd the NS growth rate increased relative to New Zealand and S.23 and a positive interaction resulted. NS continued to rank first although (between August 9th and

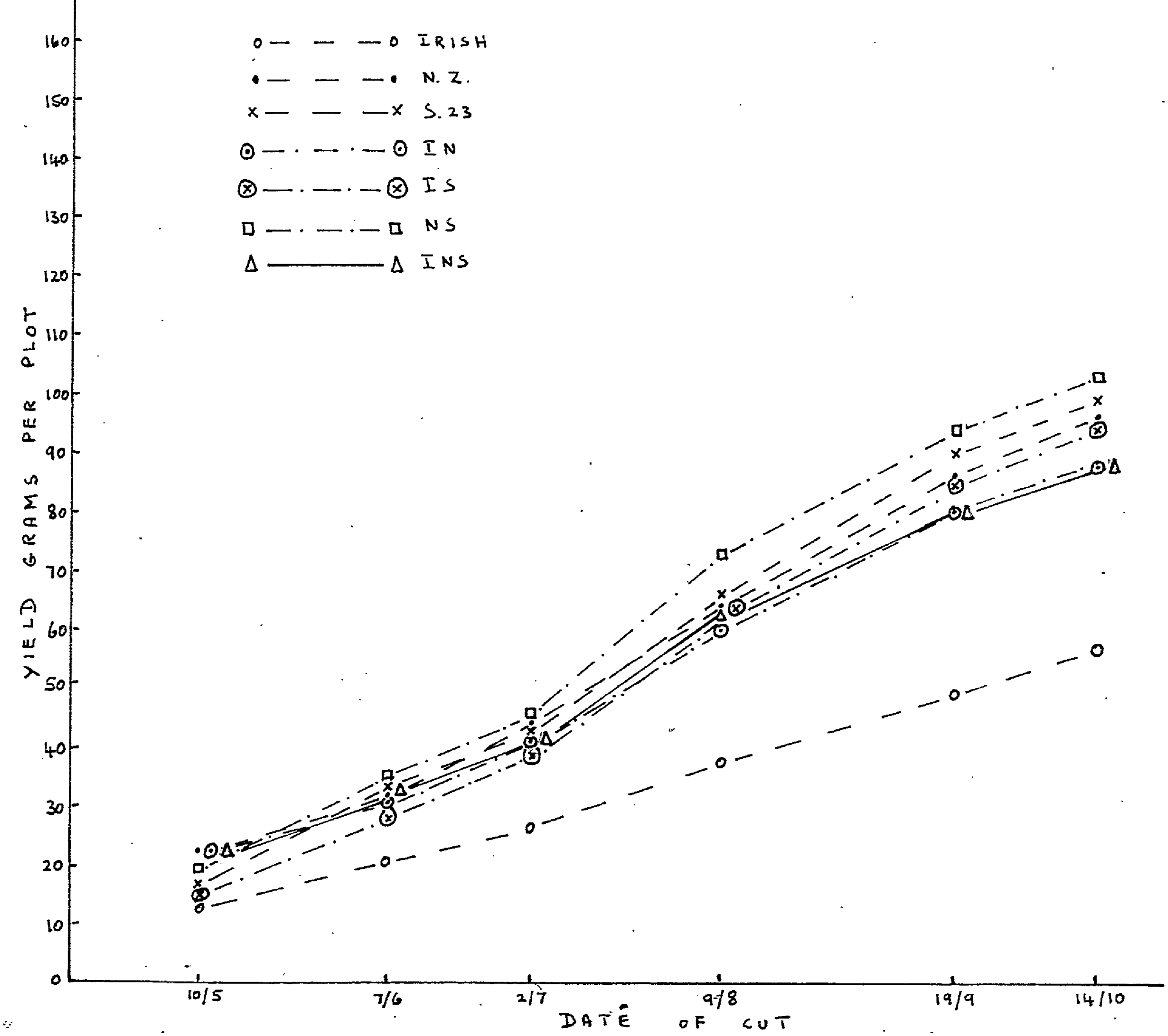


Figure 1.30 Accumulative dry matter yield of cultivars growing alone and in mixtures in section 1 during 1960.

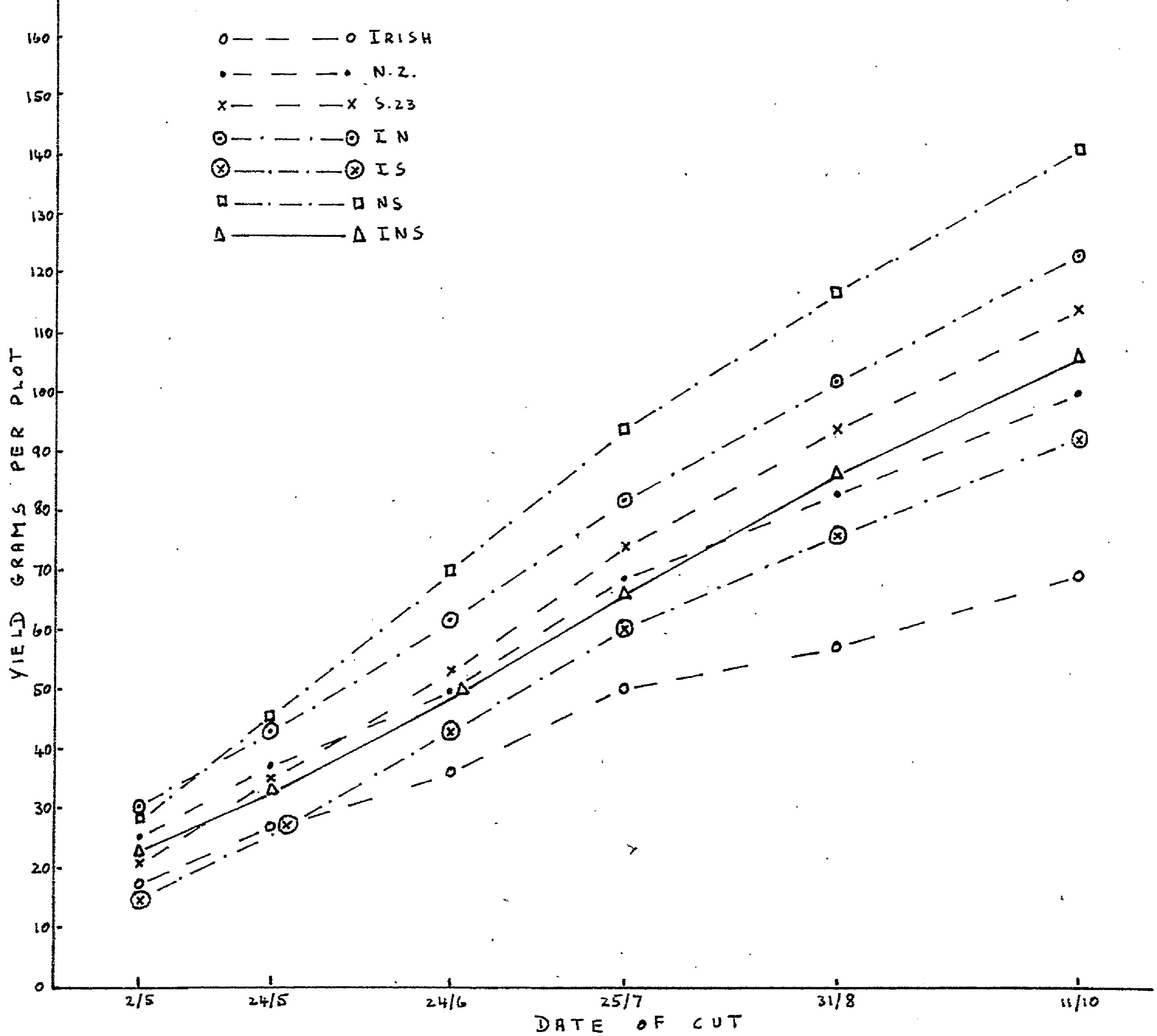


Figure 1.31 Accumulative dry matter yield of cultivars growing alone and in mixtures in section 2 during 1960.

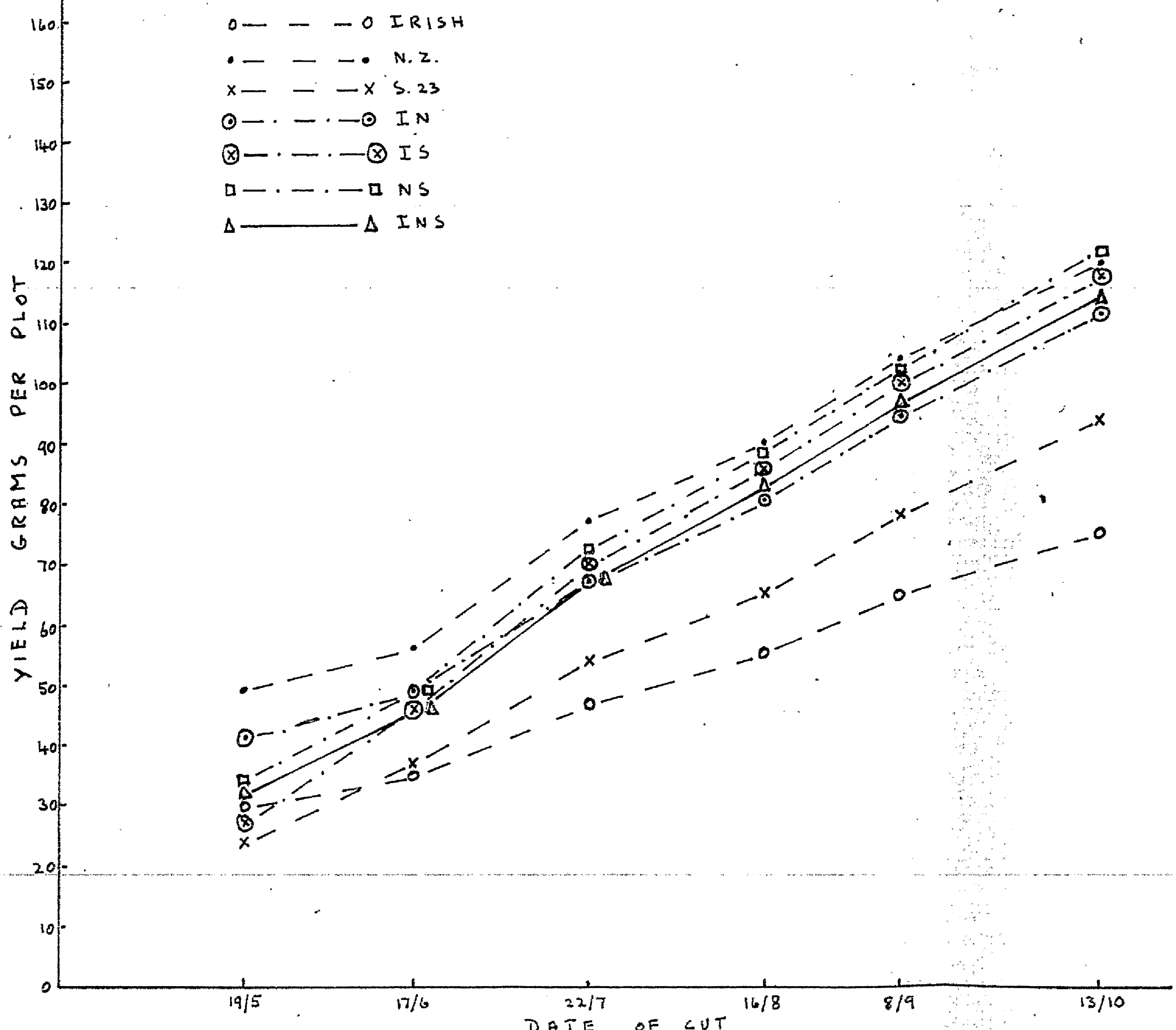


Figure 1.32 Accumulative dry matter yield of cultivars growing alone and in mixtures in section 3 during 1960.

September 19th) its rate of growth was slightly less than that of S.23. This occurrence was a repetition, to a smaller degree, of the interaction recorded in 1959 in section 3.

INS commenced with a high yield similar to New Zealand and for the remainder of the year was intermediate to, or not greatly different from, New Zealand and S.23, which were its major components.

Section 2 A wider spread of yields occurred in this section than at any other time or section during the experiment.

Irish was again lowest in yield for most of the season and, in total, yielded much less than New Zealand or S.23. The yields of these latter cultivars were closely associated until July 25th, when the New Zealand growth rate dropped and S.23 went ahead.

The IN mixture had a higher yield than New Zealand, and of course Irish, at cut 1 and was as productive as New Zealand up till July 25th when, as hadalready been stated, the New Zealand growth slowed down. From then until the end of the season IN had an advantage over New Zealand. In contrast to this the IS combination showed no advantage over its higher yielding component, S.23, and was obviously being influenced by Irish. This resulted in a production curve which lay between those of its components.

Once again the NS mixture displayed a growth rate markedly higher than either New Zealand or S.23. The largest differences in rates occurred in the first half of the season and this carried the accumulated yield of NS well above New Zealand and S.23.

The INS growth form averaged those of New Zealand and S.23 throughout the whole season.

Section 3 The later first spring cut of this section completely altered the relative positions of the cultivar treatments except for Irish which occupied its now normal place, at the bottom of the list. The cutting sequence of section 3 in previous years had always resulted in an improved production from Irish but evidently, by the third year of the trial, its vigour was so reduced that it could not now respond to more favourable management. Conversely New Zealand, which in 1958 and 1959 had not shown the typical early flush characteristic of that cultivar outyielded all treatments at the first cut. It then underwent a period of reduced growth before picking up and growing nearly as well as the most productive treatments.

The management of this section obviously did not favour S.23 as its growth rate in June did not show its normal upswing. Later in the season it did increase slightly but the initial low production prevented its final yield from reaching the high yielding group.

The IN mixture was again similar in growth pattern to New Zealand and it paralleled the New Zealand curve, at a lower level, throughout the season. The IS mixture differed from previous years in that between May 19th and July 22nd its growth rate was much higher than S.23 and, of course, Irish. In the latter part of the season the rate of production from IS was similar to S.23. The NS mixture started the season in an intermediate position relative to its components but, by its rapid growth, moved up to rank next to New Zealand and, in final yield, just exceeded it. This continued the trend seen in 1959 when NS was more productive than its components. The combination of all 3 cultivars showed characteristics of both the New Zealand and S.23 growth curves in different periods of the season and, as a result, occupied an intermediate position.

Effect on Yield of Combining Cultivars

The yields of cultivar mixtures, relative to their components, are shown in figure 1.33 as percentage increases, or decreases, compared to either Irish, New Zealand or S.23 growing alone. As individual differences have already been examined (table 1.30) remarks are confined to outlining the general trends.

Yield of Mixtures Containing Irish Relative to Irish Growing Alone

In this third harvest year the yield of Irish growing alone was exceeded by all combinations of Irish with the other cultivars in all sections. The increases on total yield for the three years were least in section 3. It should be noted that the scale of the graphs showing Irish as zero is smaller than that used for the comparisons of New Zealand and S.23 growing alone.

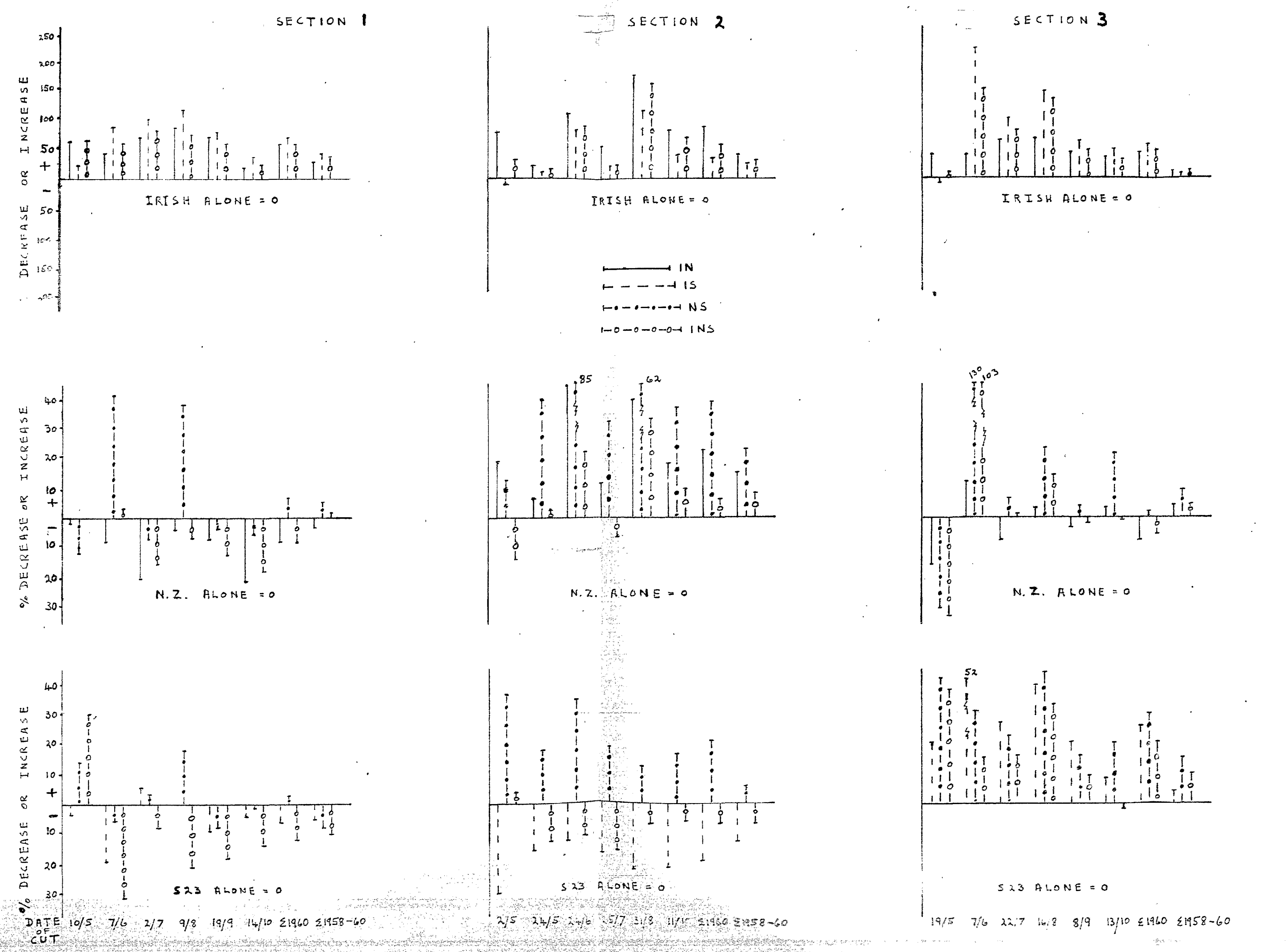
Yield of Mixtures Containing New Zealand Relative to New Zealand Growing Alone

In section 1 New Zealand was only substantially exceeded by NS on two occasions. Otherwise the mixtures tended to give a lower yield than New Zealand.

In section 2 large percentage increases were recorded especially from the NS mixture which was markedly higher producing than New Zealand in both the 1960 total and the total for the three harvest years.

In section 3 the effect of the later first cut was obvious and the yields of the mixtures were considerably lower than New Zealand at the first cut and then exceeded it at the second. Thereafter only the NS mixture consistently outyielded New Zealand.

Figure 1.33 Yields of cultivar mixtures relative to the components of the mixtures growing alone.


SECTION 1
SECTION 2
SECTION 3
DECREASE OR INCREASE
IRISH ALONE = 0
IN
IS
NS
INS
% DECREASE OR INCREASE
N.Z. ALONE = 0
85
62
130
103
S23 ALONE = 0
52
DATE OF CUT
10/5 7/6 2/7 9/8 19/9 14/10 Σ1960 Σ1958-60
2/5 24/5 24/6 25/7 31/8 11/10 Σ1960 Σ1958-60
19/5 7/6 22/7 16/8 8/9 13/10 Σ1960 Σ1958-60

Yield of Mixtures Containing S.23 Relative to S.23 Growing Alone

Apart from the first cut, when NS and INS exceeded S.23, the yields of the mixtures, in section 1, were, in general, lower than S.23. On the 1960 total only NS showed a very slight increase over S.23 growing alone and, on the 1958-60 total, all mixtures containing S.23 displayed lower yields than S.23 itself.

In section 2 the pattern was extremely interesting as the NS yield was markedly better than S.23 while IS and INS were just as markedly poorer. NS showed a substantial increase on the 1960 total and a lesser one on the 1958-60 total.

In section 3 S.23 was exceeded in yield by all mixtures and most noticably by NS.

Percentage Distribution of Seasonal Production

The seasonal production of the various treatments expressed as percentages of total yield are given in table 1.32.

Section 1 Irish and New Zealand gave nearly 25% of their total yield at the first cut and S.23 only 17%. The IN and INS combinations were similar to the early maturing cultivars but IS and NS showed the lower percentage associated with S.23. At the second cut the S.23 gave the highest percentage of total yield and in consequence the IS and NS treatments showed up slightly above the Irish or New Zealand figures.

The rest of the season showed little variation between cultivar treatments. The only difference of any note occurred at the cut on August 9th when the Irish, New Zealand, IN and INS mixtures were lower than S.23, IS and NS.

Section 2 This section displayed somewhat similar trends as were evident in section 1. At the first cut the only difference was in the NS mixture which was intermediate between the high and low figures for New Zealand and S.23 respectively. The higher bulk from S.23 did not occur until the third cut compared to the second cut in section 1 but by actual dates it can be seen that both of these cuts occurred in June. The only other noticable difference was at the late August cut when Irish and New Zealand were lower than all other treatments.

Section 3 The later first cut resulted in greatly increased percentages of total yield from Irish and New Zealand. S.23 and mixtures containing S.23 were only slightly increased. The second cut showed a complete reversal with S.23 and its mixtures giving the higher percentages. Over the remaining 4 cuts there were small but not consistent differences between treatments. As in 1958 and 1959 the greatest, and

Table 1.32 Percentage distribution of total yield during 1960.

Section 1.

Cultivar Combinations	Date of Cut 10/5	7/6	2/7	9/8	19/9	14/10
I	24	13	10	20	22	11
N	22	11	12	21	23	11
S	17	16	11	24	23	9
IN	24	11	11	22	23	9
IS	17	14	12	25	22	10
NS	18	14	11	27	21	9
INS	24	12	11	22	22	9

Section 2.

	2/5	24/5	24/6	25/7	31/8	11/10
I	24	15	13	20	11	17
N	25	13	13	18	14	17
S	18	12	16	18	18	18
IN	25	10	15	17	16	17
IS	17	13	17	19	17	17
NS	20	12	17	17	17	17
INS	21	12	15	16	18	18

Section 3.

	19/5	17/6	22/7	16/8	8/9	13/10
I	39	7	16	10	12	16
N	41	5	18	11	12	13
S	25	12	20	12	14	17
IN	37	6	18	12	12	15
IS	24	15	20	13	13	15
NS	28	12	19	13	12	16
INS	29	12	20	13	12	14

most important, changes in the distribution of yield resulted from changes in the date of the first cut, and not from varying the cultivar mixtures.

Actual Percentage, and Potential Percentage, Contribution to Yield by the Components of Cultivar Mixtures

Actual Contribution

Irish ryegrass

The percentage contribution to yield made by Irish ryegrass when growing with New Zealand and/or S.23 is shown in table 1.33 and figures 1.27, 1.28 and 1.29.

First cuts In combination with New Zealand or S.23 Irish averaged contributions of only 18 and 15% respectively. However, with New Zealand the contribution of 29% in section 3 was significantly greater than the 10% given in section 2. With S.23 the trend was for a higher percentage in section 2 but this was not significantly greater than the contribution in the other sections. With both New Zealand and S.23 present the contribution of Irish was similar in all sections and averaged 10%.

Second cuts The position here was not greatly different from the first cuts. The contribution with New Zealand rose slightly but fell to a corresponding degree with S.23 and New Zealand plus S.23. The highest contribution of 28% was again with New Zealand in section 3.

Third - Sixth cuts Over the remainder of the year the contribution of Irish varied little from cut to cut.

With New Zealand it ranged from an average of 20% to 16% but was always significantly higher in section 3 reaching a maximum of 32% at the fifth cut.

With S.23 the average varied between 7% and 9% and did not differ significantly between sections although it was always lowest in section 1.

Table 1.33 Percentage contribution to yield by Irish during 1960 and to total yield for 1958-59-60. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Cut	Section	Date	Irish With N.Z.	Irish With S.23	Irish With N.Z.+S.23	$\bar{x}$	Cut	Date	Irish With N.Z.	Irish With S.23	Irish With N.Z.+S.23	$\bar{x}$
1	1	10/5	14(20.8)	8(15.2)	10(17.2)	11	2	7/6	16	5	8	9
	2	2/5	10(17.2)	22(27.5)	10(18.0)	14		24/5	16	14	6	12
	3	19/5	29(32.2)	16(22.8)	9(12.0)	18		17/6	28	13	8	16
	$\bar{x}$		18(23.4)	15(21.8)	10(15.8)	14			20(25.4)	11(18.1)	7(14.9)	12
	L.S.D.	1=N.S. 2=6.1 3=10.6 4=14.2 C.V.=35.1%						1=N.S. 2=4.8 3&4=N.S. C.V.=28.6%				
3	1	2/7	14(20.0)	4(10.2)	6(12.8)	8	4	9/8	12(20.0)	3(9.8)	8(15.0)	8
	2	24/6	9(16.2)	8(16.0)	5(13.0)	8		25/7	12(19.5)	9(17.5)	7(14.8)	9
	3	22/7	30(33.0)	8(15.2)	8(15.8)	15		16/8	25(29.8)	8(15.8)	8(15.5)	14
	$\bar{x}$		18(23.1)	7(13.8)	6(13.8)	10			16(23.1)	7(14.3)	8(15.1)	10
	L.S.D.	1=N.S. 2=4.0 3=6.9 4=10.6 C.V.=27.6%						1=N.S. 2=3.6 3=6.3 4=9.4 C.V.=24.2%				
5	1	19/9	13(20.2)	4(10.8)	8(16.0)	8	6	14/10	13(20.8)	5(11.8)	8(14.8)	9
	2	31/8	14(20.2)	12(20.0)	6(14.4)	11		11/10	11(18.2)	11(18.8)	6(14.5)	10
	3	8/9	32(34.5)	11(17.0)	9(17.0)	17		13/10	25(31.8)	8(16.0)	8(15.2)	15
	$\bar{x}$		20(25.0)	9(15.9)	8(15.8)	12			16(23.6)	8(15.5)	7(14.8)	11
	L.S.D.	1=N.S. 2=4.8 3=8.4 4=10.4 C.V.=29.9%						1=N.S. 2=3.2 3=5.6 4=10.1 C.V.=20.8%				
Total for 1960	1		13(20.5)	4(11.8)	8(15.8)	8	Total for 1958-59-60		28	18	16	21
	2		12(19.0)	13(20.5)	7(15.0)	10			23	21	15	20
	3		28(31.5)	11(19.2)	8(16.2)	16			38	24	21	27
	$\bar{x}$		18(23.7)	10(17.2)	8(15.7)	12			30(32.6)	21(27.0)	17(24.3)	23
	L.S.D.	1=N.S. 2=3.6 3=6.3 4=9.2 C.V.=22.6%						1=N.S. 2=2.5 3&4=N.S. C.V.=10.5%				

With New Zealand plus S.23 the range was from 6% to 8% and was very consistent from section to section.

Total for 1960 The highest contribution of Irish was in section 3 when combined with New Zealand. On average S.23 had a greater depressive effect than New Zealand, but not in section 2. With all 3 cultivars together Irish averaged 8% and this was not affected by times of cutting.

Total for 1958-59-60 Irish contributed less when in combination with S.23 than with New Zealand. With both New Zealand and S.23 present Irish gave 17% of the combined yield. The effect of cutting sections was not significant but suggested that Irish was contributing more in section 3 especially when in association with New Zealand.

New Zealand ryegrass

The percentage contribution made to yield by New Zealand ryegrass when growing with Irish and/or S.23 is shown in table 1.34 and figures 1.27, 1.28 and 1.29.

First cuts New Zealand was the dominant partner with Irish averaging 83% of the yield but this was reduced to 72% at the latest cut on May 19th. In association with S.23 New Zealand held its own and produced 48% of the yield, which was not significantly influenced by cutting section. The compensating influence of the presence of both Irish and S.23 allowed New Zealand to contribute an average of 46% of the yield and although higher, at 58% in section 3 the difference was not significant.

Second - Sixth cuts The contribution with Irish remained fairly constant being always lower in section 3 but never falling below 68%.

With S.23 the contribution fell markedly from the first cut to range between an average of 28-30%. There were no consistent trends associated with the date of cutting.

Table 1.34 Percentage contribution to yield by New Zealand during 1960 and to total yield for 1958-59-60. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

			N.Z. With						N.Z. With			
Cut	Section	Date	Irish	S.23	Irish+S.23	$\bar{x}$	Cut	Date	Irish	S.23	Irish+S.23	$\bar{x}$
	1	10/5	86(69.2)	39(38.2)	40(38.5)	55		7/6	84	20	29	44
1	2	2/5	90(72.8)	54(47.2)	39(38.5)	60	2	24/5	84	44	29	53
	3	19/5	72(57.5)	52(46.0)	58(49.2)	60		17/6	72	19	25	39
	$\bar{x}$		83(66.5)	48(43.8)	46(42.1)	58			80(64.3)	28(30.8)	28(31.2)	45
	L.S.D.	1=N.S. 2=5.8 3=10.1 4=12.7 C.V.=13.4%						1=N.S. 2=7.2 3&4=N.S. C.V.=20.0%				
	1	2/7	86(69.5)	23(28.0)	26(29.8)	45		9/8	88(70.0)	26(30.5)	25(29.0)	46
3	2	24/6	91(73.8)	33(34.8)	22(28.0)	49	4	25/7	88(70.2)	34(35.2)	21(27.5)	48
	3	22/7	70(57.0)	35(35.5)	32(34.2)	46		16/8	75(60.0)	25(30.0)	32(34.0)	44
	$\bar{x}$		82(66.8)	30(32.8)	27(30.7)	47			84(66.8)	28(31.9)	26(30.2)	46
	L.S.D.	1=N.S. 2=5.9 3=10.3 4=12.3 C.V.=16.0%						1=N.S. 2=4.8 3=8.3 4=9.9 C.V.=13.0%				
	1	19/9	87(69.5)	25(29.5)	24(29.0)	45		14/10	87(69.0)	23(28.5)	27(31.0)	46
5	2	31/8	86(69.8)	33(34.8)	23(28.8)	47	6	11/10	89(71.5)	32(34.5)	23(29.0)	47
	3	8/9	68(55.5)	31(34.0)	32(34.2)	44		13/10	72(58.2)	28(32.8)	35(36.2)	45
	$\bar{x}$		80(64.9)	30(32.8)	23(30.7)	45			83(66.2)	28(31.6)	28(32.1)	46
	L.S.D.	1=N.S. 2=4.4 3=7.7 4=11.5 C.V.=12.1%						1=N.S. 2=4.0 3=7.0 4=10.8 C.V.=10.8%				
Total	1		87(69.5)	27(31.0)	29(32.0)	48	Total		72(58.2)	35(35.8)	27(30.5)	45
for	2		88(70.8)	38(37.5)	26(30.8)	51	for		77(61.2)	45(41.8)	28(31.5)	50
1960	3		72(58.2)	33(35.0)	39(38.5)	48	1958-		62(52.2)	38(37.8)	34(35.2)	45
	$\bar{x}$		82(66.2)	32(34.5)	32(33.8)	49	59-60		70(57.2)	39(38.4)	29(32.4)	46
	L.S.D.	1=N.S. 2=4.4 3=7.6 4=10.6 C.V.=11.4%						1=N.S. 2=3.5 3=6.1 4=9.8 C.V.=9.6%				

The contribution with Irish plus S.23 followed the same lines as with S.23 alone and averaged between 23 and 28%.

Total for 1960 As was evident at the individual cuts New Zealand with Irish gave the bulk of the yield (82%) and only in section 3 was there a significant reduction to 72%. With S.23 the New Zealand was suppressed and gave 32% of the yield. In combination with both Irish and S.23 New Zealand also contributed 32%.

Total for 1958-59-60 Over the 3 years New Zealand with Irish gave over 70% of the combined yield in sections 1 and 2 but in section 3 this fell to 62%. S.23 depressed the contribution of New Zealand to a mean of 39% and within the sections the percentages were not significantly different. With all 3 cultivars together New Zealand contributed, on average, 29% of the yield.

S.23 ryegrass

The percentage contribution to total yield made by S.23 ryegrass when growing with Irish and/or New Zealand is shown in table 1.35 and figures 1.27, 1.28 and 1.29.

First cuts S.23 dominated the IS mixture and produced 85% of the yield. This varied (non-significantly) from 92% in section 1 to 78% in section 2. With New Zealand the S.23 was held to an average of 52% but, as when combined with Irish, it was highest at 61% in section 1. In the INS mixture S.23 was the highest contributer in the sections 1 and 2 when it produced 50% of the yield but, in section 3, this fell to 33%.

Second cuts The percentage contributions of S.23 increased in all treatments and was most marked with New Zealand and New Zealand plus Irish. With Irish the highest contribution of 95% was again in section 1 but, with New Zealand, the percentages in sections 1 and 3 were similar

Table 1.35 Percentage contribution to yield by S.23 during 1960 and to total yield for 1958-59-60. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Cut	Section	Date	Irish	Irish With N.Z.	Irish With Irish+N.Z.	$\bar{x}$	Cut	Date	Irish	Irish With N.Z.	Irish With Irish+N.Z.	$\bar{x}$
	1	10/5	92	61	50	68		7/6	95	80	63	80(64.8)
1	2	2/5	78	46	50	58	2	24/5	86	56	64	69(56.9)
	3	19/5	84	48	33	55		17/6	87	81	67	78(63.2)
	$\bar{x}$		85(67.7)	52(46.0)	44(41.6)	60			89(71.8)	72(59.2)	65(54.0)	76
	L.S.D.	1=N.S.	2=7.3	3&4=N.S.	C.V.=16.4%			1=5.6	2=6.6	3&4=N.S.	C.V.=12.4%	
	1	2/7	96	77	68	81		9/8	97	74	68	89
3	2	24/6	92	67	73	74	4	25/7	90	66	72	88
	3	22/7	95	65	60	73		16/8	92	72	61	76
	$\bar{x}$		94(75.9)	70(57.0)	67(55.1)	76			93(75.7)	71(57.5)	67(54.9)	84
	L.S.D.	1=N.S.	2=5.9	3&4=N.S.	C.V.=11.0%			1=N.S.	2=5.1	3&4=N.S.	C.V.=9.5%	
	1	19/9	96	75	67	80		14/10	95	77	65	79
5	2	31/8	88	67	70	75	6	11/10	89	68	70	76
	3	8/9	89	68	59	72		13/10	92	72	57	74
	$\bar{x}$		91(74.0)	70(57.2)	65(54.7)	76			92(74.5)	72(58.4)	64(53.3)	76
	L.S.D.	1=N.S.	2=5.1	3&4=N.S.	C.V.=9.6%			1=N.S.	2=5.0	3&4=N.S.	C.V.=9.4%	
Total	1		96	72	63	77	Total		82	65	57	68
for	2		87	62	66	72	for		79	55	57	64
1960	3		89	67	53	70	1958-		76	62	46	61
	$\bar{x}$		90(72.7)	68(55.5)	61(51.4)	73	59-60		79(63.0)	61(51.4)	53(46.8)	64
	L.S.D.	1=N.S.	2=5.1	3&4=N.S.	C.V.=10.0%			1=N.S.	2=4.3	3&4=N.S.	C.V.=9.3%	

and higher than that in section 2. When all 3 cultivars were together the cutting section effect was very small.

Third - Sixth cuts There was little change in the S.23 contributions during the remainder of the year. With Irish, S.23 gave over 90% of the yield and between 70 - 72% with New Zealand. In both associations the contribution of S.23 tended to be higher in section 1. In combination with both cultivars the percentage varied from 64 - 67% and cutting sections did not exert any marked or significant influence.

Total for 1960 As percentages of the annual total S.23 had completely dominated its Irish partner with a mean contribution of 90% and had averaged 68% of the combined yield when in association with New Zealand. It was also dominant at 61% in the INS treatment.

Total for 1958-59-60 The effect of the early years of the trial was seen in the rather lower percentage of 79% for S.23 with Irish compared to the 90% in the 1960 total. With New Zealand, however, there was only a difference of 7% between the 3 year's and the 1960 total. With Irish plus New Zealand the S.23 still appeared as the dominant cultivar as it produced 53% of the combined yield.

Potential Contribution

In order to allow a precise measurement to be made of the effects of competition, tables 1.36, 1.37 and 1.38 were constructed, in a similar manner to tables 1.7, 1.8 and 1.9, from the yield data presented in table 1.30.

Irish ryegrass

Table 1.36 gives the data on the combinations of Irish with the other Cultivars.

Table 1.36 Potential percentage contribution of Irish ryegrass to yield during 1960 related to yield of Irish growing alone and assuming no competition between cultivars. The deviations of actual contribution (table 1.33) from potential are given alongside each result and, in parenthesis, the deviations are expressed as a percentage of potential.

Cut	Section	Date	Irish With N.Z.	Irish With S.23	Irish With N.Z.+S.23	$\bar{x}$	Cut	Date	Irish With N.Z.	Irish With S.23	Irish With N.Z.+S.23	$\bar{x}$
1	1	10/5	38-24(63)	45-37(82)	26-16(62)	36-25(69)	2	7/6	40-24(60)	30-25(83)	21-13(62)	30-21(70)
	2	2/5	40-30(75)	44-22(50)	26-16(62)	37-23(62)		24/5	47-31(66)	43-29(67)	29-23(79)	40-28(70)
	3	19/5	38 -9(24)	55-39(71)	29-20(69)	41-23(56)		17/6	45-17(38)	32-19(59)	23-15(65)	33-17(52)
	$\bar{x}$		38-20(53)	49-34(69)	28-18(64)	38-24(63)			44-24(54)	35-24(68)	24-17(71)	34-22(65)
3	1	2/7	32-18(56)	35-31(88)	20-14(70)	29-21(72)	4	9/8	35-23(66)	32-29(91)	20-12(60)	29-21(72)
	2	24/6	40-31(78)	33-25(76)	22-17(77)	32-24(75)		25/7	42-30(71)	40-31(78)	26-19(73)	36-27(75)
	3	22/7	36 -6(17)	39-31(79)	23-15(65)	33-18(54)		16/8	38-13(34)	42-34(81)	25-17(68)	35-21(60)
	$\bar{x}$		36-18(50)	36-29(80)	22-16(73)	31-21(68)			39-23(59)	37-30(81)	23-15(65)	33-23(70)
5	1	19/9	32-19(59)	34-30(88)	21-13(62)	29-21(72)	6	14/10	40-27(68)	41-36(88)	26-18(69)	36-27(75)
	2	31/8	34-20(59)	26-14(54)	17-11(65)	26-15(58)		11/10	40-29(72)	37-26(70)	24-18(75)	34-24(70)
	3	8/9	40-8 (20)	43-32(74)	26-17(65)	36-19(53)		13/10	43-18(42)	43-35(81)	27-19(70)	38-23(60)
	$\bar{x}$		37-17(46)	34-25(74)	21-13(62)	31-19(61)			42-26(62)	40-32(80)	26-19(73)	36-25(69)
Total for 1960	1		37-24(65)	36-32(89)	22-14(64)	32-24(75)	Total for 1958-59-60		43-15(35)	40-22(55)	26-10(38)	36-15(42)
	2		41-29(71)	38-25(66)	24-17(71)	34-24(70)			45-22(49)	41-20(49)	28-13(46)	38-18(47)
	3		39-11(28)	45-34(76)	26-18(69)	37-21(57)			49-11(22)	50-26(52)	33-12(36)	44-17(39)
	$\bar{x}$		39-21(54)	39-29(74)	24-16(67)	34-22(65)			46-16(35)	44-23(52)	29-12(41)	40-17(42)

First cuts The potential contribution of Irish with New Zealand was similar in all sections but, the degree of its suppression, was noticably less in section 3 where it amounted to only 24% of potential compared to 63% and 75% in sections 1 and 2 respectively.

In association with S.23 the Irish contribution was, on average, more severely suppressed and, was greatest at 82%, in section 1. In contrast to the effect with New Zealand, Irish with S.23 was least affected in section 2 where it contributed 50% less than its potential.

In combination with both New Zealand and S.23 the mean depression of Irish was 64% of potential and was not markedly changed by the varying dates of cutting.

Second cuts The suppression due to New Zealand was again least in section 3 and averaged 54% over all sections. This was also true in combination with S.23, where the average was 68%, and ranged from 83% in section 1 through 67% in section 2 to 59% in section 3.

In the INS mixture Irish averaged a depression of 71%, a similar amount to that resulting from the presence of S.23.

Third cuts New Zealand continued its suppressive influence on Irish and, as before, this was least in section 3. S.23 on the other hand increased in aggressiveness towards Irish and further reduced the contribution of the latter compared to potential by an average of 80%. The management of section 1 caused the greatest suppression of Irish. In association with both New Zealand and S.23 the suppression of Irish was intermediate to the effects of either separately and was not affected by cutting section.

Fourth cuts The results for these cuts were very similar to the previous ones and the same general pattern was maintained.

Fifth cuts At this period the dominating influence of New Zealand was rather less, and, was chiefly confined to sections 1 and 2 where it caused a 59% reduction in Irish contribution compared to only 20% in section 3. The suppression due to S.23 was also, on average, slightly down but in section 1 remained high at 89%. The suppression due to the combination of all 3 cultivars was also slightly down but still averaged 62% which, it will be noted, was greater than the effect of New Zealand.

Sixth cuts The suppressive influence of New Zealand was higher than in the fifth cuts. With S.23, in section 1, the greatest reduction of Irish contribution again took place and, on average, S.23 was still the most aggressive cultivar. The effect of both competing cultivars together on Irish was intermediate to either alone.

Total for 1960 The Irish contribution to total yield was seriously reduced by a mean of 54% when associated with New Zealand but was still further reduced ~~to~~ by 74% of its potential by S.23. With both New Zealand and S.23 present the reduction was 67%.

Interaction with cutting sections was again noticable, the New Zealand effect ranging from 28% in section 3 to 71% in section 2. With S.23 the greatest reduction was 89% in section 1 and least, at 66%, in section 2.

Total for 1958-59-60 On the total of the three years of the experiment, Irish was suppressed by an average of:-

(a) 35% by New Zealand,

(b) 52% by S.23, and

(c) 41% by New Zealand in association with S.23.

Within sections, the most marked effect of management was the relatively low suppression of 22% in section 3 (i.e. in combination with New Zealand). The effects of S.23 or New Zealand and S.23 did not vary greatly over the sections.

New Zealand ryegrass

Table 1.37 shows the effects of inter-cultivar competition on the contribution to yield of New Zealand. On average New Zealand appeared to be little affected by competition because what it gained in association with Irish it lost with S.23.

First cuts As the date of taking the first cut advanced the percentage increase of New Zealand in association with Irish fell. With S.23, New Zealand itself was suppressed, especially in sections 1 and 3. In section 2, which was the first to be cut in spring, the suppression was only 2%. With both Irish and S.23 present New Zealand was slightly suppressed in sections 1 and 2, but made a gain of 21% in section 3.

Second cuts New Zealand increased at the expense of Irish but was more severely suppressed by S.23. Again these results were modified by cutting section as, with Irish, a noticably smaller gain was made in section 3 and, with S.23, the depression in section 2 was only 4%. In contrast to the first cuts New Zealand was slightly suppressed by Irish plus S.23 in all sections.

Third cuts The average gain in the presence of Irish had fallen to 28% mainly due to the low figure of 9% recorded in section 3. With S.23, the suppression of New Zealand continued to increase but was still lowest in section 2. Similarly with all 3 cultivars together the suppression of New Zealand increased but, in this case, was least in section 3.

Table 1.37 Potential percentage contribution of N.Z. ryegrass to yield during 1960 and to the 1958-59-60 total related to yield of N.Z. growing alone and assuming no competition between cultivars. The deviations of actual contribution (table 1.34) from potential are given alongside each result and, in parenthesis, the deviations expressed as a percentage of potential.

			N.Z. With						N.Z. With			
Cut	Section	Date	Irish	S.23	Irish+S.23	x̄	Cut	Date	Irish	S.23	Irish+S.23	x̄
1	1	10/5	62+24(39)	56-17(30)	42 -2(5)	53 +2(4)	2	7/6	60+24(40)	40-20(50)	32 -3(9)	44 0(-)
	2	2/5	60+30(50)	55 -1(2)	40 -1(2)	52 +8(15)		24/5	53+31(58)	46 -2(4)	33 -4(12)	44 +9(20)
	3	19/5	62+10(16)	67-15(22)	48+10(21)	59 +1(2)		17/6	55+17(31)	36-17(47)	28 -3(11)	40 -1(2)
	x̄		62+21(34)	61-13(21)	44 +2(4)	56 +2(4)			56+24(43)	41-13(32)	31 -3(10)	43 +2(5)
3	1	2/7	68+18(26)	52-29(56)	42-16(38)	54 -9(17)	4	9/8	65+23(35)	46-20(43)	37-12(32)	49 -3(6)
	2	24/6	60+31(52)	42 -9(21)	33-11(33)	45 +4(9)		25/7	58+30(52)	47-13(28)	35-14(40)	47 +1(2)
	3	22/7	64 +6(9)	53-18(34)	41-9 (22)	53 -7(13)		16/8	62+13(21)	54-29(54)	40 -8(20)	52 -8(15)
	x̄		64+18(28)	49-19(39)	38-11(29)	50 -3(6)			61+23(38)	48-20(42)	37-11(30)	49 -3(6)
5	1	19/9	68+19(28)	49-24(49)	38-14(37)	52 -7(13)	6	14/10	60+27(45)	51-28(55)	38-11(29)	50 -4(8)
	2	31/8	66+20(30)	41 -8(20)	34-11(32)	47 0(-)		11/10	60+29(48)	46-14(30)	35-12(34)	47 0(-)
	3	8/9	60 +8(13)	52-21(40)	39 -7(18)	50 -6(12)		13/10	57+15(26)	50-22(44)	36 -1(3)	48 -3(6)
	x̄		63+17(27)	47-17(36)	37-14(38)	49 -4(8)			58+25(43)	48-20(42)	36 -8(22)	47 -1(2)
Total for 1960	1		63+24(38)	49-22(45)	38 -9(24)	50 -2(4)	Total for 1958-59-60		57+15(26)	47-12(26)	34 -7(20)	46 -1(2)
	2		59+29(49)	47 -9(19)	35 -9(26)	47 -4(8)			55+22(40)	46 -1(2)	34 -6(18)	45 +5(11)
	3		61+11(18)	56-23(41)	41 -2(5)	53 -5(9)			51+11(22)	51-13(25)	34 0(-)	45 0(-)
	x̄		61+21(34)	51-19(37)	38 -6(16)	50 -1(2)			54+16(30)	48 -9(19)	34 -5(15)	45 +1(2)

Fourth cuts The gain of New Zealand over Irish was back again to nearly the same level recorded at the second cuts with the same tendency for a lower figure in section 3. On average the effect of S.23 had not altered and was still depressing New Zealand by 42%. The combination of all 3 cultivars was also similar to its effect at cut 3 with the smallest suppression occurring in section 3.

Fifth and sixth cuts The increase of New Zealand over its potential when in combination with Irish averaged 27% in the fifth, and 43% in the sixth cut. This pattern is similar to that of the third and fourth cuts when the New Zealand increase was 28% and 38% respectively. In both the fifth and sixth cuts the percentage was lowest in section 3.

In association with S.23 New Zealand was suppressed by 36% and 42% respectively in the last 2 cuts with the smallest suppressions of 20% and 30% in section 2.

With both Irish and S.23 present the average suppression of New Zealand was smaller at the sixth cut where, in section 3, it was only 3%.

Total for 1960 On the annual total New Zealand increased in the presence of Irish to almost the same extent as it was suppressed by S.23, while with both present the influence of S.23 was the stronger and New Zealand was suppressed by 16%. The same trends as were recorded at each cut, namely a smaller gain with Irish in section 3, and a smaller suppression with S.23 in section 2, were again evident.

Total for 1958-59-60 The same general statements were true for the grand total as for the 1960 total with the additional points of interest that, in competition with Irish plus S.23, no gain or loss was evident in section 3 and the suppression due to S.23 was only half of what it had been in 1960.

S.23 ryegrass

Table 1.38 gives the percentage increases in S.23 contribution due to its combinations with the other cultivars. In all cuts and sections S.23 gained by its association and the only influence of the different combinations was on the degree of this gain. As most of the detail of these inter-cultivar relationships have been mentioned when presenting the results for Irish and New Zealand only aspects not already covered and some general points of interest will be referred to.

First - sixth cuts Irish was, on average, most severely suppressed in the first cut although, as in 1959, this did not coincide with the greatest actual contribution to yield by S.23. Over the rest of the year S.23 made gains, at the expense of Irish, amounting to 37%, 47%, 48%, 38% and 53% for the second to sixth cuts respectively. The percentages within cutting sections did vary, but not in any consistent manner.

The increase in the presence of New Zealand was less than with Irish and was fairly constant over all cuts and ranged from 22% at the second cuts to 38% at the sixth cuts. The interesting fact was, however, the much lower gain always recorded in section 2.

The increased contribution of S.23 in association with both New Zealand and Irish was, from the second cuts onwards, greater than those achieved with either singly, and reached an average maximum of 68% in the third, fourth and sixth cuts. The effects of cutting section were noticable but not consistent.

Total for 1960 S.23 made the greatest increase over its potential when in combination with both Irish and New Zealand. Irish came next in order of suppression and New Zealand last. Apart from the INS mixture, S.23 made smaller gains in section 2, especially in combination with New Zealand.

Table 1.38 Potential percentage contribution of S.23 ryegrass to yield during 1960 and to the 1958-59-60 total related to yield of S.23 growing alone and assuming no competition between cultivars. The deviations of actual contribution (table 1.35) from potential are given alongside each result and, in parenthesis, the deviations expressed as a percentage of potential.

			S.23 With						S.23 With			
Cut	Section	Date	Irish	N.Z.	Irish+N.Z.	$\bar{x}$	Cut	Date	Irish	N.Z.	Irish+N.Z.	$\bar{x}$
	1	10/5	55±37(67)	44±17(39)	32±18(56)	44±24(54)		7/6	70±25(36)	60±20(33)	47±16(34)	59±21(36)
1	2	2/5	56±22(39)	45 ±1(2)	34±16(47)	45±13(29)	2	24/5	57±29(51)	54 ±2(4)	38±26(68)	50±19(38)
	3	19/5	45±39(87)	33±15(45)	23±10(43)	34±21(62)		17/6	68±19(28)	64±17(26)	49±18(37)	60±18(30)
	$\bar{x}$		51±34(67)	39±13(33)	28±16(57)	39±21(54)			65±24(37)	59±13(22)	45±20(44)	56±20(36)
	1	2/7	65±31(48)	48±29(60)	38±30(79)	50±31(62)		9/8	68±29(43)	54±20(37)	43±25(58)	55±34(62)
3	2	24/6	67±25(37)	58 ±9(16)	45±28(62)	57±17(30)	4	25/7	60±30(50)	53±13(24)	39±33(85)	51±37(72)
	3	22/7	61±34(56)	47±18(38)	36±24(67)	48±25(52)		16/8	58±34(59)	46±26(56)	35±26(74)	46±30(65)
	$\bar{x}$		64±30(47)	51±19(37)	40±27(68)	52±24(46)			63±30(48)	52±19(36)	40±27(68)	52±32(62)
	1	19/9	66±30(45)	51±24(47)	41±26(63)	53±27(51)		14/10	59±36(61)	49±28(57)	36±29(80)	48±31(64)
5	2	31/8	74±14(19)	59 ±8(14)	49±21(43)	61±14(23)	6	11/10	63±26(41)	54±14(26)	41±29(71)	53±23(43)
	3	8/9	57±32(56)	48±20(42)	35±24(68)	47±25(53)		13/10	57±35(61)	50±22(44)	37±20(54)	48±26(54)
	$\bar{x}$		66±25(38)	53±17(32)	42±23(55)	54±22(41)			60±32(53)	52±20(38)	38±26(68)	50±26(52)
Total	1		64±32(50)	51±21(41)	40±23(58)	52±25(48)	Total		60±22(37)	53±12(23)	40±17(42)	51±17(33)
for	2		62±25(40)	53±9 (17)	41±25(61)	52±20(38)	for		59±20(34)	54 ±1(2)	38±19(50)	50±14(28)
1960	3		55±34(62)	44±23(52)	33±20(61)	44±26(59)	1958-		50±26(52)	49±13(26)	33±13(39)	44±17(39)
	$\bar{x}$		61±29(48)	49±19(39)	38±23(60)	49±24(49)	59-60		56±23(41)	52 ±9(17)	37±16(43)	48±16(33)

<u>Total for 1958-59-60</u> In the three year's total the pattern was the same except that the difference between the percentage increases of S.23 with Irish and Irish plus New Zealand was less (2%) compared to 12% on the 1960 total.

Plant and Tiller Numbers

Plant Survival

The survival of each cultivar in the spring and autumn of the 3rd harvest year is given in table 1.39.

Irish ryegrass The percentage survival of Irish was markedly reduced by its partnering cultivar. By itself 55% and 53% of the Irish plants had survived in the spring and autumn respectively. This was reduced to 43% and 40% in the presence of New Zealand and to 30% and 23% with S.23. When both New Zealand and S.23 were present the survival of Irish was 45% and 40%. There was a slight, but not significant, increase in survival between sections 1 and 3.

New Zealand ryegrass The survival of New Zealand ryegrass was greatest, at 77%, when in association with Irish. With S.23 the percentage of 54 was similar to New Zealand growing alone while in combination with both of the other cultivars it was slightly, but not significantly, higher. The variation between sections was small and not consistent.

S.23 ryegrass There were no significant differences between the survival percentages of S.23 in the spring but in all cases more S.23 plants had survived when combined with Irish and/or New Zealand than when S.23 was alone. In November the 78% survival in association with Irish was significantly higher than the 64% recorded for S.23 alone. In combination with New Zealand or New Zealand plus Irish the S.23 survival was higher than that cultivar by itself but the increases were not significant.

Comparing the figures for the cultivars growing alone it can be seen that there was little difference between Irish and New Zealand while S.23 was about 10% higher.

Table 1.39 Percentage survival in May and November 1960. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

May 1960

Irish ryegrass

Section	Alone	With N.Z.	With S.23	With N.Z.+S.23	$\bar{x}$	L.S.D.
1	54	36	17	42	37	1=N.S.
2	55	38	34	48	43	2=5
3	58	57	36	44	49	3,4=N.S.
x	55(48)	43(41)	30(32)	45(42)	43	C.V.=19.4%

N.Z. ryegrass

Section	Alone	With Irish	With S.23	With Irish+S.23	$\bar{x}$	
						1=N.S.
1	56	80	48	54	60	2=6
2	57	66	61	60	61	3,4=N.S.
3	58	70	53	71	63	C.V.=13.8%
x	57(49)	72(59)	54(48)	62(53)	61	

S.23 ryegrass

Section	Alone	With Irish	With N.Z.	With Irish+N.Z.	$\bar{x}$	
						1,2,3,4=N.S.
1	62	77	73	83	74	
2	72	78	75	77	76	C.V.=15.0%
3	61	77	63	81	71	
x	65	77	71	81	73	

November 1960

Irish ryegrass

Section	Alone	With N.Z.	With S.23	With N.Z.+S.23	$\bar{x}$	L.S.D.
1	52	32	14	42	35(36)	1=4
2	53	33	24	40	37(37)	2=6
3	53	54	30	38	44(41)	3,4=N.S.
x	53(47)	40(39)	23(28)	40(39)	39	C.V.=18.0%

N.Z. ryegrass

Section	Alone	With Irish	With S.23	With Irish+S.23	$\bar{x}$	
						1=N.S.
1	53	73	47	48	55	2=5
2	60	68	58	58	61	3,4=N.S.
3	55	68	42	66	58	C.V.=12.2%
x	56(48)	70(57)	49(44)	58(59)	58	

S.23 ryegrass

Section	Alone	With Irish	With N.Z.	With Irish+N.Z.	$\bar{x}$	
						1=N.S.
1	58	76	73	79	72	2=7
2	68	78	74	73	73	3,4=N.S.
3	64	82	69	67	70	C.V.=13.6%
x	64(53)	78(63)	72(58)	73(59)	72	

Mean tiller numbers per plant

The mean tiller numbers per plant at the end of the third harvest year are given in table 1.40.

Irish ryegrass In the presence of S.23 and S.23 plus New Zealand the tillers per plant of Irish were halved compared to Irish alone. The competitive effect of New Zealand was not so great but still caused a marked reduction in Irish tillers. Differences between sections were not significant but did show a trend towards higher tiller numbers in section 3.

New Zealand ryegrass New Zealand plants had more tillers when growing with Irish and fewer with S.23 than when growing alone. With both Irish and S.23 there was a compensating effect giving an intermediate result.

S.23 ryegrass The effect of companion cultivars on the tiller production of S.23 varied between sections. In section 1 the combination with Irish resulted in an increase in S.23 tillers to 87 per plant compared to 61 when growing alone. With New Zealand the number was 72 and, with both Irish and New Zealand present, the result was almost the same as for S.23 alone. In section 2, on the other hand, there was no increase in association with Irish but a marked increase with New Zealand and Irish plus New Zealand. Section 3 was different again, in that there was an increase with Irish and Irish plus New Zealand but a smaller and non-significant increase with New Zealand.

Considering the average figures for the cultivars growing alone it appeared that Irish and New Zealand had similar tiller development while S.23 had 7-8 more tillers per plant.

Table 1.40 Mean tiller number per plant at November 1960.

Irish ryegrass

Section	Alone	With N.Z.	With S.23	With NZ+S.23	$\bar{x}$	L.S.D.
1	52	28	16	18	28	1=N.S.
2	50	25	23	22	30	2=10
3	56	43	38	30	42	3,4=N.S.
x	53	32	26	23	33	C.V.=36.0%

N.Z. ryegrass

	Alone	With Irish	With S.23	With Irish+S.23	$\bar{x}$	
						1=N.S.
1	55	61	29	41	46	2=12
2	49	80	29	45	51	3,4=N.S.
3	59	57	51	49	54	C.V.=29.7%
x	54	66	36	45	50	

S.23 ryegrass

	Alone	With Irish	With N.Z.	With Irish+NZ	$\bar{x}$	
						1=N.S.
1	61	87	72	62	70	2=15
2	53	54	87	88	71	3=25
3	68	89	73	97	82	4=26
x	61	77	77	82	74	C.V.=23.7%

Tillers Per Unit Area

Table 1.41 and figure 1.34 give the total tillers per sq. ft. for each treatment. The differences between cultivar treatments were not significant but the management of section 3 resulted in increased tillers per unit area for all combinations except IN and NS. Averaged over all sections Irish alone had the fewest tillers and S.23 alone and mixtures containing S.23 noticably more tillers than the other cultivar treatments.

Table 1.41 Total tillers per sq. ft. at November 1960.

Section	Cultivar Treatments								
	I	N	S	IN	IS	NS	INS	$\bar{x}$	L.S.D.
1	945	1050	1322	985	1258	1175	928	1095	1=148
2	940	1048	1272	1138	852	1470	1202	1132	2,3,4=N.S.
3	1075	1160	1580	1112	1502	1282	1300	1288	C.V.=30.2%
x	987	1086	1392	1078	1204	1309	1143	1171	

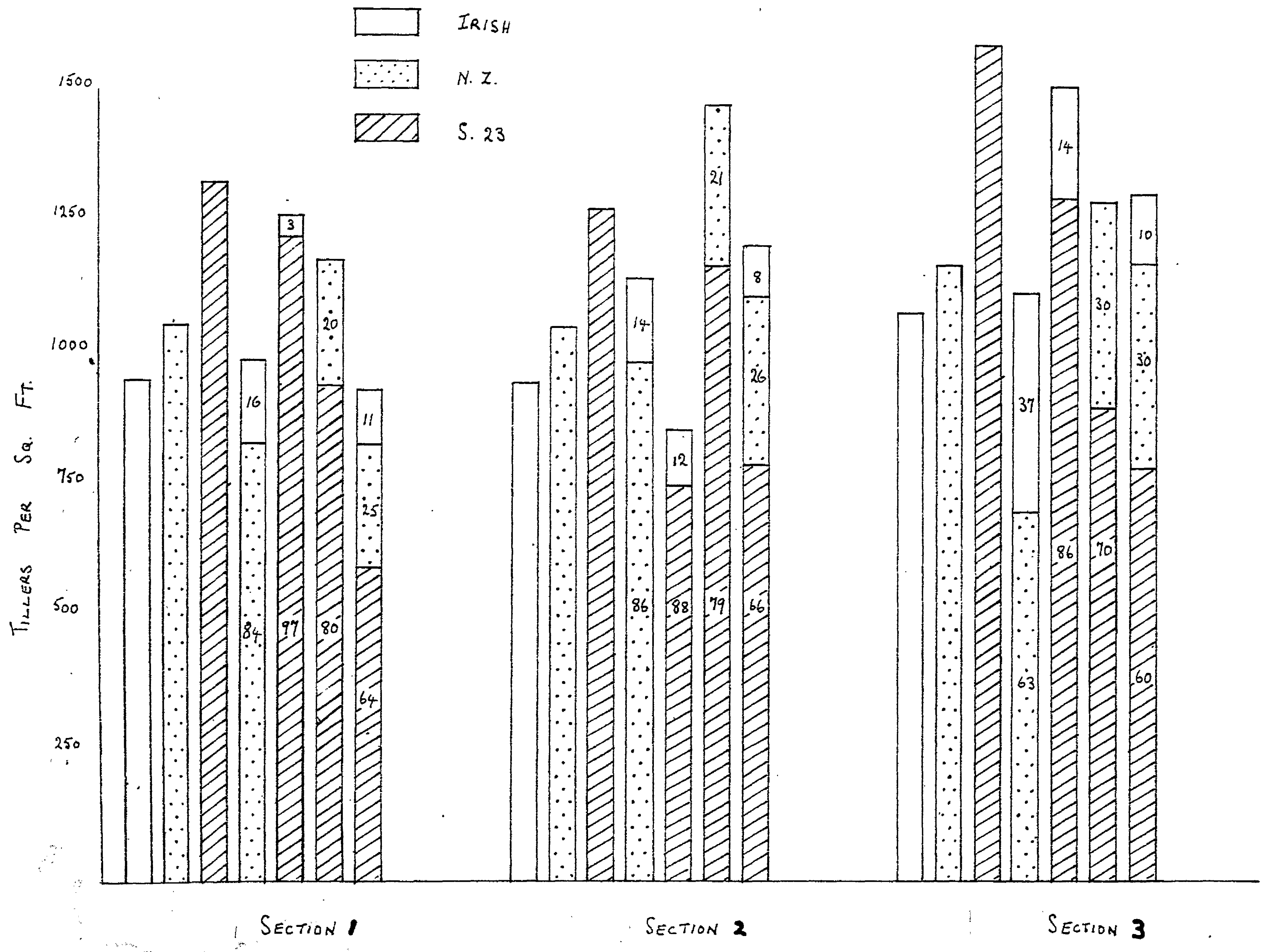


Figure 1.34 Tiller production per sq. ft. and contribution of the components of the mixtures at November 1960.

Actual Percentage, and Potential Percentage, Contribution to Tiller Production by the Components of Cultivar Mixtures

Actual Contribution

The percentages of the tillers produced per sq. ft. by the components of the various mixtures are shown in table 1.42 and figure 1.34.

Irish ryegrass The contribution of Irish had fallen to 14% averaged over all treatments. The average effect of New Zealand was reflected in a value of 22% compared to 10% with S.23. There were, however, considerable differences between the sections as in the sections 1 and 3 the contribution with S.23 was less than with New Zealand, whereas in section 2 both effects were equal. Also, the contribution of Irish with New Zealand was considerably higher in section 3 than in either of the other sections. The influence of New Zealand plus S.23 was similar in all sections and Irish averaged a 10% contribution in this association.

New Zealand ryegrass The results for the contribution of New Zealand showed that it produced only one third of the tillers in conjunction with S.23 than it did when partnered by Irish. With both Irish and S.23 present New Zealand produced 27% of the tillers. These results were modified to the extent that, with Irish in section 3, the contribution of New Zealand was reduced to 63% compared to 84% and 86% in the other sections. With S.23 there was a higher contribution in section 3.

S.23 ryegrass The contribution made by S.23 to tiller production was unaffected by cutting management but was higher (90%) with Irish than with New Zealand (76%). The figure of 63% obtained when both Irish and New Zealand were present showed that S.23 was also dominating that mixture.

Table 1.42 Percentage of total tillers per sq. ft. contributed by the components of the mixtures at November 1960. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Irish With

Section	N.Z.	S.23	N.Z.+S.23	$\bar{x}$	L.S.D.
1	16(23)	3(10)	11(18)	10	1=N.S.
2	14(21)	12(20)	8(16)	12	2=4
3	37(37)	14(22)	10(18)	20	3=7
$\bar{x}$	22(27)	10(17)	10(18)	14	4=10
					C.V.=22.9%

N.Z. With

	Irish	S.23	Irish+S.23	$\bar{x}$	
1	84(67)	20(26)	25(30)	43	1=N.S.
2	86(69)	21(27)	26(30)	45	2=4
3	63(53)	30(33)	30(33)	41	3=7
					4=10
$\bar{x}$	78(63)	24(29)	27(31)	43	C.V.=11.7%

S.23 With

	Irish	N.Z.	Irish+N.Z.	$\bar{x}$	
1	97	80	64	80	1=N.S.
2	88	79	65 66	77	2=5
3	86	70	59 60	72	3,4=N.S.
$\bar{x}$	90(73)	76(61)	63(53)	76	C.V.=9.8%

Potential Contribution

In table 1.43 the potential, or hypothetical, contributions of the components of cultivar mixtures are given. This table was constructed, in a similar manner, to table 1.15, from the data in table 1.41 which gives the tiller production of the cultivars growing alone.

Irish ryegrass The presence of New Zealand suppressed the Irish tiller contribution by an average of 54% but the effect varied with sections and was 66, 70 and 23% in sections 1, 2 and 3 respectively. The suppression due to S.23 was higher, on average, but was similar to the New Zealand effect in section 2. In section 1 the extremely high reduction of 93% was recorded but, in section 3, Irish did relatively better and was only suppressed by 65% of its potential.

The suppressive effect of both New Zealand and S.23 together gave a result intermediate to either separately, which did not vary greatly between sections and averaged 64%.

New Zealand ryegrass New Zealand contribution was suppressed by S.23 to almost the same degree as it increased in the presence of Irish. In both associations the smallest decrease or increase occurred in section 3. With all 3 cultivars present the aggressive influence of S.23 dominated, and New Zealand was suppressed by 22% and 19% in sections 1 and 2 respectively. In section 3, the effects balanced, and the New Zealand contribution was the same as its potential.

S.23 ryegrass S.23 dominated all associations but always to a lesser extent in section 3. On average, S.23 increased its contribution by 52 and 36% with Irish and New Zealand respectively. In combination with both cultivars 54% was averaged.

Table 1.43 Potential percentage contribution of cultivars to total tiller production in 1960 related to tiller production of cultivars growing alone and assuming no competition between them. The deviations, of actual contributions (table 1.42), from potential are given alongside each result and, in parenthesis, the deviations expressed as a percentage of potential.

Irish With

Section	N.Z.	S.23	N.Z.+S.23	$\bar{x}$
1	47-31(66)	42-39(93)	28-17(61)	39-29(74)
2	47-33(70)	42-30(71)	29-21(72)	39-27(69)
3	48-11(23)	40-26(65)	28-18(64)	39-19(49)
$\bar{x}$	48-26(54)	41-31(76)	28-18(64)	39-25(64)

N.Z. With

Section	Irish	S.23	Irish+S.23	$\bar{x}$
1	53+31(58)	44-24(54)	32 -7(22)	43 0(-)
2	53+33(62)	45-24(53)	32 -6(19)	43 +2(5)
3	52+11(21)	42-12(28)	30 0(-)	41 0(-)
$\bar{x}$	52+26(50)	44-20(45)	31 -4(13)	42 +1(2)

S.23 With

Section	Irish	N.Z.	Irish+N.Z.	$\bar{x}$
1	58+39(67)	56+24(43)	40+24(60)	51+29(57)
2	58+30(52)	55+24(44)	39+26(67)	51+26(51)
3	60+26(43)	58+12(21)	42+17(40)	53+19(36)
$\bar{x}$	59+31(52)	56+20(36)	41+22(54)	52+24(46)

DISCUSSION

Comparison of Methods

The technique of individually cutting grasses growing within the squares of metal mesh, which was developed for the experiment, may appear onerous, but when the aids to accurate and quick sampling are employed the time required for sampling is not excessive; two men were able to sample 28 plots in under 2 hours.

A technique described by Jones (1958a) in which the cultivars were grown in rows 4" apart, is similar to the mesh but does not allow such intimate mixing of plants nor could individuals be so easily traced.

The persistence of cultivars in a sward can be estimated by the method described by Charles (1961). This, however, involves the removal of a random selection of tillers from the sward, growing them as spaced plants and typing them by their habit of growth, time of ear emergence etc. Two major sources of error may effect the results obtained in this way, firstly the error in drawing the tiller samples and secondly, errors in classifying the plants due to the overlapping range in growth habits and times of ear emergence displayed by certain cultivars. For example, it is doubtful if New Zealand and Irish could be separated by this method. In addition, the time, labour and space required to deal with a large number of spaced plants compares unfavourably with the mesh technique where the area of ground taken up is very small and the only limitation to the number of treatments and replications used is the labour available for sampling. By the use of the mesh, plant deaths can be immediately seen and population changes followed throughout.

The mesh technique is obviously not applicable to creeping grasses and even with ryegrass there is a tendency for plants to spread beyond their original squares due to the death or suppression of a weaker neighbour. It was, however, usually possible to determine the origin of a plant and by charting the position of each plant (as was done at the start of the third harvest year) an absolute check was made.

The method of establishing the plants in the mesh by growing them firstly in individual paper containers and them dibbling them into the mesh was rather tedious. In experiment 2 the plants were established by sowing direct into the mesh and, provided suitable precautions are taken to avoid movement of seeds from one square to another, this method is satisfactory.

The use of the wire mesh gives a control of plant units usually achieved only under greenhouse conditions, as throughout the course of the experiment the different cultivars were always readily identifiable although on casual inspection the plots appeared to be part of a normal sward. It is noteworthy that, in spite of working with very small plots, the coefficients of variation were similar to those obtained from the much larger plots commonly used in cultivar comparisons. The technique could be applied to any investigation which required the rapid and accurate identification of individual plants or species whose vegetative characters are similar. It may be especially useful to plant breeders who desire to test small quantities of seed under sward conditions or even to make selections on the basis of sward competition. The alternative to this appears to be the use of spaced plants whose usefulness as a guide to performance in a sward is doubtful, Green and Eyles (1960), Lazenby and Rogers (1960) and Wright (1960).

Choice of Cultivars

The 3 cultivars used represent distinct types of perennial ryegrasses which are commonly used in seeds mixtures either alone or more usually, mixed together. Irish was chosen as representing the early growing, stemmy, short lived type and because it is the most widely used ryegrass in Britain. New Zealand, a more leafy and persistent version of the early ryegrass, was included as in a previous trial at Auchincruive, Hunt (1956), it displayed a fairly even growth cycle and outyielded the other ryegrass cultivars in the trial and so appeared particularly suitable for west of Scotland conditions.

To provide a contrast, a late maturing ryegrass was necessary and for this S.23 was chosen to represent the extreme pasture type, rather late in spring, very persistent and leafy.

Cutting Method and Manuring

The 18 cm. height which had to be reached before the plots were cut was selected as approximating the correct stage at which the grasses would have been grazed under farm conditions.

The decision to base the time of cutting of the main plots on the height of the cultivars growing alone was made so as to permit each cultivar to reach its "grazing height" at every cut in at least 1 section. The results of Heddle et al. (1950) showed that when length of herbage was used as the criteria for cutting, the late cultivars gave a much higher yield than when all cultivars were cut on a fixed time basis. This was attributed to differences in sward density rather than any undue delay in cutting the samples.

In the present experiment each cultivar, in its own section, was allowed to reach the predetermined height before cutting and thus should not have suffered by being cut either too soon or too late.

The divergence in growth form displayed by the cultivar treatments in the different cutting sections amply justified the adoption of varying cutting frequencies. Had the investigation been confined to any one of the three frequencies used, several of the conclusions that were drawn would have been, if not erroneous, of limited application. It would therefore seem advisable, in cultivar evaluation trials, to cover a wide range of sampling frequencies, unless the cultivars are to be tested for their utility in a given set of circumstances. Although, in practice, any given sequence of events seldom occurs as envisaged.

The 2" stubble that was left after cutting was in fact a more severe treatment than would be produced by leaving a 2" stubble with an ordinary mower. In this case not only was every plant pulled upright before cutting thereby including close growing leaves as well as upright ones, but the 2" height (measured from the top of the wire mesh) was a true 2" and did not vary with ground irregularities.

The cutting technique also ensured that a like amount of herbage was removed from each cultivar thereby avoiding any bias due to cutting treatment. Kuhn and Kemp (1939) have shown how prostrate cultivars of Poa pratensis are favoured by cutting at a fixed height compared to upright ones as a greater proportion of the leaves of the upright cultivars is removed.

One of the problems associated with cultivar comparisons on small clipped plots is that the influence of the grazing animal must be ignored, both from the point of view of manurial return and the treading and tearing action of the animal. There is the further problem that unless the level of fertilizer exceeds the requirements of all cultivars the higher yielding ones may not be able to reach their full potential. By adopting the technique described by McNeur (1953), the problems of manurial return were overcome and results obtained comparable to actual return of dung and urine.

Dry Matter Yield

Annual and total production of cultivars growing alone

The total amounts of dry herbage produced in the first harvest year were not significantly different for all three cultivars. Examination of the growth curves in figures 1.14, 1.15 and 1.16 does, however, clearly show that Irish benefited by having a longer uninterrupted growing period in spring and, conversely, that S.23 was more productive when defoliations were commenced earlier in the year. The yield of S.23 was greatest in section 1 which differed from section 2, the other early cut section, by having longer intervals between cuts in the latter part of the season. As these longer growing periods occurred at a time of decreasing day length there was no differentiation of flowering heads by any of the cultivars and production was dependent upon a plant's ability to produce vegetative tillers. Since S.23 is noted for its profuse tillering habit this was, no doubt, the underlying cause of its superiority in section 1. New Zealand was slightly lower in yield than Irish or S.23 in sections 1 and 3 and was noticeably poorer in section 2, the cutting times of which were based on New Zealand growth. As New Zealand was particularly poor in early spring, the reason for its better yield in section 3 was probably an outcome of the later spring cut, while in section 1 the longer growing periods in late summer and autumn permitted it to make up some of the ground that it had earlier lost. The fact that the management of section 2 did not allow any of these compensating influences, offers a possible explanation for the rather poorer production of New Zealand in that section.

In 1959 Irish yield diminished in the two sections that were cut earliest in spring. Where the first cut had been delayed until the beginning of May, when Irish was approaching the heading stage, its yield was similar to New Zealand and S.23.

The total yields of S.23 and New Zealand were not dissimilar in any section in this year and in fact New Zealand behaved more like a later maturing pasture type ryegrass than an upright growing early cultivar.

In the final year of the trial Irish was the lowest in yield under all cutting treatments and not even the previously favourable management of section 3 was sufficient to offset its lack of vigour. New Zealand in this third year finally assumed the characteristics normally associated with an early ryegrass and, as Irish had done in 1958 and 1959, displayed a rather better yield in the later spring cut section 3. S.23 again showed its preference for regular and fairly frequent cutting although differences between sections were not so great as in previous years.

The total yields for the 3 years of the trial showed Irish to be by far the lowest in yield in sections 1 and 2 but to be as productive as New Zealand and S.23 in section 3. The New Zealand and S.23 were not significantly different in any section although in sections 1 and 2 the S.23 yield was 14% and 16% greater than New Zealand respectively. In section 3 New Zealand had a small, 5%, advantage over S.23.

The similarity in yield of New Zealand and S.23 and the poor yield of Irish are in direct conflict with yields previously obtained at Auchincruive, Hunt (1956, 1957), in other areas of Scotland, Copeman et al. (1958) and in Ireland, McFetridge et al. (1958), Proudfoot (1957). The reasons why such anomalous results can arise would seem to stem from the cutting technique used, the interval between defoliations and the method of assessing the results.

In all of these trials (cited in the preceeding paragraph) a reciprocating bladed motor scythe was used to cut the plots and this method invariably leaves a considerable amount of herbage of the prostrate types, such as S.23, untouched beneath the cutter blade. As a result their yield is underestimated. This fact is acknowledged by Hunt (1956) in his discussion and amply confirmed in another trial by the same worker, on the same farm, when under grazing S.23 yielded slightly more than Irish, Hunt and Thomson (1955).

In the present experiment the cutting technique removed approximately equal amounts of top growth of all cultivars and, as is confirmed by Davies (1956), S.23 was shown to yield as well as the early cultivars even in the first year and to surpass Irish in later years.

In the Scottish trials, Copeman et al. (1958), Hunt (1956) a strict monthly cutting schedule was adhered to and this would tend to favour the early cultivars as, by running rapidly to head, their dry matter production would be boosted. Heddle et al. (1950) have shown how such a technique can militate against the pasture types. This method is obviously different from the technique used in this experiment where time of cutting was decided on the height of herbage, measured by pulling the plant upright and so including leaf length.

There is also ample evidence, Charles (1961), Davies (1939), Jones (1958), Jones (1958a), Stapledon (1924) and Stapledon and Jones (1925) which shows that lenient cutting, which six monthly cuts with an autoscythe must be considered, favours the early cultivars. The results from the present trial are in agreement with this in that, by allowing Irish to produce a bulky crop in spring, its yield was comparable with S.23 at least for the first two years.

Although McFetridge et al. (1958) show S.23 to be inferior to Irish and New Zealand their results are for total herbage which includes, in the case of Irish and to a lesser extent New Zealand, a high proportion of rough stalked meadow grass. Had the comparisons been made on the basis of the sown cultivar the results might well have been different. A similar experience was recorded by Hughes (1956).

When the possible interactions of these factors (cutting technique, timing of cuts and interpretation) are considered it is not surprising that divergent results are reported. It is considered, however, that the methods employed in experiment 1 present an unbiased picture of a strict assessment of the potential yield of ryegrass cultivars under cutting conditions.

Seasonal yield of cultivars growing alone

Early spring production In spring, the complementary growth cycles of the early and late cultivars were demonstrated to best advantage as the successive cutting dates of the three main plots allowed changes in growth rate to be measured over this important period.

In 1958, a late season, the first cuts were not made until May 5th at which time Irish and S.23 were not materially different and New Zealand was rather lower than either, but when the late section was cut 18 days later the Irish yield was considerably in excess of New Zealand and S.23.

In the second year, the first cut was made earlier, on April 18th, and no real differences were found between cultivars. At the next cut, three days later, there were still no differences although the yield of New Zealand had significantly increased. But at the third cut, on May 5th, Irish had shot ahead while New Zealand and S.23, although yielding more than at the previous cuts, had not grown nearly so rapidly.

The 1960 season presented yet another situation due to the poor yield of Irish, which by this time had lost its initial vigour, and the improved performance of New Zealand which up till then had not exhibited the characteristics of an early ryegrass. The first cut was made on May 2nd when New Zealand yielded more than Irish but not S.23 and the second cut 8 days later showed the same position. At the third cut on May 19th New Zealand had gone well ahead while Irish and S.23 were not significantly different. The Irish plants had spindly shoots with relatively few leaves and consequently did not show the expected high dry matter yield usually associated with heading.

In all three springs, the interesting fact emerged that at the earlier cuts the yield of the supposed late cultivar, S.23, was equal to that of the earlies. Only in section 3 which was cut 14 - 18 days after sections 1 and 2, and was based on the height of S.23 growing alone, did Irish and New Zealand show their capacity for early spring growth. This growth was, however, mostly in the form of stem and, in 1958 and 1960, flowering heads. This suggests that only when stem elongation and associated flowering head production take place does the growth rate of the early cultivars increase relative to the late types.

A similar opinion is also held by Charles (1961a) who quoted the following results obtained at Aberystwyth:-

	Yield lb/acre		
Date of cut	S.23	S.24	Irish
20/3/52	605	636	607
8/4/52	849	1078	1188
18/4/52	1316	1720	1740

This data confirms the hypothesis put forward and would indicate that growth at Auchincruive is 3-4 weeks later than at Aberystwyth.

It is not, however, suggested that, because plants are in the stemmy stage, their value is reduced. It has been shown, Minson, Raymond and Morris (1960) that, up to the point of ear emergence, ryegrasses are equally digestible; therefore, although the more rapid growth of New Zealand and Irish is associated with preparation for flowering, it does not reduce its usefulness up to this point of development.

Following this question further, it is interesting to compare the yields of Irish and S.23 in 1959, when section 3 was cut on May 5th, with the total of the two cuts (April 18th and May 7th) of section 2 that covered approximately the same period of time. Also a comparison of New Zealand and S.23 in 1960 in the single cut of section 3 (May 19th) with the two cuts of section 2 (May 2nd and May 24th) is revealing. By extracting this information from tables 1.16 and 1.30 the following picture appears:-

Date of cut	Yield g/plot Irish	S.23
May 5th 1959	37.8	19.8
April 18th + May 7th 1959	21.6	27.4
	N.Z.	S.23
May 19th 1960	49.2	24.0
May 2nd + May 24th 1960	37.3	35.2

It would therefore appear that when the growth of Irish and New Zealand is interrupted, and heading retarded, then S.23 can give a comparable yield during the spring period. Similar comparisons were not possible for 1958 as the cutting dates did not fall in the necessary pattern.

The relatively poor spring growth of New Zealand in seasons 1958 and 1959 (atypical for an early maturing ryegrass) may have been due to weather conditions in March and April of those years. Reference to table A1.2 shows that there were considerably more days of recorded frost in those years than in 1960 when New Zealand displayed its expected early growth. Observations of New Zealand species at Auchincruive have indicated that they are susceptible to frost damage in early spring and Davies (1960) noted a similar effect in autumn. Conversely, the early spring yield of Irish was greatest in 1958 and 1959 but this can be attributed to a reduction of both stand and vigour rather than a climatic effect.

Late May and June production During this period S.23 grew much more rapidly than the other cultivars especially where they had headed at the previous cut. This coincides with the findings of Davies (1956) and demonstrates how regrowth following the removal of headed tillers is slower than from vegetative shoots. This growth peak of S.23 in June was also noted by Hunt (1959) and can undoubtedly be associated with the later maturing characteristics of this cultivar.

Summer and autumn production Yield differences between the cultivars in the first and second harvest years were very much less during the latter part of the season but were influenced by the varying cutting times of the sections.

It was noticeable that in the longer intervals between defoliations of section 1 the yield of New Zealand and S.23 was greatly increased relative to Irish, indicating the difference in potential yield of these cultivars.

In the first and second harvest years the yield of Irish in the section cut late in spring was better or as good as New Zealand and S.23 and it would seem that this particular management is more favourable to Irish, or less favourable to the others, than the more intensive treatments of sections 2 and 3.

In the final year, when Irish had lost most of its vigour it was outyielded by New Zealand and S.23 under all cutting managements while there was little practical difference between New Zealand and S.23.

Apart from the fall off in the yield of Irish during the third year the most important yield differences occurred in the spring and early summer and these were modified by the cutting sequence; the largest differences taking place when the first cut was delayed until S.23 had reached the pre-arranged grazing height by which time both New Zealand and Irish were about to, or had, headed.

Yield of cultivar mixtures

Irish + New Zealand

By combining two cultivars with approximately the same growth cycle no benefit from a more level seasonal production could be expected. The mixture did, however, show several advantages over either cultivar separately. The poor spring growth of New Zealand in 1958 and 1959 was compensated for by the Irish fraction of the mixture and, in 1960, the position was reversed when New Zealand was the more productive and the IN mixture again responded to its higher yielding component.

At other times, in the first harvest year, the IN yield was not materially different from Irish or New Zealand but during the second year, when the yield of Irish was beginning to fall, the IN mixture was maintained by New Zealand and outyielded Irish alone. In the third year IN was distinctly better than Irish and behaved in a similar manner to New Zealand. There were two occasions (3rd and 5th cuts of section 2) when the IN mixture significantly outyielded both Irish and New Zealand. By reference to figure 1.22 this is seen to have been due to the New Zealand component of the mixture giving a greater yield than New Zealand alone. This indicates that, as the Irish plants weakened, New Zealand was able to exploit the space vacated, both above and below ground, and produce more herbage from a smaller number of plants than were present in the pure New Zealand plots. There were 1048 tillers per sq. ft. in the New Zealand treatment in section 2 at November 1960 (table 1.41) and 1138 tillers in the IN mixture of which New Zealand produced 86% or 979 tillers (table 1.42). Thus the higher yield of New Zealand in association with Irish must have come from a higher yield per tiller from the fewer, and more widely spaced New Zealand plants. In an experiment comparing broadcast and widely spaced grasses, Gardner (1958) described how cocksfoot in 21" rows gave a higher yield than when broadcast. This suggests that there may be a spacing, varying with species, at which a higher yield will be obtained.

Holliday (1961) in his examination of plant population/yield relationships found, in the second year of a trial comparing New Zealand ryegrass sown at rates of from 5-160 lb. per acre, that the 5 lb. seed rate gave a slightly higher yield than all others. He suggests, however, that a parabolic relationship between population and yield is only obtained when growth is associated with reproduction. It was further contended that, where production is confined to vegetative growth, a maximum is reached beyond which increases in population will neither increase or decrease yield.

Although statistically significant increases over Irish and New Zealand were only obtained at 2 cuts in section 2 during 1960, there were small, but consistent, increases at every cut of that year in section 2, and, on the total for the year, a 46% increase over the mean yield of Irish and New Zealand was recorded. The New Zealand share of this total was 88% and in actual weight of herbage the New Zealand in the IN mixture again gave slightly more than the New Zealand growing alone. As will be seen when the positive interaction between New Zealand and S.23 is discussed neither of the yields of these cultivars in mixture exceeded that produced in pure culture. It would therefore appear that these positive interactions exhibited by the IN and NS mixtures resulted from different causes. The advantage of the IN combination was derived, as indicated, from the greater productivity of more widely spaced plants of New Zealand while, as discussed later, the NS advantage appeared to come from a better utilization of available growth space.

Prendergast (1959) referred to a trial in which a positive interaction was obtained from Irish and New Zealand, and the present results do tend to confirm this finding.

Irish + S.23

If there is to be any advantage in combining early and late cultivars then it must come in spring and early summer when the growth rates are different. In the present experiment this situation did not arise until stem elongation of Irish had commenced. Up to that point, as can be seen from the results of sections 1 and 2, S.23 was equally productive and the yield of the combination was little different to either component alone. In 1958 and 1959, the first cut of section 3 was taken at a time when Irish was markedly more productive than S.23. In 1958, the IS mixture did not reflect this higher Irish yield being 65.9 g., 45.6 g. and 44.5 g. for Irish, S.23 and IS respectively. In 1959 the result was slightly better and the yields were, again respectively, 37.8 g., 19.8 g. and 23.2 g. This very slight upward movement of IS compared to S.23 can hardly be described as levelling the flow of herbage as it came so far below the high yield of Irish. Obviously S.23 was exerting the major influence in the mixture and suppressing the free expression of the more rapid spring growth of Irish. This is all the more interesting when it is considered that the 1958 effect occurred at the first cut of the first harvest year.

By 1960, the productivity of Irish had so diminished that its late spring yield was little (and that not significantly) better than S.23. This position was similar to that in sections 1 and 2 and the IS yield, as in those sections, was not significantly different from either component. The yields were respectively for Irish, S.23 and IS 29.9 g., 24.0 g. and 28.9 g.

These results are contrary to the theoretical benefits of combining early and late maturing ryegrasses with complementary growth cycles, and the failure of the mixture to display any benefit can be traced to two main causes. The first was the relatively high yield of S.23 in early spring, prior to Irish stem elongation, and the second was the rapid suppression of Irish by S.23.

When S.23 entered its rapid growth phase in late May and June the IS yield did show a small upward movement compared to Irish which was now the lowest yielder. From a practical viewpoint there is no advantage in providing a more level production of herbage from a mixture of cultivars if an overall higher production, which may fluctuate more, can be achieved from one cultivar by itself. This, in general terms, describes the IS production except in 1960 (Section 3, Cut 2) when the IS yield was significantly greater than either Irish or S.23. From figure 1.23 it can be seen that this was due to the S.23 component of the mixture producing more than S.23 growing by itself. This was similar to the situation which existed when the IN mixture exceeded New Zealand alone and has already been discussed. This gain of IS over its components continued throughout the season and, in total, amounted to a 26% increase over S.23 and 38% over Irish.

There would therefore appear to be little advantage in terms of yield of combining Irish and S.23 over S.23 alone unless the first cut is delayed until Irish has reached the ear emergence stage, when a slightly more level spring yield can be obtained, and possibly, as in 1960, a higher total yield. The advantages over Irish alone were obvious, but, since Irish was considerably lower yielding than S.23 this was to be expected.

New Zealand + S.23

The combination of New Zealand with S.23 was similar to the IS mixture in that an early and late maturing cultivar were placed together but, in the case of the NS mixture, the New Zealand (apart from the early part of the first harvest year) by itself was as productive as S.23, whereas Irish declined in productivity over the three years of the trial.

In sections 1 and 2 which were first to be cut each year, the S.23 yields were, as has been shown when the cultivars growing alone were considered, equally as good as New Zealand and therefore any smoothing of the growth curve, by the mixture, could not be expected. Such was the case in 1958 and 1959 but in 1960, in section 2, the NS yield was slightly greater than New Zealand and significantly greater than S.23. This, as will be seen, was the beginning of a growth pattern which was to carry the NS yield well above those of its components.

In section 3 (first-cut each spring at a time when New Zealand had a higher rate of growth than S.23) the NS yield did improve relative to S.23, except in 1958 when New Zealand growth was slow. Thus at the cut taken on May 5th 1959, the NS yield rose above both of its components, the increase over S.23 being significant, and on May 19th

1960 the NS again outyielded S.23 but was less than New Zealand. These results are what would be hoped for from such a mixture and agree with the work of Charles (1961) already quoted.

When S.23 passed into its rapid growth phase in late May and June the NS yield did not noticeably reflect this change in 1958 and the average yield of NS was significantly less than S.23. This was due to the New Zealand exerting a suppressive influence on S.23. In 1959 and 1960 when S.23 had become dominant no such suppression occurred and NS yields rose with the increased growth rate of S.23.

In the first harvest year, after the spring period was passed, the NS yield was similar to S.23 but, in the second year, the mixture produced significantly more than its components in the fourth cut of section 3. This trend had been obvious from the first cut of 1959 and was seen at all succeeding cuts and, although statistical significance was not reached at every cut, the accumulated benefit resulted in a significant positive interaction on the year's total. The actual increase was 20% on the mean yield of New Zealand and S.23, an amount which was not without practical importance.

The final year produced more evidence of the superiority of NS over New Zealand or S.23 and this was not confined to section 3. Although this advantage was not present at each cut of every section and the trend was for larger increases in sections 2 and 3 the increase on the mean total yield of New Zealand and S.23, averaged over all sections, was 16%. In sections 1, 2 and 3 it was respectively 5%, 30% and 14%.

The reason for this interaction was probably a better utilization of available growth space, and sunlight, by the mixture of upright and prostrate plants than by either one singly. At the earlier cuts in spring it was noticed that the cultivars tended to occupy two distinct layers with New Zealand above and S.23 below. It is unlikely that the taller New Zealand, with its smaller number of relatively heavy tillers, would shade the high tillering S.23 sufficiently to inhibit its growth, and in this manner the higher yield recorded could have been obtained. Since the interaction was only apparent in certain years and sections its success may depend on a certain balance between New Zealand and S.23 which was not achieved until S.23 assumed dominance. A discussion on the relative contribution and development of these cultivars will be included in a later section (page 208).

Similar advantages have been found by several workers, Gregor (1940), Manson et al. (1952), Prendergast (1959) when cultivars of a species were combined, although Charles (1961) found no such benefits.

In general terms it can be said that the mixture of New Zealand and S.23 was better able to exploit the available growth space, and sunlight, than either cultivar separately and a higher yield ensued. Also, at the times in spring when New Zealand was outyielding S.23, and when subsequently S.23 outyielded New Zealand, the mixture reduced these fluctuations and provided a more even yield.

Irish + New Zealand + S.23

In the first harvest year the combination of all three cultivars in section 3 led to a more even distribution of yield, as the early Irish growth raised the yield of the mixture to a point between that of Irish and the lower yielding New Zealand and S.23. This did not happen when Irish and S.23 were combined and may be explained by the fact that there were fewer S.23 plants present in the INS mixture and these were unable to retard the Irish growth. This result was repeated in 1959 and 1960 due respectively to the production from Irish and New Zealand. As with the IS and NS mixtures the similarity in yield of all cultivars in sections 1 and 2 precluded any marked levelling of seasonal growth.

In all years the second cuts of section 3 were influenced by the S.23 component and the yield was, in most cases, raised above those of Irish and New Zealand. This levelling of the supply of herbage in the first and second cuts, like the NS mixture, was a near perfect example in practice of cultivars with complementary growth cycles dovetailing together. In terms of available herbage such dovetailing does of course mean that, in most cases, there will be a smaller amount of herbage on offer at any one period than would have been possible from the highest yielding component of a mixture. If, however, the difference between the best cultivar and the mixture is not too great and final yield does not suffer (as in the mixtures under discussion) there would seem to be a good case for the use of mixtures of cultivars. A high percentage of the flush growth in spring is often wasted under farming conditions and a slightly smaller but more even production of herbage would help to overcome this difficulty.

During the remainder of each season there were small, and usually non-significant, differences between the yields of INS and its components; on no occasion was the yield of the highest-yielding cultivar, growing alone, significantly exceeded by that of INS. Although Irish, in the final year, produced very little in the mixture, no positive interaction was recorded as took place in the NS mixture; this may have been due to an incorrect balance between the cultivars. This point is taken up later (page 210).

While there were benefits in spring from the INS combination, when a relatively late cut was taken (i.e. compared to the cultivars grown alone), there was no advantage in terms of total yield over the season but the evidence does add to that already obtained in favour of combining cultivars.

Effect of cultivar combination on percentage distribution of yield

In the discussion on yields, references were made to seasonal distribution; this will now be considered in more detail.

The most outstanding feature revealed by the conversion of the yield data into percentage distribution was the tremendous effect of the date of the first cut. The changes in distribution that resulted from modifying the date of cutting far outweighed any differences due to cultivar mixtures. From the practical viewpoint, this is the critical factor determining the pattern of yield; the longer the first cut is delayed, the greater will be the percentage of total yield in that cut. The distribution of yield after a large spring crop was more even and a subsequent autumn flush, which tended to develop under the earlier spring cutting managements, was avoided. The frequency of cutting also had an effect on the second flush since section 2, which was cut at fairly regular intervals of 2-3 weeks, displayed rather less of an increase in the August period than section 1 in which the intervals between cuts were longer.

Within each cutting section, there were slight differences due to the mixing of cultivars of different growth cycles but these were seen to occur consistently only in the early part of the season.

The combination of Irish with S.23 did give a more level production in the first year before S.23 became dominant but thereafter the distribution was similar to that of S.23.

As the growth patterns of New Zealand and S.23 were similar in 1958 the yield of the mixture of these cultivars was little different from either alone. In the following year there was a slight levelling of growth where a late spring cut had been taken and in the final year this was apparent under all cutting managements. Taken overall therefore the INS mixture had the most level production of the cultivar mixtures but, as has been already stated, a slight change in management would have caused a much greater shift in seasonal yield than any permutation of cultivars.

Contribution to yield by components of mixtures

Inter-cultivar competition was strongly reflected in the contribution to the total yield of the mixtures by the associated cultivars. The percentage contributed by each cultivar is an absolute measure of its ability to compete with its neighbours in a sward. Plant survival and development were also recorded and obviously bear a relationship to production but the true assessment of a plant's worth is most easily measured by its yield. As there ARE no published data on this aspect of the subject no comparisons of results were possible. The work of Charles (1961) whereby samples of tillers were removed from a sward, grown as spaced plants and classified, gives a measure of the relative proportion of tillers of each cultivar present but gives no information on their contribution to seasonal yield as no measure of the varying productivity of the tillers over the year is possible. Also, as has already been pointed out, cultivars of similar growth habits could not be differentiated by this method. Charles' work, so far as it goes, is in accordance with the findings of the present investigation.

Irish + New Zealand

New Zealand became the dominant partner of the mixture in the first harvest year as, apart from one occasion, it contributed over 50% of the yield. Despite the fact that New Zealand did not necessarily contribute the major portion of the yield at every cut it did suppress associated Irish plants so that they contributed less than they would have done if both cultivars had been of equal vigour. There were two occasions in 1958 (3rd & 5th cuts in section 3) when Irish was not suppressed but on neither of these did Irish give over 50% of the yield.

The contribution of Irish became progressively smaller during the second and third years and its average contribution fell from 42% to 18% at the end of 1959 and 1960 respectively. This was modified to a degree by management, as, where Irish had been allowed to mature before taking the first spring cut (section 3) its contribution was always higher. The interesting point was that this higher contribution was not confined to the first cut but continued during the rest of the season. This was particularly noticable in the final year when the difference was confirmed statistically.

These results suggest that, in spring, by allowing Irish to reach the heading stage before cutting it was better able to compete with New Zealand, not only at the first cut but also subsequently. This hypothesis is borne out by the results given in table 1.35 which showed that in section 3 the depression of Irish when in company with New Zealand was 28% on the annual total while in the sections 1 and 2 it was 65% and 71% respectively. A similar effect was seen on the total for the 3 years where Irish was suppressed by 22%, 35% and 49% in the sections

3, 1 and 2 respectively. As the main difference between the cutting sections was in the timing of the first cut the degree to which Irish is suppressed must hinge, to a large extent, on this one point.

The downward trend of Irish contribution suggests that, had the experiment been continued, the yield from Irish would have become even less, until a point was reached when the IN mixture would have become virtually a pure New Zealand sward.

Irish + S.23

The more aggressive nature of S.23 compared to New Zealand was confirmed by the severity with which Irish was suppressed in the IS mixture. Only in the first cut of the experiment was the Irish contribution 50% of the total yield. In the second cut it fell to 32% and gradually tailed off to 27% at the end of the first year. There was a slight resurgence at the beginning of 1959 but by the end of that year the average contribution was down to 14%. Irish never recovered from this position and the fall continued during 1960 to the final average figure of 8%. This almost complete domination of Irish by S.23 had been reached gradually over the three years rather than by any sudden upswing of S.23 in any one year.

The competitive ability of S.23 was so great that even the more mature Irish growth produced in the first cut of section 3 which, as has been discussed, allowed Irish to better compete with New Zealand, did not prevent S.23 from becoming dominant. As was seen in table 1.6 Irish was actually being suppressed by S.23 at this period to 22% less than its potential.

In contrast to the IN mixture, the Irish contribution to yield and its percentage suppression were never very different in section 3 from section 2 which had a completely different cutting cycle. Evidently the aggressive nature of S.23 was so much greater than that of New Zealand that Irish was unable to benefit from the longer growth period, afforded in spring, to section 3. Another point of interest, which arises from the same cause, was the greater suppression of Irish by S.23 in section 1. This effect was more apparent in the last year of the trial, when there were longer intervals between the cuts of section 1 than the other sections. During these longer intervals the suppressive influence of S.23 developed with the result that Irish was suppressed by 89% in section 1 compared to 66% and 76% in sections 2 and 3, respectively. This result supports the conclusion drawn by Norman (1960) who said "- the maximum competitive effect would be exerted by a vigorously growing sward cut or grazed moderately at intervals long enough to allow the effects of competition upon top/root ratios and species habit to reassert themselves during the period of recovery."

Thus, it is quite clear from this data why the yield of the IS mixture soon took on the pattern of the pure S.23 sward and why no advantage was derived from the more rapid spring growth of Irish.

<u>New Zealand + S.23</u>

As in the IS mixture S.23 soon assumed the dominant role when in combination with New Zealand. There were, however, several important differences in the behaviour of S.23 in association with New Zealand compared to its behaviour in association with Irish.

First, New Zealand was not suppressed to the same extent as was Irish and was able to make a significant contribution to the combined yield throughout the whole trial period. At the last cut of the final year, New Zealand was still contributing 28% of the yield and for the total yield of the three years the proportion averaged 39%.

Secondly, New Zealand exhibited a remarkable elasticity in that, except for the first three cuts of 1958 when S.23 was suppressed, it was suppressed by S.23 at all periods but was able to revive each spring and contribute more, or not far short of, that given by S.23. Despite this there was a gradual fall in the average contribution of New Zealand over the years. The average figures at the last cut of each year were 42%, 35% and 28% for 1958, 1959 and 1960 respectively. Had this continued at the same rate, the sward would have become completely S.23 dominant in its seventh harvest year. Charles (1961) who investigated the competition between S.24 (a similar type to New Zealand) and S.23 found that the benefit in spring, relative to S.23, of combining S.24 and S.23 had disappeared by the fifth harvest year. In another trial he found that the surviving S.24 tillers in an S.24/S.23 sward had fallen to 3% by the sixth harvest year. These results strongly support the findings of the present experiment.

There was a tendency for the contribution of New Zealand to be higher in section 2 and this was specially noticeable during the second harvest year. In this year section 2 had been cut first and was cut once oftener than the others. This would suggest that the more intensive utilization prevented the S.23 from becoming as dominant as it did in the other sections.

The yield data showed that a positive interaction took place between New Zealand and S.23 in section 3 during 1959 and to some extent in all sections during 1960 although it was chiefly confined to sections 2 and 3. It was suggested that this may have been due to an optimum balance having been reached between the cultivars. In 1958 when no advantage was recorded for the NS mixture the yield (after the first cut) was divided approximately 40/60 from New Zealand/S.23. In 1959 section 3, where the interaction showed up, had a division of yield 30/70 while the proportions were 48/52 and 30/70 for sections 2 and 1 respectively. In 1960 the proportions in sections 1, 2 and 3 were respectively, 23/77, 35/65 and 28/72. Apart from section 1 in 1959, the division of yield when a positive interaction took place was around the 30/70 mark. If this is indeed the optimum proportions, it is not apparent from the data why there was no interaction in the 1959 section 1 yields.

Irish + New Zealand + S.23

As would be expected, S.23 was the dominant cultivar in this mixture contributing approximately as much as the other two together. Its average contribution rose from 48% in 1958 to 61% in 1960. The division of yield therefore did not reach the 30/70 proportion suggested as being necessary before a positive yield interaction takes place. As the dominance of S.23 was increasing this proportion may have been achieved in the following year. But, as in all mixtures, this division of yield would only be a transitory phase unless, by careful management, along the lines indicated by the results of this experiment, the New Zealand contribution can be maintained. This would involve the taking of a silage cut in spring when, as has been shown, the aggressiveness of S.23 can be curtailed.

There was never any significant difference between the contributions in the different sections, but the trend was for a slightly lower percentage in, the late spring cut, section 3. Evidently this particular management somewhat reduced the competitive effect of S.23.

In the first harvest year, New Zealand and Irish shared equally the balance of the yield but in the second year the contribution from Irish fell while that of New Zealand increased. This was repeated in the third year when the average Irish contribution was only 8%.

It can therefore be seen that the S.23 dominance was gained more at the expense of Irish than New Zealand. This statement is supported by the data in tables 1.35, 1.36 and 1.37 which showed that on the total for the 3 years of the experiment the suppression of Irish and New Zealand in the INS mixture was 41% and 15% of their potential respectively, while S.23 showed a gain of 43%.

It is probable that in the fourth and subsequent years of such a sward, when Irish had been virtually eliminated, S.23 would compete more strongly with New Zealand and eventually dominate it.

Plant Survival and Development

Cultivars growing alone

Free from the effects of inter-cultivar competition, the cultivars exhibited differences in their ability to survive and tiller under the managements imposed.

The survival and tiller production of Irish and New Zealand were similar and both reached the final stage of the trial with 53% and 56% respectively of their plants surviving. As their tiller production per plant had also been the same so was their tiller production per unit area.

S.23 displayed a higher survival and tillering rate and in November 1960 64% were still surviving with nearly 10 more tillers per plant than Irish or New Zealand.

All three cultivars showed a levelling off of the downward survival curve in the last year which suggests that the less persistent types had already died, and the remainder were of a more permanent nature and may have survived for several years. Or it may be that the less frequent defoliations of 1960 permitted the survival of plants that would otherwise have died.

The difference in survival and development between the early and late types is in accordance with the findings of Cooper and Saeed (1949) who explored the underlying causes.

Cultivars in competition

Irish ryegrass The survival and tillering of Irish were markedly reduced when growing in the presence of New Zealand and/or S.23. As would be expected the effect was noticable first on tillers per plant and then plant survival. As S.23 by itself has been shown to be more persistent and of higher tillering potential than Irish or New Zealand, it is not surprising that Irish was suppressed or that the effect of S.23 was greater than that of New Zealand. In the final year the Irish tillering capacity was reduced by 76% and 54% in company with S.23 and New Zealand respectively.

Since the tiller and plant numbers of Irish and New Zealand growing alone were similar the fact that New Zealand was able to dominate Irish when in association indicates the more vigorous and productive nature of New Zealand tillers. This is borne out by the relative yields of Irish and New Zealand in 1960 when Irish yielded considerably less although it had a similar tiller number per sq. ft. This point will be enlarged in a later section, (page 214).

Management too had an influence on the development of Irish, as, in mixture with New Zealand, the suppression of its tillering capacity was less when a late spring cut was taken than when the herbage was removed at an optimum grazing stage. This effect was less noticable when S.23 was present; the more aggressive nature of this cultivar suppressing Irish under all managements especially, as with dry matter yield, in the less intensively managed section 1.

New Zealand ryegrass More New Zealand plants survived and produced more tillers per plant when partnered by Irish than when growing alone. This was undoubtedly due to the inherent ability of New Zealand to recover more rapidly after defoliation and to the difference in the productivity of each tiller of New Zealand and Irish (Table 1.44).

The influence of S.23 on New Zealand was not nearly so great as it had been on Irish and at no time was the survival of New Zealand growing with S.23 significantly below that of New Zealand alone. Similarly with Irish + S.23 present the New Zealand survival was not depressed. Not until the third harvest year did S.23 cause a significant reduction in tillers per plant of New Zealand while with Irish also present there was a compensating effect and New Zealand tillers per plant were similar to New Zealand alone.

It was, however, obvious from the results of the contributions to yield that New Zealand was being slightly suppressed by S.23 right from the first year and this fact was reflected in the contribution made by New Zealand to total tillers per sq. ft., a more sensitive measurement embracing both plant numbers and tillers per plant.

At the end of the first harvest year, New Zealand contribution to the joint total tiller numbers was reduced by only 7% in the presence of S.23 but, by the final year, the aggressiveness of S.23 was depressing the New Zealand contribution to 45% below its potential. This means that although neither survival or tillers per plant were reduced sufficiently to be recorded as significantly depressed, their joint expression was.

S.23 ryegrass It has already been shown how tiller production per sq. ft. of Irish and New Zealand is reduced in the presence of S.23 and it is therefore not unexpected that S.23 plants tillered more freely when in association with these two cultivars.

In terms of increase over potential tillering capacity, S.23 increased finally by 52% and 36% in association with Irish and New Zealand respectively. With both together the increase was slightly higher at 54%. In section 3 the taking of a later spring cut reduced the advantage of S.23 quite noticably especially when it was growing with New Zealand, which again shows how this management is more favourable to early maturing cultivars.

Tiller weight and yield relationship

Although plant numbers per plot fell steadily over the three years of the trial, the total number of tillers produced in the cultivar treatments remained very constant. The average numbers of tillers over all treatments were 1097, 930 and 1171 for 1958-59-60 respectively. Obviously as plants died, or were suppressed, the more aggressive ones tillered more freely so taking up the available space. The only significant difference that occurred between the total numbers of tillers per sq. ft. of the various treatments was in autumn 1958 when Irish and S.23 alone had more than any other mixture. This did not, however, result in a significantly higher yield for these two cultivars which indicated that a higher tiller number was balanced by a corresponding lower weight per tiller.

This point can be illustrated by dividing the total yield for the year by the number of tillers produced. The following summary in table 1.44 shows the results of this calculation.

Table 1.44 Weight per tiller (in grams) of Irish, New Zealand and S.23 and relative weight where Irish = 100.

	Actual			Relative		
	Irish	N.Z.	S.23	Irish	N.Z.	S.23
1958	0.1016	0.1295	0.1178	100	127	116
1959	0.1349	0.1559	0.1391	100	116	103
1960	0.0679	0.0976	0.0740	100	144	109

From these results it can be seen that tiller for tiller Irish was inferior to New Zealand but only slightly less productive than S.23. This means that tiller number alone will not bear an exact relationship to yield although comparison of the percentage contribution to annual yield shown in figures 1.11, 12, 13, 19, 20, 21, 27, 28 and 29 with the corresponding percentage contribution to tiller production in figures 1.18, 26 and 34 show how near they come. The complex interactions of inter-cultivar competition upon tiller number, weight per tiller and actual yield make it difficult to exactly relate these variables when the cultivars are growing together in a sward. However, the results of this experiment do show that a fairly accurate determination of a cultivar's contribution to yield in a mixture can be obtained from its tiller production.

Relative Competitive Ability

When tiller weight is considered in conjunction with the poor survival and tillering ability of Irish compared to S.23 the reasons for Irish suppression and the general failure of its mixtures to reflect its early growth are obvious.

The more balanced nature of the mixture of New Zealand and S.23 derives from the fact that the higher weight of New Zealand tillers is outweighed by the better survival and more numerous tillers of S.23.

New Zealand dominated the associated Irish plants because of its higher weight per tiller (and the consequent implications on growth rate and mutual shading effect).

Under the conditions of this experiment, the general expression S.23 > N.Z. > Irish summarises the relative aggressiveness of these cultivars.

SUMMARY OF EXPERIMENT 1

1. The technique devised (and described herein) to measure the yield and development of three cultivars of perennial ryegrass (when growing under sward conditions) was successful. Cultivars planted at 2" centres were readily identified and sampled over the 3 year period of the experiment.
2. The advantages claimed for the method are (a) the small area required; (b) positive and immediate identification of plants in spite of their very similar vegetative characteristics; and (c) inter-plot variation which is no greater than that normally associated with agronomic experiments. The sampling technique is simple and can be learned very quickly.
3. The investigation showed that very intense competition existed between the selected cultivars of perennial ryegrass which affected their ability to tiller and survive. The main facets of this competition were as follows:-

Irish ryegrass

Irish was suppressed by both New Zealand and, to a much greater extent, S.23. Both plant survival and tiller production per plant were reduced. The effect on tiller numbers was apparent before plant numbers were affected. In the final analyses, S.23 reduced Irish plant and tiller numbers to approximately the same degree while New Zealand and New Zealand in association with S.23 had their greater effect on tiller numbers. By allowing Irish to reach the heading stage before cutting each spring, the above effects were somewhat mitigated (especially those of New Zealand).

New Zealand ryegrass

New Zealand ryegrass was suppressed by S.23 but to a much lesser extent than was Irish. The presence of S.23 did not significantly reduce the survival of New Zealand but did reduce the tillers per plant. When New Zealand was in combination with Irish and S.23, there was a compensating effect, the aggressiveness of S.23 being balanced by the weakness of Irish. The New Zealand plants were then similar, in number and tiller production, to New Zealand growing alone. In competition with Irish, the survival and tiller production of New Zealand was greater than when New Zealand plants were competing with each other. In all combinations, the increase or decrease of New Zealand contribution to the total tillers produced was least where a late spring cut had been taken.

S.23 ryegrass

S.23 dominated associated Irish plants so that a great number of plants, with more tillers per plant, survived than when S.23 was growing alone. With New Zealand the survival of S.23 was not significantly affected but tillers per plant were increased. This was also the case with Irish and New Zealand present. By delaying the first cut in spring until Irish and New Zealand had reached the ear emergence stage the aggressiveness of S.23 was somewhat reduced.

4. In all treatments tillering increased as plant numbers fell so that tiller numbers per unit area remained fairly constant. Apart from Irish and S.23, which had rather more tillers in the first harvest year, there were no significant differences between the tiller numbers per unit area of the various cultivar treatments. In the final year the cutting sequence which allowed the longest uninterrupted growth in spring produced the greatest number of tillers.

5. In the first year, total yields of cultivars growing alone were not significantly different but thereafter the yield of Irish diminished so that it was very much less than New Zealand and S.23, with the exception of its 1959 yield in section 3. Section 3, with its later spring cutting, favoured Irish so that in the 3 years total it was not significantly different from the others, but in both sections 1 and 2 it was considerably less productive. Seasonal production of the contrasting cultivars did vary, but only noticeably in the spring, and this variation was relatively small compared with that resulting from changes in the time of the first cut. Cuts taken in spring before Irish and New Zealand had entered the very rapid growth stage associated with heading showed no significant differences between the yield of the late maturing S.23 and the early Irish and New Zealand.

6. (a) The Irish plus New Zealand mixture did, on several occasions, improve the yield compared to New Zealand alone and was never significantly below it. Where a positive interaction did occur, the New Zealand plants in the mixture produced a greater amount of herbage than New Zealand growing alone by virtue of a higher weight per tiller. New Zealand was always the dominant partner of the mixture and, by the end of the second year, Irish was making little contribution to the yield except in section 3 where it continued to give approximately 25%. On the total production for the 3 years of the experiment the average contribution made by Irish, when in association with New Zealand, was suppressed to 35% below its potential.

(b) The combination of Irish and S.23 did not show the expected advantages of a mixture of an early and late maturing ryegrass.

In early spring S.23 produced a comparable yield to Irish and thus their mixture was no different to either alone. By allowing the Irish to shoot before taking the first cut in spring, the benefit of its higher growth rate was seen in the mixture and a slightly more even flow of herbage was obtained, compared to Irish or S.23 growing alone. By the third year S.23 was contributing an average of 90% of the yield and the growth cycle of the mixture followed the S.23 pattern. There were occasions in the final year when the IS yield exceeded both Irish and S.23 and this was due to a higher yield from the S.23 component of the mixture which produced more than S.23 growing alone. The average suppression of Irish by S.23 on the 3 year's total was 52% of the potential Irish yield.

(c) The New Zealand plus S.23 mixture was the most interesting one and in the second and third years showed in practice the theoretical advantages of combining early and late cultivars in levelling out the growth curve. In addition there was a positive interaction between the cultivars in section 3 in 1959 and, to a degree, in all sections in 1960. The increases over New Zealand or S.23 growing alone were of practical as well as statistical significance.

From observation of New Zealand and S.23 in combination it was suggested that part of the increased yield from the mixture may be attributed to the fact that the upright and prostrate growth habits make maximum use of the available space. A possible hypothesis is that the optimum ratio of New Zealand to S.23 is 30/70; but the reasons why no gain from this mixture was found, under certain managements, were not apparent. This aspect therefore merits further investigation. Although S.23 contributed the major portion of the yield every year, from the second cut onwards, New Zealand was always able to recover and produce approximately 50% of the yield each spring. There was however an indication that, had the experiment been continued for a further 3-4 years, the contribution of New Zealand would have fallen to an insignificant level.

(d) Combining all three cultivars was, on the whole, beneficial as a more even flow of herbage resulted without any reduction in total yield compared to the best of the components. As in the other mixtures, S.23 became the dominant cultivar due mainly to the death and suppression of Irish plants. The New Zealand component on the other hand was able to maintain its position due to the compensating effects of Irish submission and S.23 aggression.

7. The general conclusions can be drawn that, in a mixture of early and late maturing ryegrasses, cut at approximately grazing height, the late type will become dominant and provide the bulk of the herbage. This effect will be modified, to a degree, by time of cutting and by the persistence and productivity of the early cultivar used; but, eventually, the late prostrate cultivar will completely dominate the sward.

Experiment 2.

Persistency and Development of Perennial Ryegrass Cultivars when in Competition Under Varying Systems of Defoliation.

INTRODUCTION

In experiment 1 the yield, persistency and development of competing ryegrass cultivars were measured under a strictly controlled cutting regime. Experiment 2 was designed to allow an assessment of competition between the same cultivars (Irish, New Zealand & S.23) under varying intensities of sheep grazing and hay and aftermath management.

Assessment under these managements, which approach more closely to actual farm practice, was felt to be necessary since selective grazing and differences in palatability and growth habit of ryegrass cultivars could interact to alter the competitive pattern as compared with a cutting technique which removed almost identical portions of top growth from each cultivar. A hay and aftermath treatment was included so as to provide a contrast to very intensive grazing and thus to cover the widest range of conventional management techniques.

EXPERIMENTAL METHOD

Preparation and Design

In order to allow rapid identification of the cultivars when growing together, the wire mesh technique developed for experiment 1 was employed. Before the wire meshes were laid in position the existing turf was skimmed off the site and each area levelled. To reduce interference from weed and extraneous grass seeds all areas were thoroughly scorched with a flame gun prior to sowing.

The statistical design was a split plot randomised block with 3 management systems as the main plots and the 7 possible combinations of equal parts of the 3 cultivars as the sub plots. With 4 replicates this gave a total of 84 plots.

The main plots were placed 1 yard apart with the undisturbed sward between them. The shape of each main plot was governed by the size (9' x 4') of the cages which were to be placed over them as protection from the grazing sheep. This necessitated a change in shape from the plots used in experiment 1 and the arrangement of 1 replicate and the detail of 2 sub plots are shown in figure 2.1. The whole experiment was enclosed in a paddock 90' x 16' in size.

Main Plot Treatments

The management systems making up the 3 main plots were designed to cover a wide variation in defoliation practices and comprised:-

(1) grazing whenever the average height of the plants was 3",

(2) grazing whenever the average height of the plants was 6" and

(3) cutting at the hay stage followed by two aftermaths.

Height was measured by pulling a plant upright and judging the modal height of both leaf and flowering stem against a ruler held at

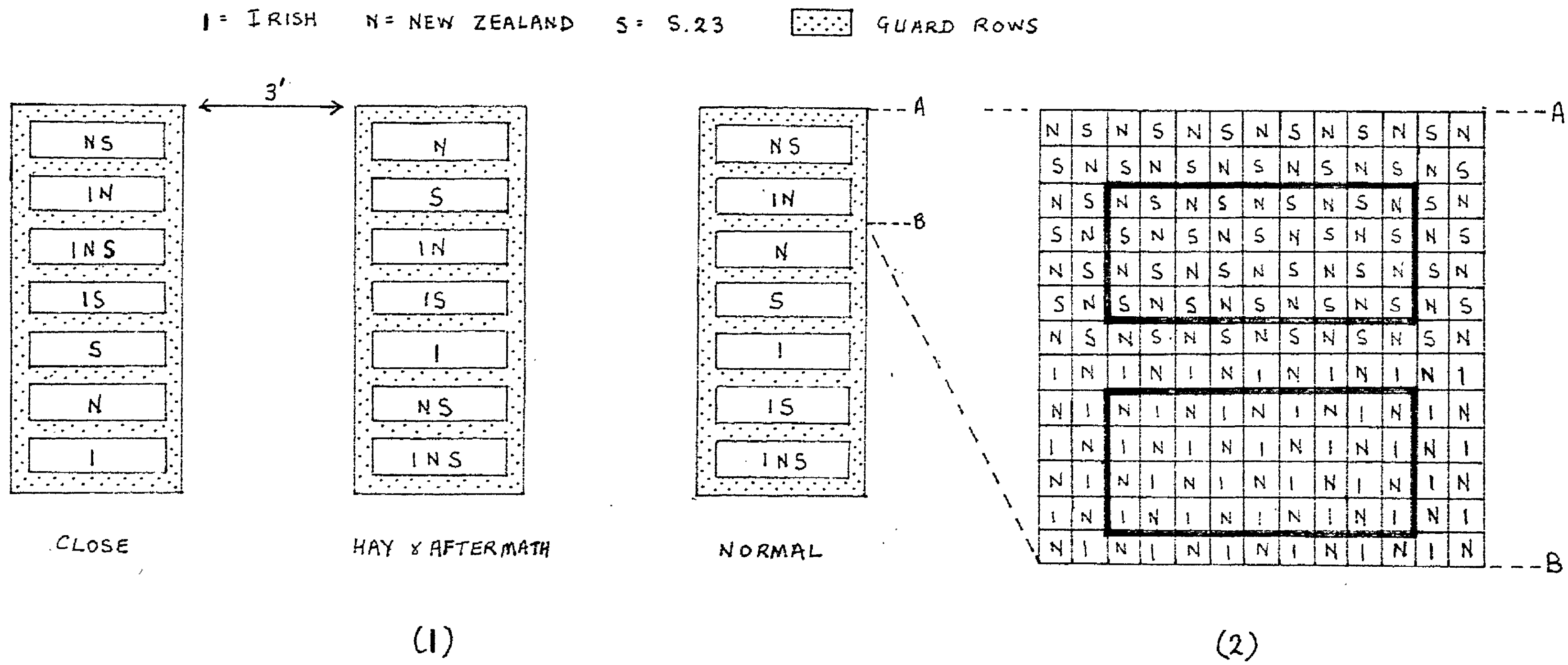


Figure 2.1 (1) Layout of 3 main plots comprising 1 replicate.
(2) Details of arrangement of cultivars within 2 plots. The sampling areas are enclosed by the heavy lines.

ground level. Since all cultivars did not reach this height simultaneously, especially in the second year of the trial, a compromise had to be made so that the faster growing cultivars did not greatly exceed the selected limits.

Sub Plot Treatments

The cultivar treatments which made up the sub plots were exactly the same as those in experiment 1.

Establishment

On July 21st and 22nd 1958 the plots were sown by placing 2 seeds of ryegrass in each square of the wire mesh. The appropriate cultivar to sow was indicated by the colour code previously painted on the wires. As each sub plot was completed the seeds were carefully covered by sieved top soil. Suitable wind breaks were erected to prevent the seed being blown before it could be covered. Weed seedlings were removed as they appeared and on August 12th the ryegrasses were singled to 1 plant per square and surplus plants used to fill squares not occupied by a ryegrass.

At the end of August all plots were cut down to a height of $1\frac{1}{2}$" - 2" by a rotary grass cutter which collected all clippings. This was repeated in early November by which time all cultivars had developed a good sward. Figure 2.2 gives a general view of the experimental site about this time.

Grazing and Cutting

The grass around the plots was kept closely cut so that when sheep were put into the paddock they would be sure to graze the experimental areas. Main plots not to be grazed were covered by cages made of a frame work of tubular iron covered by wire netting. The hay and aftermath plots were enclosed by permanent netting fences as the cages were

Figure 2.2 General view of experimental paddock. The grass around each main plot has been cut down and the experimental swards can be identified by their taller growth.

Figure 2.3 Blackface x Border Leicester sheep used to defoliate the plots. Part of a fenced hay and aftermath and a grazing plot are also illustrated.

not high enough to prevent sheep grazing the tall growth of a developing hay crop. Figure 2.3 shows the sheep (Blackface x Border Leicester) in the paddock beside part of a hay and aftermath, and a grazing plot.

The number of sheep put in to graze varied between 2 and 6. Grazing time was adjusted so that the plots were grazed to an approximate stubble height of $\frac{1}{2}$" and this was usually accomplished in 24 hours. Ungrazed tufts were cut by hand shears. Faeces, which might effect subsequent grazings, were lifted from the experimental areas after each grazing.

The hay and aftermath cuts were made by hand shears leaving a 2" - $2\frac{1}{2}$" stubble. The hay was cut when all cultivars had headed but before flowering and the aftermaths were representative of silage production.

Manuring

Prior to sowing, 3 cwts. per acre of 15.5% nitro-chalk and 18% superphosphate were applied. Further dressings of 2 cwts. per acre of 18% superphosphate and 1 cwt. 60% muriate of potash were applied in November 1958 and 3 cwts. per acre of a compound containing 12% N, 12% P_2O_5 and 18% K_2O were given on March 2nd 1959. Thereafter all manuring consisted of the special mixture and technique used in experiment 1 (McAlister (1943)). The amount of fertilizer to be returned could not be accurately measured since yield determinations were not made, but an approximation was reached by cutting with hand shears, drying and weighing the 8 discard plants immediately adjacent to the outer edges of the sampling areas in each plot containing Irish, New Zealand and S.23. This meant that, for each main plot, the manurial return was calculated from the yield of 32 squares, 8 in each replicate, and was distributed evenly over all sub plot treatments. Blanks or weed grasses which occurred in the 32 yield determining squares were assumed to equate with similar occurrences in the sampling areas.

Plant and Tiller Counts

Yield determinations were not made in this experiment as it would have been impracticable to remove pre-grazing samples from the very small plots used without influencing the inter-cultivar associations. The effects of management and competition were therefore assessed by plant survival and tiller production.

Plant counts were made in November 1958, in July and November 1959 and April, July and November 1960.

Tillers were counted in November 1958, 1959 and 1960. The counting was done on plants in the centre of a plot and continued outwards until 6 plants were completed for each cultivar in the plot, where this was possible. At the final count in November 1960, all plants were lifted and the tillers and plants counted indoors. Where more than 6 plants were present, selection was made by the use of random numbers.

Statistical Analysis

All basic data were analysed by the analysis of variance technique. The formulae for significant differences used in the interpretation of the split-plot analyses were obtained from Cochran and Cox (1957).

RESULTS

The results of experiment 2 are presented in the following order:-

(a) grazing and cutting frequencies,

(b) plant survival,

(c) tiller production per plant,

(d) tiller production per unit area, and

(e) contribution and potential contribution to tiller production by the components of cultivar mixtures.

Statistical Interpretation

In all tables (unless where otherwise stated) the least significant differences (L.S.D.) at $P < 0.05$ are numbered 1-4 and can be applied in the following comparisons:-

1. Between management treatments (Main plots).
2. " cultivar treatments (Sub plots).
3. " cultivar treatments within the same management treatment.
4. " management treatments of any cultivar treatment.

Where an "F" value failed to reach the required level for significance this is denoted by the letters N.S. Summaries of the "F" values obtained in each analysis are given in appendix 2.

Abbreviations

The names of the sub plot cultivar treatments have been abbreviated as in experiment 1. Thus where a cultivar is growing by itself the full name is used, viz. Irish, New Zealand and S.23. For treatments where the cultivars are combined only the initial letter of each cultivar present is used, viz. IN, IS, NS, INS.

Terminology

The main plot management treatments are referred to by the following terms.

"Close grazing" - Main plots grazed whenever the average height of the grasses reached 3 inches.

"Normal grazing" - Main plots grazed whenever the average height of the grasses reached 6 inches.

"Hay treatment" - Main plots cut for hay and two aftermaths.

Grazing and Cutting Frequencies

The dates of grazing or cutting (and the interval between defoliations) the main plot management treatments are given in table 2.1. The close grazing plots were defoliated a total of 20 times in 1959 and 12 times in 1960. This, as intended, was very intensive utilization; the average interval between grazing being 11.5 and 16.2 days for 1959 and 1960 respectively. The normal grazings amounted to 12 and 7 in 1959 and 1960 respectively with average intervals of 19.2 and 28.0 days. This management was more lenient than the close grazing treatment but still intensive by farming standards. The aftermath cuts were made at approximately equal intervals each year. 1960 was a later year than 1959 and the date of taking the hay cut delayed accordingly.

Table 2.1 Dates and intervals between grazings of the close and normal treatments and of cutting the hay + aftermath treatment.

Close Grazing				Normal Grazing				Hay + Aftermath			
1959		1960		1959		1960		1959		1960	
Date	Interval	Date	Interval	Date	Interval	Date	Interval	Date	Interval	Date	Interval
25/3	0	19/4	0	2/4	0	29/4	0	3/6	0	22/6	0
2/4	8	2/5	13	20/4	18	23/5	24	1/8	59	6/8	45
13/4	11	11/5	9	8/5	18	13/6	21	7/10	67	13/10	68
20/4	7	30/5	19	19/5	11	11/7	28				
27/4	7	13/6	14	2/6	14	5/8	25				
8/5	11	28/6	15	16/6	14	26/8	21				
13/5	5	14/7	16	7/7	21	14/10	49				
22/5	9	28/7	14	27/7	20						
2/6	11	12/8	15	10/8	14						
11/6	9	8/9	27	28/8	18						
29/6	18	24/9	16	25/9	28						
10/7	11	14/10	20	30/10	35						
21/7	11										
27/7	6										
6/8	10										
16/8	10										
28/8	12										
17/9	20										
18/10	31										
30/10	12										

Plant Survival

November 1958

Due to the method of establishment a 100% stand was initially obtained for each cultivar and at the count made in November of the seeding year only 6 plants (4 Irish and 2 New Zealand) were missing, out of the 3024 making up the sampling areas, (the missing plants were not associated with any particular treatment).

The results of the plant counts made in July and November 1959 are given in table 2.2.

July 1959

Analysis of the data failed to show any significant differences due to management or competition between cultivars. The survival of Irish averaged 72%, which was already noticably below that of New Zealand or S.23 which averaged 87% and 94% respectively. This was less marked in the hay treatment which, by this date, had only been cut once for hay. The survival of S.23 was extremely constant and was obviously unaffected by the imposed treatments.

November 1959

Irish ryegrass By November the survival of all cultivars had fallen considerably but Irish was by far the most affected having dropped to an average of 34%. Irish survival was not significantly affected by companion cultivars or management and, like the S.23 in July, showed little variation between treatments. The trend was, however, for a lower survival wherever S.23 was present.

New Zealand ryegrass Survival of New Zealand had fallen to 65% but inspection of the results showed that this had mostly come from the large fall to 42% in the hay treatment. The competitive influences

Table 2.2 Percentage survival of cultivars alone and in mixtures at July and November 1959. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Management	July					November				
	Irish with					**Irish with**				
	Alone	N.Z.	S.23	NZ+S.23	$\bar{x}$	Alone	N.Z.	S.23	NZ+S.23	$\bar{x}$
Close	74	82	57	73	72	39	44	26	29	35
Normal	59	64	54	67	61	33	39	33	38	36
Hay	82	80	83	88	83	37	26	32	27	31
$\bar{x}$	72	75	65	76	72	36	37	31	31	34
	L.S.D. 1,2,3,4=N.S. C.V.=14.2%					1,2,3,4=N.S. C.V.=8.3%				
	N.Z. with					**N.Z. with**				
	Alone	Irish	S.23	Irish+S.23	$\bar{x}$	Alone	Irish	S.23	Irish+S.23	$\bar{x}$
Close	95	86	83	90	88	87	76	70	77	78 (63)
Normal	86	83	78	88	84	72	84	65	77	75 (61)
Hay	89	93	89	90	90	31	54	34	48	42 (40)
$\bar{x}$	90	88	83	89	87	63	72	57	67	65
	L.S.D. 1,2,3,4=N.S. C.V.=11.2%					1=9, 2,3,4=N.S. C.V.=15.9%				
	S.23 with					**S.23 with**				
	Alone	Irish	N.Z.	Irish+NZ	$\bar{x}$	Alone	Irish	N.Z.	Irish+NZ	$\bar{x}$
Close	100	97	97	94	97	93	92	92	92	92 (77)
Normal	86	92	96	88	90	73	86	86	83	82 (67)
Hay	96	93	99	92	95	41	46	36	58	45 (42)
$\bar{x}$	94	94	97	91	94	69	74	71	78	73
	L.S.D. 1,2,3,4=N.S. C.V.=10.5%					1=13, 2,3,4=N.S. C.V.=17.7%				

of Irish and S.23 did not alter the New Zealand survival significantly but there did appear to be a greater survival in the presence of Irish especially where hay had been taken compared to New Zealand alone or with S.23.

S.23 ryegrass The mean survival of S.23 showed a fall from 94% to 73% similar to that of New Zealand, most of the fall again occurred in the hay treatment. Cultivar combinations had no significant influence on S.23 plant numbers.

Table 2.3 gives the percentage survival of cultivars during 1960.

April 1960

There was little loss of plants over winter and the counts made in spring 1960 were only slightly less than the November 1959 figures.

Irish ryegrass Irish plant numbers were not significantly affected by any treatment and the only noticeable trend was a lower survival with S.23 under all managements.

New Zealand ryegrass New Zealand survival, however, was much lower in the hay treatment than under the 2 grazing managements, which were identical. The average effects of cultivar treatments over the management systems showed that the survival of New Zealand with Irish was significantly greater than New Zealand with S.23. The increase due to the presence of Irish over New Zealand alone just failed to reach significance at the 5% level. With both Irish and S.23 present, the survival of New Zealand plants was practically the same as New Zealand alone.

S.23 ryegrass The management systems had a considerable effect on the survival of S.23. The highest figure of 90% was recorded under

Table 2.3 Percentage survival of cultivars alone and in mixtures at April, July and November 1960. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

Management	April					July					November				
	Irish with					Irish with					Irish with				
	Alone	N.Z.	S.23	NZ+S.23	$\bar{x}$	Alone	N.Z.	S.23	NZ+S.23	$\bar{x}$	Alone	N.Z.	S.23	NZ+S.23	$\bar{x}$
Close	40	47	25	27	35	27	29	20	25	25	22	28	26	23	25
Normal	31	40	29	38	34	20	32	22	38	28	18	26	23	29	24
Hay	34	21	29	33	29	31	22	26	27	27	26	20	24	31	25
$\bar{x}$	35	36	28	33	33	26	28	23	30	26	22	24	24	28	25
L.S.D.	1,2,3,4=N.S. C.V.=24.8%					1,2,3,4=N.S. C.V.=24.8%					1,2,3,4=N.S. C.V.=28.3%				

Management	April					July					November				
	N.Z. with					N.Z. with					N.Z. with				
	Alone	Irish	S.23	Irish+S23	$\bar{x}$	Alone	Irish	S.23	Irish+S.23	$\bar{x}$	Alone	Irish	S.23	Irish+S.23	$\bar{x}$
Close	87	78	60	71	74(60)	74	69	56	67	66(55)	74	63	57	64	64(54)
Normal	70	86	64	73	73(60)	62	78	47	65	63(53)	57	71	46	67	60(51)
Hay	27	52	35	46	40(39)	26	46	33	42	36(37)	22	39	31	44	34(35)
$\bar{x}$	61(52)	72(59)	53(46)	63(54)	62	54(47)	64(54)	45(42)	58(50)	55	51	57	44	58	53
L.S.D.	1=8 2=8 3,4=N.S. C.V.=18.6%					1=8 2=7 3,4=N.S. C.V.=18.6%					1=7 2,3,4=N.S. C.V.=17.2%				

Management	April					July					November				
	S.23 with					S.23 with					S.23 with				
	Alone	Irish	N.Z.	Irish+NZ	$\bar{x}$	Alone	Irish	N.Z.	Irish+NZ	$\bar{x}$	Alone	Irish	N.Z.	Irish+NZ	$\bar{x}$
Close	92	90	88	92	90(75)	84	88	82	88	85(70)	82	84	76	88	83(68)
Normal	70	77	82	79	77(63)	65	71	78	71	71(58)	61	68	72	67	67(55)
Hay	34	47	32	44	39(37)	22	32	28	42	31(33)	24	32	25	36	29(32)
$\bar{x}$	65	72	68	72	69	57	63	62	67	62	56	61	58	63	60
L.S.D.	1=11 2,3,4=N.S. C.V.=19.0%					1=12 2,3,4=N.S. C.V.=18.5%					1=8 2,3,4=N.S. C.V.=17.6%				

close grazing and was significantly less at 77% when normally grazed. Hay production reduced this still further to 39%. Apart from the higher survival under close grazing these figures were similar to those of New Zealand. As at previous counts the combination of S.23 with either or both of the other cultivars did not significantly affect its survival.

July 1960

At this time the survival of all cultivars had dropped by an average of 7% from the April figures.

Irish ryegrass There were no significant differences in the results for Irish and the figures for all treatments were extremely close.

New Zealand ryegrass New Zealand showed more variability and the survival under the hay management was significantly lower than under grazing. In association with Irish, the survival of New Zealand was greater, but not quite significantly, than New Zealand alone. The presence of S.23 did however lower the survival of New Zealand below its value in the IN and INS mixtures.

S.23 ryegrass The survival of S.23 was markedly affected by the managements imposed. With close grazing the survival was 85% while less frequent grazing reduced this to 71% and cutting for hay gave a further reduction to 31%. The combining of S.23 with other cultivars did not significantly affect its survival although, on average, it was always slightly higher when combined with either of the other cultivars.

November 1960

Irish ryegrass The number of Irish plants surviving averaged 25% showing very little change during the autumn period and still displaying no response to the different managements and cultivar combinations.

New Zealand ryegrass As with Irish, the population of New Zealand had altered little over the latter period of the trial but was still, on average, double that of Irish and only 7% less than S.23. A lower survival was again recorded for the hay treatment while the difference between grazing systems was not significant. The mean square for cultivar mixtures just failed to reach significance at the 5% level (table A2.9) but apart from a slight fall in survival in the presence of Irish, the means were of the same relative magnitude as in July when significant differences were recorded. The count made in April revealed certain interesting aspects. In association with S.23, the survival of New Zealand was lower than New Zealand alone in both of the grazing treatments but in the hay treatment it was 31% in the NS mixture compared to 22% for New Zealand alone. Also, in combination with Irish, New Zealand survival was higher than New Zealand alone in all management treatments except close grazing, where it was always less.

S.23 ryegrass S.23 had the highest average survival of 60% with a range from 83% under close grazing to 29% in the hay treatment. With normal grazing the survival of 67% was significantly less than that for close grazing. Combining S.23 with New Zealand and/or Irish did not materially affect its survival compared to S.23 alone.

Tiller Production

November 1958

The results of the tiller count made in November 1958 are given in table 2.4. At this stage, the main plot management treatments had not been started and the results therefore refer only to cultivar treatments. As can be seen the tiller production of all cultivars growing by themselves had been similar, and mixing them had not affected their development.

November 1959

The mean tiller numbers per plant assessed at the end of the first and second harvest years are shown in table 2.5.

Irish ryegrass At November 1959, management systems did not significantly affect the tiller numbers per plant of Irish but the plants in the hay treatment appeared to have slightly more tillers than those under grazing. Irish alone averaged 25 tillers per plant and this was reduced to 18, 12 and 16 when competing with New Zealand, S.23 and New Zealand plus S.23 respectively.

New Zealand ryegrass The tillers per plant of New Zealand growing alone were not significantly affected by management system. When growing with Irish however there were significantly more tillers under normal grazing than in the hay treatment. The difference between normal and close just failed to reach significance. With S.23, there were considerably more tillers in the hay treatment than under grazing.

S.23 ryegrass The association of S.23 with Irish or Irish plus New Zealand resulted, on average, in an increase in the tillers per plant of S.23. The increase, in combination with New Zealand, was least

Table 2.4 Mean number of tillers per plant at November 1958.

Cultivar	Treatment		Cultivar	Treatment		Cultivar	Treatment	
Irish	Alone	15.1	New Zealand	Alone	16.2	S.23	Alone	15.2
	with N.Z.	16.9		with Irish	16.4		with Irish	14.5
	" S.23	17.4		" S.23	16.2		" N.Z.	15.5
	" N.Z.+S.23	16.8		" Irish+S.23	15.6		" Irish+N.Z.	13.5
	$\bar{x}$	16.5			16.1			14.7
C.V. =		14.9%			13.9%			16.2%

No differences significant.

Table 2.5 Mean tiller number per plant of cultivars alone and in mixtures at November 1959 and 1960.

Management	November 1959						November 1960					
		Irish with				L.S.D.		Irish with				L.S.D.
	Alone	N.Z.	S.23	N.Z.+S.23	$\bar{x}$		Alone	N.Z.	S.23	N.Z.+S.23	$\bar{x}$	
Close	26	20	9	9	16	1=N.S.	49	27	19	14	27	1,2,3&4=N.S.
Normal	20	16	12	13	15	2=7	48	21	24	22	29	C.V.=88.4%
Hay	29	17	16	25	22	3&4=N.S.	44	26	66	39	44	
$\bar{x}$	25	18	12	16	17	C.V.=50.8%	47	25	37	25	33	
		N.Z. with						N.Z. with				
	Alone	Irish	S.23	Irish+S.23	$\bar{x}$	1&2=N.S.	Alone	Irish	S.23	Irish+S.23	$\bar{x}$	1=9
Close	29	26	20	22	25	3=14	32	48	30	40	37	2=10
Normal	26	43	18	21	27	4=17	43	74	26	37	45	3=18
Hay	20	21	37	23	25	C.V.=37.9%	28	26	32	28	28	4=18
$\bar{x}$	25	30	25	22	26		34	49	29	35	37	C.V.=33.1%
		S.23 with						S.23 with				
	Alone	Irish	N.Z.	Irish+NZ	$\bar{x}$		Alone	Irish	N.Z.	Irish+NZ	$\bar{x}$	
Close	26	39	49	58	43	1=7	42	76	54	67	60	1,2,3&4=N.S.
Normal	32	54	33	42	40	2=12	69	84	67	86	76	C.V.=31.0%
Hay	24	33	32	44	33	3&4=N.S.	54	61	49	54	54	
$\bar{x}$	27	42	38	48	39	C.V.=38.5%	55	74	57	69	63	

and not quite statistically significant. The hay management produced fewer tillers than close or normal grazing although the latter difference failed to reach significance.

November 1960

Irish ryegrass By November 1960, an increase in tillers had occurred over all treatments. The results were, however, extremely variable and statistical analysis showed no significant differences. Examination of the means showed that, apart from the mixtures with S.23 and, to a lesser degree, with S.23 plus New Zealand in the hay treatment, all the results for Irish in combination with the other cultivars were considerably less than for Irish alone. Also, the average value for the hay treatment was higher than those of the grazing treatments.

New Zealand ryegrass The tillers per plant of New Zealand had also increased compared to the first harvest year but to a lesser extent than Irish. New Zealand plants tillered more freely in mixture with Irish, and normally grazed than when they were growing alone, but in the presence of S.23 their tillering was reduced. Where close grazed the increase with Irish was still observed, although not quite significant, whilst the presence of S.23 had only a slight depressive effect. When managed for hay, New Zealand tillering was not materially affected by cultivar treatments.

S.23 ryegrass S.23 showed an increase in tillering between 1959 and 1960. Relative to the 1959 figure, the increase was 62% and those of Irish and New Zealand had been 94% and 42% respectively. S.23 did, however, have a much higher average tiller number per plant than either Irish or New Zealand. No statistically significant differences were recorded between treatments but in general the pattern was similar to that observed in November 1959. S.23 had a higher tiller count in association with Irish than when growing alone, especially in the grazing treatments. With New Zealand, the S.23 tillers were slightly reduced in the hay and normal grazing treatments but increased in the close treatment. Where all cultivars were together, S.23 tillered more freely under the grazing treatments and had an identical number to S.23 alone when cut for hay.

Tiller Production per Unit Area

Table 2.6 gives the total number of tillers produced per sq. ft. by each cultivar alone and in mixtures at the end of the first and second harvest years. Figures 2.4 and 2.5 show the data in diagrammatic form.

November 1959

After only one year of grazing, the number of tillers per sq. ft. produced by Irish was significantly lower than all other treatments except IN in the close grazing treatment. IN was significantly lower than all others except IS which, in turn, was significantly less than NS. It therefore appeared that, under close grazing, Irish (and mixtures where Irish originally made up 50% of the plants) produced fewer tillers than other cultivar treatments.

With the less frequent defoliation of the normal treatment, Irish was also well below all other cultivars but the IN and IS mixtures were considerably higher and not significantly different from the other treatments.

In the hay treatment, a quite different picture was presented, there being no significant differences between any cultivar treatments. Under hay, all cultivars produced markedly fewer tillers than when grazed (except for Irish, which had its highest number when cut for hay).

November 1960

In the following year the increased tillering of all cultivars, especially S.23, gave rise to some different results compared to 1959.

Irish was the cultivar having fewest tillers under grazing. The unique features of the tiller numbers for Irish under hay management

Table 2.6 Total number of tillers produced per sq. ft. by each cultivar alone and in mixtures at November 1959 and 1960.

Date	Management	I	N	S	IN	IS	NS	INS	$\bar{x}$	L.S.D.
		Cultivar Treatments								
Nov. 1959	Close	368	922	870	548	692	1068	892	766	1 = 175
	Normal	238	668	842	785	835	705	678	678	2 = 168
	Hay	395	225	345	320	370	398	492	364	3 = 290
	$\bar{x}$	333	605	686	551	632	723	688	603	4 = 320
										C.V. = 33.7%
Nov. 1960	Close	315	840	1248	688	1292	1060	1055	928	1 = 296
	Normal	282	865	1492	955	1098	1078	1058	975	2 = 198
	Hay	560	238	440	250	480	360	560	412	3 = 344
	$\bar{x}$	386	648	1060	631	957	832	891	772	4 = 433
										C.V. = 31.1%

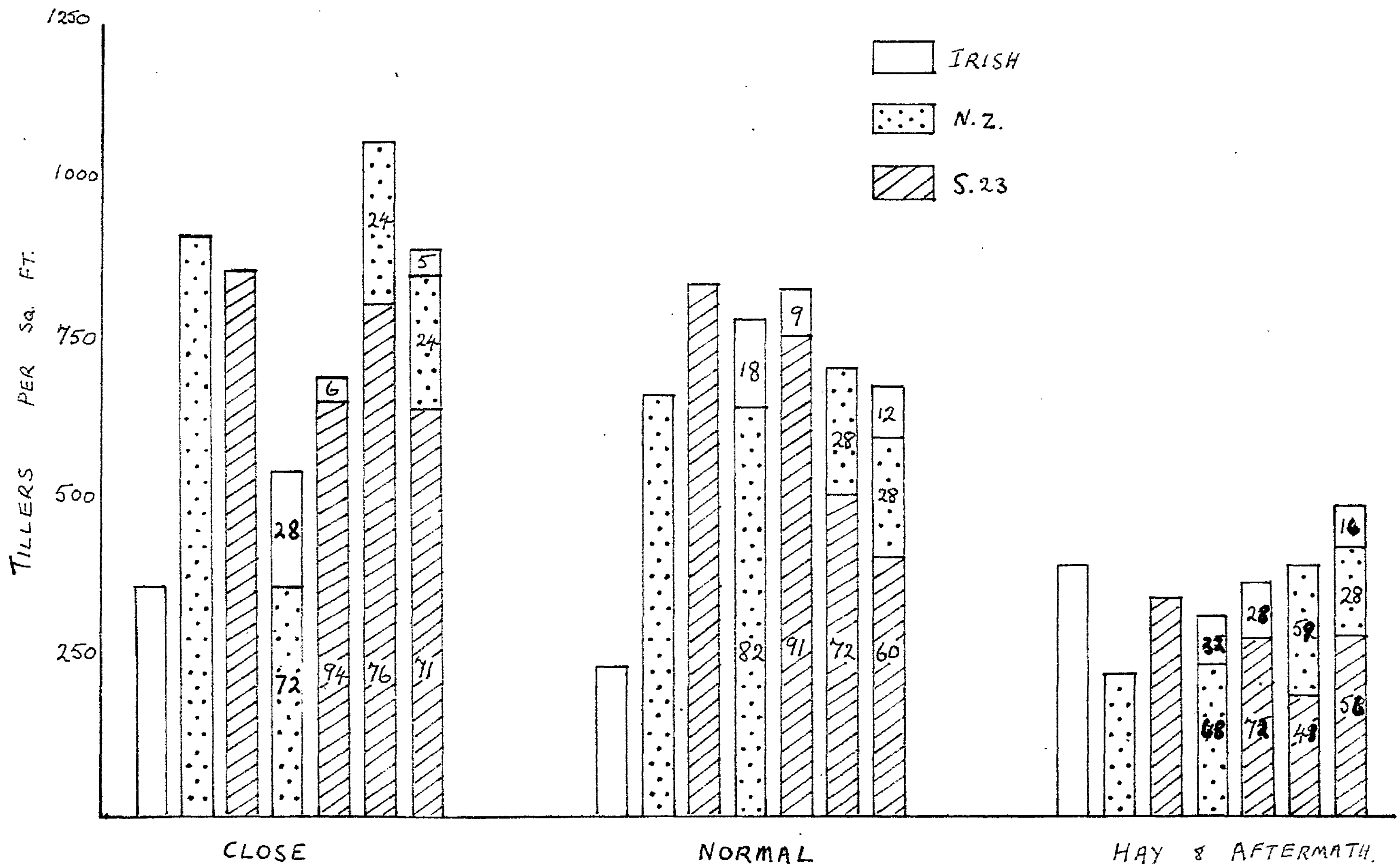


Figure 2.4 Tiller production per sq. ft. and contribution of the components of the mixtures at November 1959.

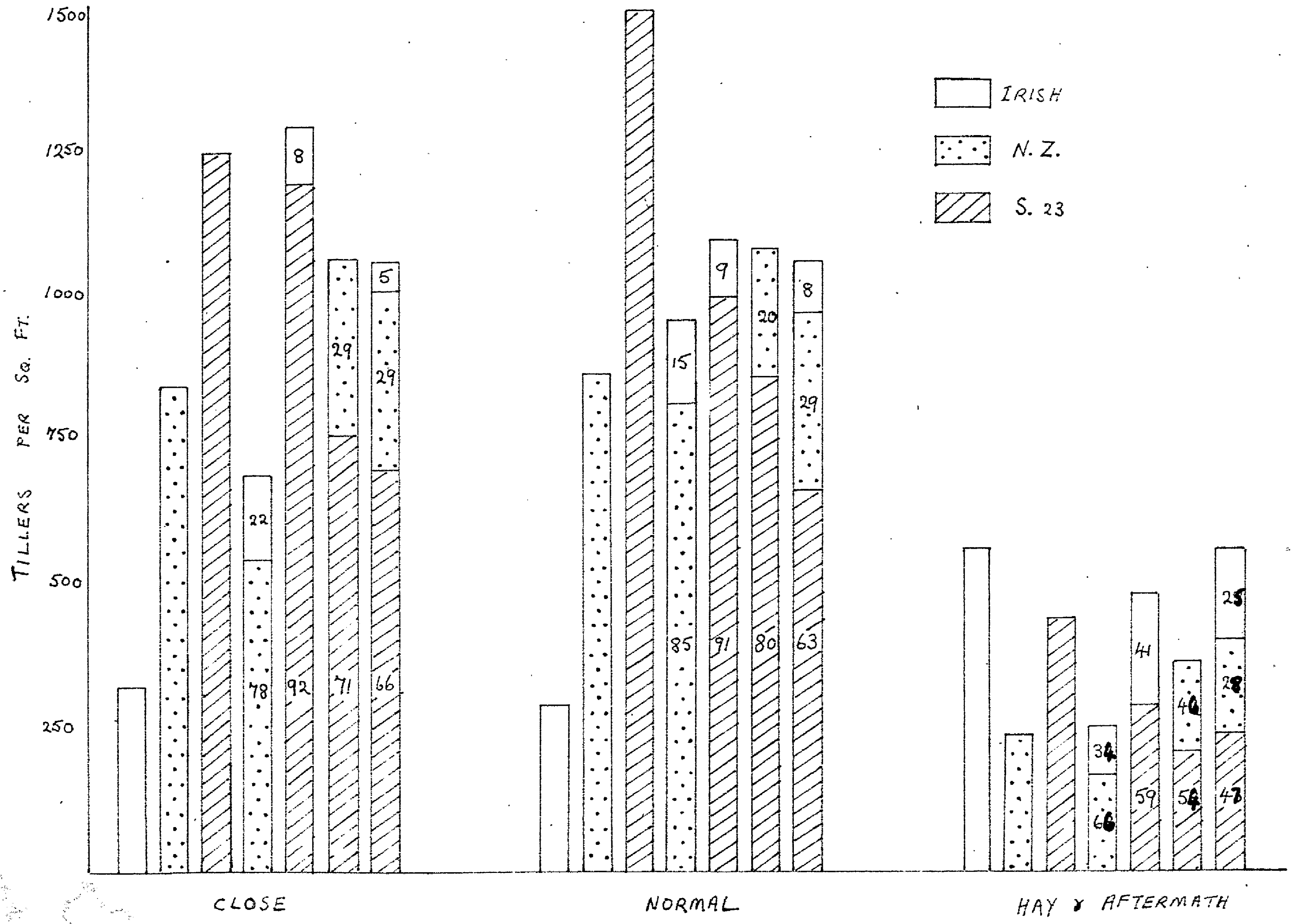


Figure 2.5 Tiller production per sq. ft. and contribution of the components of the mixtures at November 1960.

were repeated in 1960. There were higher numbers under hay management than either of the other two managements and more tillers were produced than by any other variety or combination of two varieties. S.23 alone, and all mixtures with S.23, had the greatest number of tillers in the grazing treatments. S.23 under both grazing systems, and IS in the close treatment, were particularly high.

The smallest number of tillers for all cultivar treatments was recorded in the hay section apart from Irish which did not vary significantly whatever the management.

Contribution and Potential Contribution to Tiller Production by the Components of Cultivar Mixtures

Contribution

The number of tillers produced by the cultivars when growing in mixtures are expressed as percentages of the total tillers produced in table 2.7 and superimposed on the tillers per sq. ft. data in figures 2.4 and 2.5.

November 1959

Irish ryegrass   These results show clearly the suppressive influence of S.23 on Irish especially under grazing conditions where Irish tillers never rose above 9% of the combined total.   In the hay section, Irish did rather better and produced 28% of the tillers.

The effects of New Zealand on Irish were less marked but still of importance.   The trend was for a higher Irish percentage in the close grazed plots, where it was 28% compared to 18% under normal grazing. Under hay management, 32% of the tillers were produced by Irish, an amount comparable to that produced in company with S.23.

The Irish contribution under grazing when combined with New Zealand and S.23 or with only S.23 were similar.   The 16% contributed in the hay treatment, while higher than under grazing, still showed that Irish was being suppressed by its associated cultivars.

New Zealand ryegrass   The New Zealand plants growing with Irish gave the bulk of the tillers produced by the mixture.   The highest contribution of 82% was achieved under normal grazing but was not significantly different from the other management treatments.   In combination with S.23 only 25% and 28% of the tillers were produced in the close and

Table 2.7 Percentage of total tillers per sq. ft. contributed by the components of the mixtures at November 1959 and 1960. Significant differences were calculated from angularly transformed values which are shown (where appropriate) in parenthesis.

Management	1959 Irish with N.Z.	S.23	N.Z.+S.23	$\bar{x}$	L.S.D.	1960 Irish with N.Z.	S.23	N.Z.+S.23	$\bar{x}$	L.S.D.
Close	28	6	5	13	1=N.S.	20	8	5	11(17)	1=9
Normal	18	9	11	13	2=7	14	8	8	10(16)	2,3,4=N.S.
Hay	32	28	16	25	3,4=N.S.	34	41	25	33(35)	C.V.=33.3%
$\bar{x}$	26(29)	14(20)	11(17)	17	C.V.=35.8%	23	19	13	18	

Management	1959 N.Z. with Irish	S.23	Irish+S.23	$\bar{x}$	L.S.D.	1960 N.Z. with Irish	S.23	Irish+S.23	$\bar{x}$	L.S.D.
Close	72	25	25	41	1=N.S.	80(65)	30(33)	30(33)	46	1=N.S.
Normal	82	28	29	46	2=8	86(71)	20(26)	28(32)	45	2=7
Hay	68	59	28	52	3,4=N.S.	66(54)	46(42)	28(32)	47	3=13
$\bar{x}$	74(61)	37(37)	27(31)	46	C.V.=23.1%	77(64)	32(34)	29(32)	46	4=14
										C.V.=19.7%

Management	1959 S.23 with Irish	N.Z.	Irish+N.Z.	$\bar{x}$	L.S.D.	1960 S.23 with Irish	N.Z.	Irish+N.Z.	$\bar{x}$	L.S.D.
Close	94	75	70	80(65)	1=8	92	70	65	76(62)	1=11
Normal	91	72	60	74(61)	2=7	92	80	64	79(64)	2=6
Hay	72	41	56	57(49)	3,4=N.S.	59	54	47	53(47)	3,4=N.S.
$\bar{x}$	86(70)	63(53)	62(52)	70	C.V.=13.9%	81(66)	68(56)	59(50)	69	C.V.=11.6%

normal treatments respectively. In contrast to this New Zealand tillers made up 59% of the total in the hay treatment. With all cultivars in combination New Zealand gave the same contribution under grazing as it had in association with S.23 but did not show the same increase in the hay section as it did in the NS mixture.

S.23 ryegrass Averaged over the management treatments, S.23 was responsible for 86% of the tillers in the IS mixture and significantly less (63% and 62% respectively) in the NS and INS associations. The effect of management was, however, highly significant and the contribution of S.23 was greatly reduced when hay was cut except in combination with both Irish and New Zealand, when the reduction was very slight.

November 1960

The average percentage contributions of the three cultivars were almost identical with the 1959 figures despite the influence of a further year's treatments.

Irish ryegrass For Irish the only major changes were in the hay treatment in association with S.23 as here the contribution was 41% compared with 28% in 1959 and with New Zealand plus S.23 the contribution had risen from 16% to 25%. Otherwise the position of New Zealand and S.23 dominance was maintained.

New Zealand ryegrass The percentages of New Zealand tillers in the various mixtures and managements had not materially altered but statistical confirmation of many of the differences noted in 1959 were obtained. Of most importance was the fact that under hay management the contribution with Irish went down compared to grazing while with S.23 the percentage rose.

S.23 ryegrass The S.23 contributions to tiller numbers were not materially different from the previous year except for the contribution with Irish under hay management which had fallen from 72% to 59%. Overall the highest percentage contributions were obtained under grazing and in mixtures with Irish.

Potential Contribution

As in experiment 1 the precise effect of competition on the tillering ability of the component cultivars in mixtures was calculated by comparing their actual contribution to tiller production with their potential. Table 2.8 shows the results of these calculations which were based on the tiller production of the cultivars growing alone, free from competition, given in table 2.6 and their actual percentage contribution given in table 2.7. The calculations involved were similar to those used in preparation of tables 1.7, 1.8 and 1.9.

November 1959

Irish ryegrass By the end of the first harvest year Irish was being suppressed by New Zealand, S.23 and New Zealand plus S.23 by an average of 28%, 52% and 48% respectively. Behind these averages, there were some very interesting interactions between managements and cultivar treatments.

In combination with New Zealand, no depression of Irish occurred under close grazing, but a 31% suppression was recorded under normal grazing. With S.23, on the other hand, the greatest suppression of 80% occurred in the close treatment and only 59% in the normal. As a further contrast the effects of both New Zealand and S.23 were similar in the hay treatment. In combination with both New Zealand and S.23 the suppression of Irish was similar to the effect of S.23 in the close

Table 2.8 Potential percentage of total tillers per sq. ft. contributed by the components of the mixtures at November 1959 and 1960 assuming no competition between cultivars. The deviation of actual contributions (table 2.7), from potential, are shown alongside each result, and, in parenthesis, the deviations are expressed as a percentage of potential.

Management	1959				1960			
	Irish with				Irish with			
	N.Z.	S.23	N.Z.+S.23	$\bar{x}$	N.Z.	S.23	N.Z.+S.23	$\bar{x}$
Close	28 0(-)	30-24(80)	17-12(71)	25-12(48)	27 -7(26)	20-12(60)	13 -8(62)	20 -9(45)
Normal	26 -8(31)	22-13(59)	14 -3(21)	21 -8(38)	24-10(42)	16 -8(50)	11 -3(27)	17 -7(41)
Hay	64-32(50)	53-25(47)	41-25(61)	53-28(53)	70-36(51)	56-15(27)	45-20(44)	57-24(42)
$\bar{x}$	36-10(28)	33-17(52)	21-10(48)	30-13(43)	37-14(38)	27 -8(30)	18 -5(28)	27 -9(33)
	N.Z. with				N.Z. with			
	Irish	S.23	Irish+S.23	$\bar{x}$	Irish	S.23	Irish+S.23	$\bar{x}$
Close	72 0(-)	51-26(51)	43-18(42)	55-14(25)	73 +7(10)	40-10(25)	35 -5(14)	49 +3(6)
Normal	74 +8(11)	44-16(36)	38 -9(24)	53 -7(13)	76+10(13)	37-17(46)	33 -5(15)	49 -4(8)
Hay	36+32(89)	39+20(50)	23 +5(22)	33+19(58)	30+36(120)	35+11(31)	19 +9(47)	28+19(68)
$\bar{x}$	64+10(16)	47-10(21)	37-10(27)	49 -3(6)	63+14(22)	38 -6(16)	31 -2(6)	44 +2(4)
	S.23 with				S.23 with			
	Irish	N.Z.	Irish+N.Z.	$\bar{x}$	Irish	N.Z.	Irish+N.Z.	$\bar{x}$
Close	70+24(34)	49+26(53)	40+30(75)	53+27(60)	80+12(15)	60+10(17)	52+17(33)	64+12(19)
Normal	78+13(17)	56+16(28)	48+12(25)	61+13(21)	84 +8(10)	63+17(27)	56 +8(14)	68+11(16)
Hay	47+25(53)	61-20(33)	36+20(56)	48 +9(19)	44+15(34)	65-11(17)	36+11(30)	48 +5(10)
$\bar{x}$	67+19(28)	53+10(19)	42+20(48)	54+16(30)	73 +8(11)	62 +6(10)	51 +8(16)	62 +7(11)

management, but was less than either the New Zealand or S.23 effect under normal grazing. By cutting for hay Irish was suppressed by 61% which was rather higher than the New Zealand and S.23 effects separately.

New Zealand ryegrass New Zealand made an overall gain in association with Irish, but was suppressed by S.23 and the combination of Irish and S.23.

The greatest increase by New Zealand was in association with Irish and cut for hay when the potential was exceeded by 89%. In the normal grazing treatment New Zealand made a gain of 11% but under close grazing no increase was recorded. It should be noted that the largest increase achieved by New Zealand over its potential did not correspond with its largest contribution to yield; this was achieved in the normal treatment when 82% of the tillers were from New Zealand. This situation is understandable when it is considered that the suppression of Irish by New Zealand, as shown by the deviations from the potential contributions, was dependent on the vigour of Irish growing by itself. Where this was low, and few tillers produced, New Zealand could not necessarily be said to be suppressing associated Irish plants even although it contributed well over 50% of the total tillers produced by the mixture. Thus New Zealand made its greatest gain of 89% over Irish in the hay section because Irish growing alone was much more vigorous under this management than under grazing.

New Zealand was suppressed by S.23 under both grazing systems, the tendency being for a higher suppression in the close treatment. The change to hay cutting reversed this position and New Zealand gained by 50% over its potential, and also contributed 59% of the tillers. The combination of Irish and S.23 suppressed New Zealand under grazing but to a lesser extent than S.23 alone. New Zealand again showed a gain under hay management which at 22% was lower than with either Irish or S.23 separately.

S.23 ryegrass S.23 showed an increase over its potential under all managements and all cultivar treatments except the hay cut with New Zealand where it was suppressed by 33%. In the grazing managements S.23 made greater gains under close grazing and was particularly high, 75%, in association with both Irish and New Zealand. Increases of the same magnitude were recorded in association with Irish and Irish plus New Zealand in the hay treatment. Evidently so long as Irish was present S.23 was able to increase its tillering but, as has been mentioned, the presence of New Zealand caused a reduced tillering in S.23(under hay).

November 1960

Irish ryegrass By November 1960 Irish was being suppressed by New Zealand under all management systems; ranging from 51% in the hay treatment through 42% in normal to 26% in close. The average depression had increased by 10% from 1959. With S.23 the reverse was true and the average depression had fallen by 22%. This was mainly due to a fall in the depressions under the close grazing and hay treatments. In association with both of the other cultivars, the average depression of Irish was also less than in 1959 due, in this case, mainly to a large fall in the hay treatment.

New Zealand ryegrass New Zealand tillered more freely in association with Irish than with S.23. The gain with Irish was slightly up on the 1959 figure because of increases in the close grazing and hay managements. The suppressive influence of S.23 was noticably less in the close grazing treatment than it had been and, the actual contribution of New Zealand had increased from 25% to 30%. Under normal grazing, the depression of New Zealand was higher than under close grazing and was also slightly higher than the 1959 figure. New Zealand continued to suppress S.23 in the hay section but to a smaller degree than the previous year.

New Zealand, on average, was slightly depressed in combination with Irish plus S.23 but did, in fact, make a substantial gain in the hay section and small, similar losses under the two grazing treatments.

S.23 ryegrass The gain of S.23 in association with Irish averaged 11% but was mostly made in the hay section where a 34% increase was recorded. With New Zealand, S.23 continued to show a larger contribution than its potential under grazing but, as in 1959, was suppressed by cutting for hay. In the INS mixture S.23 made gains in all management treatments but it is of interest to note that all were less than in 1959.

DISCUSSION

Assessment of the Method

The wire mesh technique allowed identification of plants with similar vegetative appearance over the two years of the experiment under both intensive sheep grazing and hay management.

The grazing of the sheep was, on the whole, very even and few tufts had to be removed by hand. Due to the arrangement of the main plots within the paddock, the close grazing treatment (in replicate 1) was at one end and separated from the next close grazing plot by two hay and aftermath and two normal grazing plots. As a result the sheep tended to neglect this plot which, although evenly grazed, was never so closely grazed as the others. This suggests that either a larger paddock should have been used in order to give the sheep more freedom of movement or, alternatively, strict adherence to randomisation could have been waived in order to bring similar grazing treatments closer together. This could have been accomplished while still retaining the basic block arrangement.

The siting of the trial in an already established grass field removed the necessity for controlling weed growth around the plots and provided the animals with a firm footing. The contiguity of the plots and the holding area made the sheep quiet and apparently unaware of any departure from normal. Any tendency for the established turf to encroach on the mesh was easily controlled by occasionally clipping round each main plot with sheep shears.

The method of establishment by sowing two seeds per square was successful and less tedious than the method used in experiment 1. But it was fortunate that there was no excessive rainfall during the establishment period which could have caused the movement of seeds. To guard against such a possibility it would be advisable to protect the plots, during the establishment phase, by the use of transparent polythene sheeting which could be carried on a framework over each main plot.

It was obvious when counting tillers that, the greater the number that could be counted, the better would be the result since plant to plant variation was high. Initially, every plant in each plot was counted but progress was so slow that this had to be abandoned. Eventually, six was arbitrarily selected as being the number that could be counted in a reasonable time. In practice, it took almost 2 man-weeks to count the tillers on 6 plants of each cultivar per plot.

Development of Cultivars when Growing Alone

The 3 cultivars showed little difference in development by the end of the establishment year, the tillers per plant being 15.1, 16.2 and 15.2 for Irish, New Zealand and S.23 respectively. This indicates that, initially, the rate of tiller production was similar for these cultivars and agrees with the work of Davies (1960). Only 4 Irish and 2 New Zealand plants had died which, of no consequence at this date, did foreshadow what was to come.

Percentage survival

By July of 1959, differences in survival of the cultivars were noticeable especially where the plots had been grazed. S.23 was most persistent followed by New Zealand and Irish, in that order, although the difference between S.23 and New Zealand was very slight. Where the hay crop had been taken the ranking of the cultivars was the same but the range from top to bottom was very much less. This interaction of cultivars with management was due to two factors: 1) The inherent ability of S.23 to survive under grazing by the production of new tillers and the lack of this faculty in Irish and to a lesser degree in New Zealand. 2) The prostrate growth habit of S.23 ensured that, although the sheep grazed fairly close, a certain proportion of basal tillers always remained after defoliation, whereas with Irish in particular, but also New Zealand, their upright habit allowed the sheep to remove practically all top growth. This effect could be seen quite clearly by eye after most grazings.

When these two factors operate together under field conditions it can be appreciated why, under grazing, more Irish and New Zealand plants will die compared to S.23. By cutting for hay, the effect of selective defoliation is removed and as this management was not conducive to profuse tillering, the difference between the cultivars was therefore less. Previous work in the Netherlands, Sonneveld (1955) and Van den Bergh et al. (1958) has shown that hay management is favourable to upright cultivars and grazing to prostrate types.

Four months later (November 1959), the average percentage survival of Irish had been halved and was 36% compared to 63% and 69% for New Zealand and S.23 respectively. The important fact was, however, that the cultivars did not react similarly to the management imposed.

Under grazing, the survivals of New Zealand and S.23 were respectively 80% and 83% while that of Irish was only 36%.

As the Irish survival was not affected by the number of grazings this suggests that a point had been passed in the normal treatment (12 defoliations) beyond which further grazings had little effect. The level to which the plants were grazed was $\frac{1}{4}$" - $\frac{1}{2}$" for both close and normal grazing and may have been a more important factor. The survival of New Zealand and S.23, on the other hand, was apparently higher under the more frequent defoliation system, although this was not confirmed statistically.

The poor survival of Irish emphasised the need for avoiding the use of upright, stemmy cultivars in mixtures intended for intensive grazing by sheep. Davies (1959) discussed the physiological background of plant reserves and defoliation relationships and showed how upright plants will suffer under frequent defoliation compared to prostrate types. Figure 2.6 shows a pure Irish plot alongside a pure S.23 plot prior to grazing in the spring of 1960. The open nature of the Irish sward and the extreme poverty of its production can be appreciated.

Figure 2.6 A pure sown Irish plot (on the left) alongside a pure S.23 sown plot (on the right) prior to grazing in the spring of 1960.

Neither tiller nor plant numbers can record this situation as, in counting, a poor plant or tiller has the same value as a good one. This photograph does not exaggerate the difference between these cultivars and was typical of all replicates. It is therefore important when interpreting the numerical results to remember that, under grazing, Irish was - plant for plant and tiller for tiller - much inferior to S.23. The same remarks apply, but to a lesser degree, to the comparison of Irish and New Zealand.

The reason why New Zealand, also of upright habit, was better able to survive sheep grazing than Irish can be attributed to its morphology; being a leafier plant with a higher ratio of vegetative to flowering tillers than Irish, New Zealand is better able to withstand frequent defoliations.

It was observed that some plants had been completely or partially uprooted by the sheep and these were mostly confined to the Irish plots. By frequent defoliation not only is the amount of top growth produced lowered but, the root growth suffers in a like manner (Roberts and Hunt (1936)). Therefore the frequent sheep grazing must have reduced root growth to a point where the plants no longer had a sufficiently strong hold on the soil, and were then pulled out. Under a cutting management such plants may well have survived for a longer period.

The survival of all three cultivars in the hay treatment was similar and, in the case of New Zealand and S.23, very much lower than under grazing. Evidently, with New Zealand and S.23, intra-cultivar competition was more severe within the tall growths of the hay and aftermath crops than in the shorter growths of the grazing treatments, resulting in a greater suppression of the weaker members of their populations. In this present experiment, the position may have been accentuated as there was some scorching of plants when a dry spell followed the fertilizer application after the first aftermath crop. It was impossible to determine which plants had died through the competitive action of their neighbours and which by fertilizer scorch. This could have been avoided by dividing the fertilizer into 2 or 3 parts and applying them at weekly intervals and this procedure was followed after subsequent harvests.

In the case of Irish, where survival under grazing was no better than when hay was cut, the effect of the grazing animal was similar to the inter-plant competition of the hay and aftermath management.

Plant death rate slowed down considerably during 1960 suggesting that the weaker members of the populations had been eliminated in the first year and the survivors would only gradually succumb given the same management. Or it is possible that the less intensive utilization of 1960 allowed plants to survive which would otherwise have died. It is interesting to note that between November 1959 and November 1960 the mean percentage survival of Irish, New Zealand and S.23 fell respectively by 14%, 12% and 13%. It is also noteworthy that the major portion of this loss took place during the 1960 growing season and not over the winter of 1959-60.

The open spaces left in the grazed Irish swards, as the ryegrass was grazed out, were colonised by annual meadow grass (Poa annua L.) which did not encroach on the surviving Irish plants and the presence of which can therefore be discounted as having any competitive effect.

The survival of Irish was not significantly affected by management at any period during 1960 whereas, both New Zealand and S.23 had very much reduced percentage survivals in the hay section, thus continuing the trend seen in the previous year. S.23 had a significantly lower survival under the normal grazing management than under close grazing. The actual difference at the final count was 21% between close and normal grazing. New Zealand showed a similar, but not significant, trend and the difference between its survival under normal and close grazing was, at the final count, 17%. Such a situation could have arisen because the more upright types within the S.23 and New Zealand populations were eliminated by the management of the normal treatment which allowed longer intervals between grazings and so would permit the more erect types to be carried into a position where they were more readily available to the sheep and consequently were grazed out. As will be seen when tiller numbers are discussed this did not lead to a more open sward as the surviving plants tillered more freely in the greater space available to them. This supports the above hypothesis which suggests that the poorer tillering, or upright, types were eliminated leaving the more prostrate ones, and these were able to flourish under the management which caused the death of the others.

Irish did not show this effect to the same degree, there being only 4% difference between its survival in the normal and close treatments. This may have been due to the inherent poor tillering and stemmy characteristics of Irish, which caused all but an average of of 20% of its initial number to die under the intensive grazing of both systems.

<u>Tiller Production</u>

Considering now the tiller production per plant, the 1959 results revealed no important differences between cultivars signifying that, although there were considerably fewer plants per unit area of Irish and consequently more room for development, the Irish did not possess the ability to exploit it by producing more tillers per plant.

In the second year, the tiller number per plant rose for all cultivars and this may have been a reflection of the fewer number of plants present and, in the case of the grazing managements, a combination of this and the less frequent defoliations. Overall, New Zealand exhibited the smallest increase, and S.23 the largest, especially in the normally grazed plots, which was undoubtedly a result of the poorer survival in this treatment. The final result, in November 1960, was therefore that, averaged over the three managements, Irish, New Zealand and S.23 had respectively 47, 34 and 55 tillers per plant. Although this suggests that New Zealand was the least productive, the results of experiment 1 showed it to have a higher weight per tiller which would counterbalance the smaller number. As for Irish, figure 2.6, as already seen, describes much more clearly than could be done by words or numerals the productivity of Irish tillers.

Management had no significant effect on tillers per plant in 1959, but in 1960, both New Zealand and S.23 produced more tillers under normal grazing than when cut for hay. In the close section, the difference was not great and S.23 actually had rather more tillers in the hay treatment. Irish plants appeared quite unaffected by management.

Survival and Development of Cultivars in Mixtures

Irish + New Zealand

The survival of Irish was not significantly affected by competition from New Zealand in either year of the trial but there was a consistent trend towards a lower survival under hay management indicating that New Zealand exercised its greatest competitive effect when a mature vegetation was allowed to develop. Apart from a rather lower survival in 1959, and up till July 1960 when in association with S.23, the survival of Irish was singularly unaffected by companion cultivars, irrespective of the management imposed. This could be explained in four ways:-

(a) that there was no competition between cultivars,

(b) that competition did occur but was not severe enough to result in the death of plants,

(c) that competition occurred, but was reflected purely in the productivity of each tiller or plant and not in tiller or plant numbers, and

(d) that the grazing managements were of such intensity as to outweigh any effect of competition on plant numbers. The hay and aftermath section, on the other hand, provided the most congenial environment for Irish and it was thus able to compete to greater advantage with New Zealand and S.23.

In view of the evidence provided by experiment 1, the first explanation would appear to be most unlikely. The true explanation probably lies in a combination of the other factors mentioned. The grazing pressure was undoubtedly heavy and could have eliminated all but the most persistent plants of Irish irrespective of companion cultivars. It must, however, be borne in mind that a plant with only one weak tiller had to be considered as surviving; plant numbers can therefore be a very imperfect measure of competition.

The second point is supported by the results for tillers per plant at November 1959 when Irish growing with New Zealand and/or S.23 had fewer tillers than Irish growing alone. These effects were quite substantial and amounted to depressions of 28%, 52% and 36% in the IN, IS and INS mixtures respectively. The following year the extreme variability of the results made interpretation difficult but it did appear that, under grazing, the presence of New Zealand and/or S.23 did reduce the tillering ability of Irish.

As the number of Irish plants present in the IN mixture were relatively small and New Zealand reduced the tillering capacity of the survivors it is not surprising that New Zealand contributed the greatest number of tillers to the total of the mixture. Irish contribution was lowest under normal grazing where only 18% and 14% were recorded in 1959 and 1960 respectively. With close grazing, Irish performed slightly better and gave 28% and 20% in 1959 and 1960. Since a taller growth of herbage was permitted under normal grazing the more vigorous New Zealand had a better opportunity to shade, and so suppress, neighbouring Irish plants. The suppression of Irish compared to its potential confirms this as, in 1959, no suppression was apparent in the close treatment while 31% was recorded under normal grazing. The following year, Irish was being suppressed under both grazing managements and the figures for close and normal respectively were 26% and 42%. It therefore appears that New Zealand was exerting a progressively greater influence on Irish especially where a longer interval was allowed between defoliations.

The hay management of this mixture gave Irish a better opportunity to exhibit its main attribute, the production of a large crop. But as New Zealand was also of upright habit it still continued to play the dominant role in the mixture. Thus, although Irish contributed 32% and 34% to the total tiller production in 1959 and 1960 respectively, it was in fact being more severely suppressed than under grazing. The reduction from its potential was 50% and 51% in the first and second years respectively. It will be noticed that despite the fact that New Zealand was exerting its greatest influence under this management it had not increased from 1959 to 1960 as it had done under grazing.

The very low productivity of Irish tillers observable when Irish was growing alone plus its low contribution to tiller numbers in the IN mixture under grazing, indicated that its contribution to the yield of the mixture must have been very low. The yield contribution to the hay and aftermath crops would, however, have been higher, not only because of a higher tiller contribution, but there was no noticable difference between the tillers of Irish and New Zealand under hay cutting.

The overall picture therefore appears to be that, in a mixture of Irish and New Zealand, the New Zealand will become dominant under all management systems and that its dominance will increase as the intervals between defoliations lengthen.

Irish + S.23

Under grazing, S.23 rapidly gained almost complete ascendency over Irish so that, by the end of the first harvest year, Irish contributed only 6% and 9% of the total tillers produced by the mixture in the close and normal treatments respectively. This was due to several causes, not the least of which was the basic differences between these two cultivars which were displayed when they were growing alone. Thus when placed together S.23 caused a sharp reduction in the number of tillers produced by each plant of Irish and this added to the low survival of Irish accounts for its very poor performance in this mixture.

Under the different defoliation system of experiment 1, it was the third harvest year before S.23 gained a similar degree of dominance over Irish, and the probable reason for these divergent results can be found in the work of Norman (1960). He showed how competition can induce a plant to assume a more upright habit and so become more vulnerable to defoliation. Thus, the competitive influence of the more rapid tillering S.23 on Irish would force it into an even more upright position than it naturally assumes, with the consequent removal of a higher proportion of its herbage at the next grazing. In experiment 1 where the defoliation system was quite unselective as regards upright or prostrate habit such an effect would be unimportant or non-existent.

In 1960, the Irish contribution with S.23 was 8% in both close and normal treatments, showing little change from the previous year. Consideration of the suppression of Irish compared to its potential shows that Irish was being suppressed to a lesser extent in 1960 than 1959 in the close grazing system. The suppression in the normal treatments was also less but only slightly. This situation arose because so many plants in the pure Irish plots had died off under close grazing. In November 1959 33% were surviving when Irish was alone and 26% with S.23 but in November 1960 only 22% had survived in the pure plots while 26% still survived in association with S.23. This result gave Irish a lower potential in 1960 and so the suppressive influence of S.23 was less. The underlying cause of this result is not apparent from the available data.

The inability of S.23 to dominate Irish to the same extent, where hay and aftermath were taken, as it did under grazing was very striking. The trend was actually in the opposite direction since the contribution of Irish rose from 25% in 1959 to 41% in 1960. Undoubtedly the taller growth of Irish produced under these conditions prevented its complete suppression. It is interesting to find that Irish had increased its contribution in the final year as, if S.23 was going to be eventually suppressed, the expectation would have been for this to occur in the first year. The relative growth cycles and growth habits of Irish and S.23, and the work of Jones (1958a), lead to this conclusion.

As a sheep grazing mixture, the combination of Irish and S.23 would be unsuccessful in providing a more level seasonal production since, by the end of one season, it would be virtually an S.23 sward. Moreover early grazing, at the heights of growth adhered to in this experiment, would prevent the expression of the rapid growth phase of Irish which was shown, in experiment 1, to be associated with heading. Therefore, not even in the spring of the first harvest year, would any benefit accrue from this mixture compared to S.23 alone.

The hay and aftermath crops, on the other hand, did contain a significant amount of Irish and such a mixture might be expected to produce an earlier, bulkier crop than would be possible from S.23 alone. Conversely the presence of the later maturing S.23 would make for a better quality product than Irish alone.

New Zealand + S.23

In this mixture, a better balance between the early and late maturing cultivars was achieved, and maintained, over the two harvest years. Under close and normal grazing respectively New Zealand contributed 25% and 28% of the tillers at November 1959. By November 1960, these had changed only slightly to 30% and 20%. In terms of actual suppression, New Zealand was gaining on S.23 under close grazing, the depression from its potential falling from 51% in 1959 to 25% in 1960. S.23 gained its dominance over New Zealand by reducing the number of tillers on each New Zealand plant and also by causing a greater number of deaths than took place when New Zealand was growing alone. That these effects were more severe under normal grazing, where the foliage was taller, is quite understandable as this would lead to greater mutual shading.

In both grazing managements, the proportion of tillers contributed by New Zealand and S.23 approached the hypothetical ideal yield ratio of 30/70 advanced in the discussion of experiment 1. That such a ratio was recorded in experiment 2 (when the management was completely different) is extremely interesting; but it cannot be assumed that a positive yield interaction would follow under grazing conditions.

When hay was taken, not only was New Zealand able to resist the aggressiveness of S.23 but, in 1959, actually produced 59% of the tillers. The only surprising aspect is that New Zealand did not dominate the mixture to a greater extent, and the fact that it did not emphasises the ability of S.23 to succeed under adverse conditions. As it was, however, S.23 was suppressed by 33% of its potential.

The following year the contribution of New Zealand was down to 46% and S.23 was only being suppressed by 17% of its potential. This was mainly due to a reduction in the number of tillers per plant of New Zealand. It would therefore appear, if two year's results can be taken as sufficient to show trends, that even by taking a hay and two aftermath cuts the prostrate S.23 was more than holding its own in association with New Zealand. This result does not agree with the findings of Jones (1958a) who maintained that, by allowing the herbage to reach the silage stage before cutting each spring, the late cultivar would be progressively suppressed.

Judging by the results of experiment 1, the contribution to total tiller production of 59% in November by New Zealand would indicate a much larger share of the yield in the early part of the year. It may therefore be assumed that the hay crop would be dominantly New Zealand and the aftermaths an approximately equal mixture with S.23.

Irish + New Zealand + S.23

In this mixture the percentage contribution of S.23 remained between 60 - 70 under both grazing managements and in both years. New Zealand was the next highest contributor giving between 25% - 30% which did not vary greatly between years or managements. Irish had the lowest contribution which was 5% under close grazing in both years and slightly higher at 11% and 8%, under normal grazing, in 1959 and 1960 respectively. S.23 was therefore gaining its dominance at the expense of Irish while New Zealand was only slightly suppressed.

The proportions of approximately 10/25/65 in which the tiller production was divided for Irish/New Zealand/S.23 (in the grazing treatments) were similar to the ratios obtained in the final year of experiment 1. The grazing managements of experiment 2 had, therefore, not changed the actual inter-cultivar competition effects in this mixture but had accelerated them by one season.

When cut for hay and aftermath, the dominance of S.23 was somewhat reduced and in November 1959 only 56% of the tillers produced were from S.23 compared to 70% and 60% in the close and normal grazing treatments respectively. New Zealand was again the major contributor of the early maturing cultivars giving 28% of the tillers while the balance of 16% was made up by Irish. The following year saw a fairly substantial change in these proportions; the S.23 percentage fell to 47% and Irish increased to 25% while New Zealand remained unaltered.

As in the IS mixture, under hay management, the increase of S.23 over its potential was less in 1960 than 1959 which showed that the early cultivars were, not only withstanding, but reducing the aggressiveness of S.23. In the NS mixture, S.23 had been suppressed and therefore its gain in the INS combination was obviously made at the expense of Irish.

New Zealand in the INS combination, like S.23, was contributing more than its potential and showed an increase from 22% in 1959 to 47% in 1960. Irish too, although suppressed in both years, did better its position between 1959 and 1960 and the depression, compared to its potential, changed from -66% to -44%. By examination of the results for percentage survival and tillers per plant (tables 2.2, 2.3 and 2.5) the reduction in S.23 contribution and aggressiveness was seen to be due to a considerable fall in its survival which was 58% in 1959 and only 36% in 1960. These survivors did produce 10 more tillers per plant, but this was not sufficient to offset the loss in plant numbers. Irish and New Zealand had little or no loss of plants over the same period, and both showed an increase in tillers per plant, especially Irish which increased by 14. It would therefore appear that the large loss of Irish and New Zealand plants occurred in the first harvest year while S.23 had a more gradual fall, which was still continuing. The continuation of such a trend may have led to the eventual suppression of S.23.

It was seen that in the IS mixture (under hay management) Irish was suppressed, but appeared to be improving its position, while in the NS mixture, S.23 was suppressed but to a lesser extent in the second year. These results were obtained from plots originally composed of 50% of each cultivar and therefore in the INS mixture, when the balance was weighted against S.23, it is not surprising that the early cultivars were moving into the dominant position and, at the last count, jointly provided more tillers than S.23. Even these results cannot be said to confirm the findings of Jones (1958a), but it may be, as has been suggested, that in subsequent years a suppression of the late cultivar would have occurred.

SUMMARY OF EXPERIMENT 2

1. Using the wire-mesh technique developed for experiment 1, the persistence and development of Irish, New Zealand and S.23 ryegrass, and mixtures of these cultivars, were assessed under two sheep grazing treatments and a hay and aftermath cutting treatment. No difficulty was experienced in getting the sheep to graze the plots evenly. The siting of the experiment in an existing sward removed the necessity for controlling weed-growth around the plots and aroused no anxiety in the sheep since the experimental plots blended with the surrounding sward.

Cultivars Growing Alone

2. Irish ryegrass

At the end of the seeding year, the persistency and tiller development of Irish was very similar to that of New Zealand and S.23. But, in the following year under the impact of sheep grazing and hay management, the Irish plants rapidly died off; indeed, only 36% were surviving by the end of the year. The continuation of the treatments for a second year caused further deaths of Irish plants and, at the end of the experiment, only an average of 22% were surviving. In terms of tiller numbers per plant, Irish did not differ materially from New Zealand or S.23 but, when grazed, the appearance of the Irish swards showed them to be completely devoid of vigour.

3. New Zealand ryegrass

The percentage survival of New Zealand under grazing fell gradually but was always higher under the close grazing treatment. At the end of the second harvest year the survival under close and normal grazing was, respectively, 74% and 57%. Under hay management the survival fell sharply between July and November of the first harvest year to 31%. Thereafter the fall was gradual to a final level of 22%. Tiller numbers per plant were similar to the other cultivars in the first harvest year but less in the second year. Under normal grazing more tillers were produced than in the close grazing and hay treatments.

4. <u>S.23 ryegrass</u>

S.23 had the highest survival of all cultivars when grazed. At the final count, 82% and 61% of the plants were surviving in the close and normal grazing treatments respectively. When cut for hay and aftermath the survival had fallen to 41% by the end of the first harvest year and continued to fall at a lower rate to 24% at the final count. The tillering was similar to Irish and New Zealand in the first harvest year but showed a greater average increase in the second year than either of the others. More tillers were produced under normal than close grazing or hay treatment.

<u>Cultivars in Mixtures</u>

5. <u>Irish + New Zealand</u>

New Zealand dominated Irish under all managements and its effect was most noticeable in reducing the number of tillers produced per plant of Irish. As the intervals between defoliations lengthened the aggressiveness of New Zealand increased. Despite this Irish was able to contribute a greater proportion of tillers to the total produced by the mixture under hay management than under grazing. The suppression of Irish was progressive under grazing but remained unchanged over the two harvest years when hay and aftermath was taken.

6. Irish + S.23

The mixture was completely dominated by S.23 under both grazing managements; Irish contributing less than 10% of the tillers produced. The presence of S.23 caused a large reduction in the number of tillers produced per plant of Irish. Under hay management Irish was also suppressed, but to a much smaller extent, and produced a substantial proportion of the tillers, especially in the second year.

7. New Zealand + S.23

Under grazing, S.23 was the major cultivar but did not suppress New Zealand to the same extent as it did Irish. The aggressiveness of S.23 was more marked in the taller growths permitted in the normal grazing treatment. Both the number of plants and tillers per plant of New Zealand were reduced in competition with S.23.

The hay treatment changed the relative aggressiveness and S.23 was suppressed by New Zealand although it did contribute an average of 50% of the tillers.

8. Irish + New Zealand + S.23

S.23 produced the bulk of the tillers in both harvest years when this mixture was grazed. The S.23 dominance was gained more at the expense of Irish than of New Zealand which contributed approximately three times the number of tillers produced by Irish. When cut for hay and aftermath the dominance of S.23 was reduced and in the second year the early cultivars jointly produced the greater proportion of the tillers. This reduction in the contribution and aggressiveness of S.23 was caused by a relatively high death rate of plants.

Conclusions

9. Under both close and normal grazing managements, S.23 dominated Irish and New Zealand either singly or in combination by virtue of its higher survival and tillering capacity. New Zealand was the dominant cultivar in mixture with Irish due to a better survival and higher tillering capacity. The relative contributions of the cultivars to tiller production were similar to those recorded in experiment 1 but were achieved within two harvest years. In the case of the IS mixture this position was reached in one year as compared to the third harvest year in experiment 1. Therefore, the grazing treatments speeded up the inter-cultivar effects without changing their magnitude.

10. The hay and aftermath cutting gave rise to different results from the grazing treatments. There were also differences from the cutting treatments of experiment 1. Irish continued to be suppressed by S.23 but to a lesser extent, while New Zealand was able to dominate S.23. Where all three cultivars were in association, S.23 was the major contributor only in the first year and was exceeded by the joint tiller production of the early maturing cultivars in the second year. It may be surmised that had this trend continued the suppression of S.23 would have ensued.

Experiment 3

The Competition between Cultivars of Perennial Ryegrass During the Establishment Year of a Sward

INTRODUCTION

In experiments 1 and 2 the swards were established respectively by planting out or sowing seed at 2 inch centres. This spacing, while typical of plants in established pastures, was much wider than that available to young seedlings in a newly sown sward. It was therefore felt that some information may have been lost on the competitive relationships during the period when the young plants were in extremely close association and the sward rapidly thinning out. As seed and shoot weight have been shown to be closely correlated during the seedling stage (Davies (1960)), the possibility of a suppression of S.23 by New Zealand and Irish, which have heavier seeds, could not be ignored. If such a suppression were to take place, and was severe enough to cause the death of S.23 plants, it would have meant that, under actual sward conditions, the equal proportions of cultivars planted or sown in experiments 1 and 2 could not have been achieved in practice from initial sowings of the same number of seeds of each cultivar.

Experiment 3 was carried out to measure the inter-cultivar competition between Irish, New Zealand Certified Mother Strain and S.23 perennial ryegrass in the year of sowing when the plants had one quarter of the area allowed each plant in experiments 1 and 2. The object being to verify, or disprove, that the mixture proportions of the cultivars, at the commencement of the treatment years in experiments 1 and 2, were typical of what would follow from normal sowings of equal seed numbers of each cultivar.

EXPERIMENTAL METHOD

Identification Equipment

The similarity in appearance of the cultivars again demanded that a technique for their positive identification be employed. Since the plants were to be grown at much closer spacing than that used in experiments 1 and 2 another form of mesh had to be devised. It was considered that "Weldmesh" would occupy a disproportionately large area of the surface, at the closer spacing, compared to that available for the plants. Such a situation could conceivably influence the results.

The mesh was constructed of a frame of 12" perforated Meccano strips bolted together to form a square with fine gauge, lacquered, copper wire interlaced at right angles to form 36 one inch square areas within the Meccano frame work. Figure 3.1 shows two completed frames ready for positioning in the field. A complete replicate is shown in figure 3.2 where the seven frames required to accommodate the different cultivar combinations can be seen. Each frame was secured to two wooden runners which were buried in the soil thus bringing the wires of the mesh to ground level and serving to anchor the frames firmly.

Design and Treatments

A simple randomised block design was used to compare the seven possible combinations of Irish, New Zealand and S.23. Four replicates were allowed for, making a total of 28 plots.

The arrangements of the cultivars within each sampling area was the same as was used in experiment 1 (see figure 1.3). Each sampling area was surrounded by two discard rows.

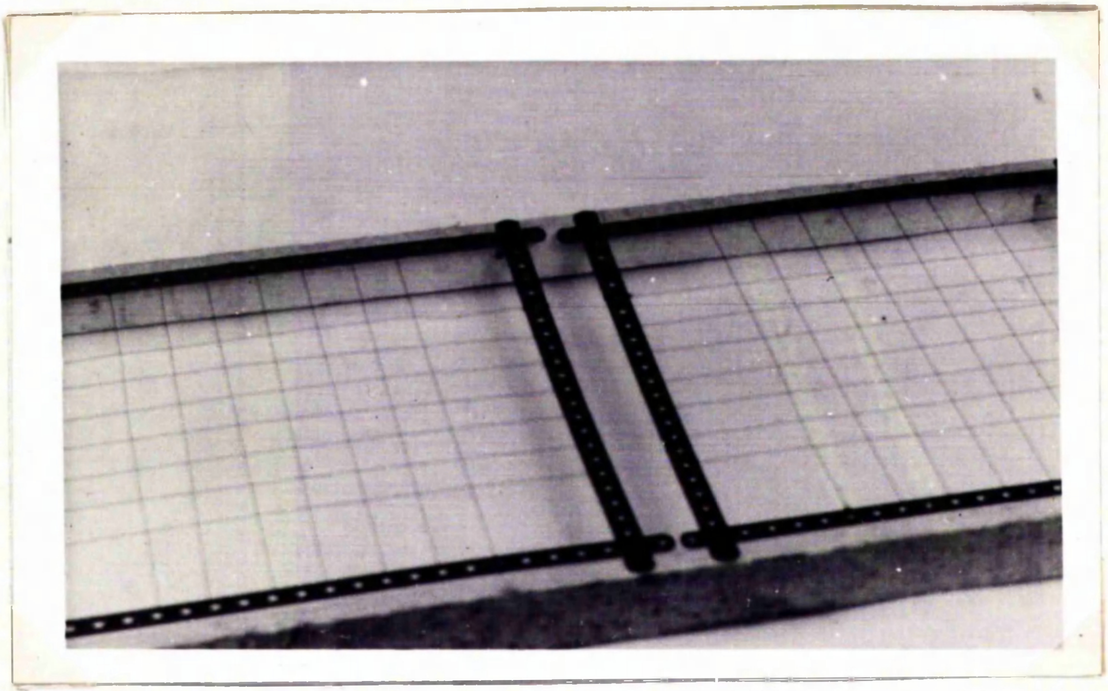


Figure 3.1 Two Meccano strip frames interlaced with fine wire and secured to wooden runners.

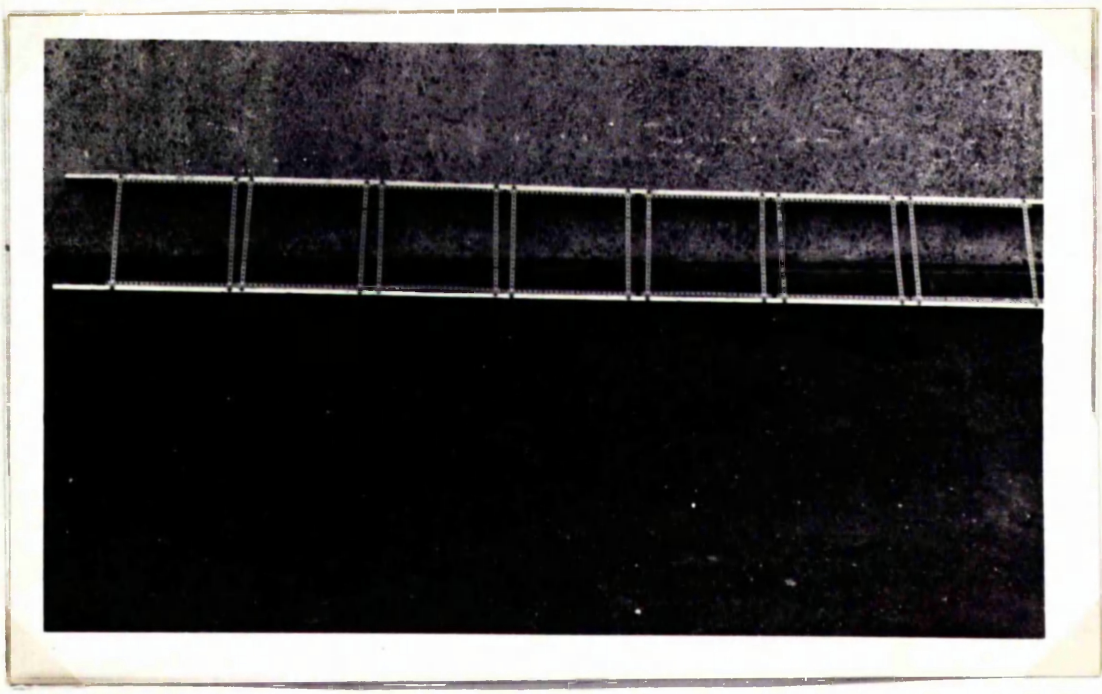


Figure 3.2 A complete replicate of 7 frames ready for positioning in the field.

As the wire used was very fine it was impossible to colour it (as in Experiment 1) in order to assist in identification of the cultivars. A master-plan was therefore drawn up at the commencement of the experiment which showed the position of each cultivar within the sampling areas. Constant reference to these plans during plant and tiller counts enabled accurate identifications to be made. This method of identification was much slower than that previously used but as the trial was intended to run for only a short period of time, and the number of plots relatively small, rapidity of identification was not an important factor.

Preparation of Site and Establishment

The field site was prepared during March 1959 by first skimming off the turf from an established pasture to expose an area large enough to accommodate the four replicates. The top 3" of soil was riddled, then levelled and rolled.

The area was then scorched, using a flame gun, to reduce weed competition and the possibility of finding an unsown ryegrass appearing in the experiment. Three cwt. per acre of the special fertilizer mixture employed in experiment 1 was applied over all plots.

On 15th - 16th April the frames were placed in position and two seeds were placed in each square according to the design of the master plan. As each plot was sown the seeds were carefully covered by riddled top-soil.

The seedlings were singled to one per square on 15th May and blank squares were filled from the surplus plants available. The end plots of one replicate had suffered from rain washing and several plants were seen to be displaced from their original squares. As there were not sufficient seedlings available to completely re-plant these plots the whole replicate was discarded so reducing the experiment to 3 replications of 7 treatments; a total of 21 plots.

The seed sources were the same as for experiment 2.

Assessment of Competition

The competition between cultivars was estimated by plant and tiller counts taken at varying intervals after sowing. The actual dates and number of days after sowing are shown in table 3.1.

At the first and last counts, when there was little leafage on the plants, no pre-cutting was carried out but at all other times the plots were trimmed down to approximately 2" using a rotary cutter which collected the clippings. This was done to facilitate more rapid and easier counting as the very close spacing of the plants and consequent intertwining of stems and leaves made identification very difficult when the full top-growth was present. Figure 3.3 shows the plants in the frames prior to being cut and counted.

The tiller counts were made on six plants of each cultivar occurring in a plot. The counts were made along the diagonals chosen at random and, where plants were missing, the counting was continued to neighbouring rows until six were counted.

All basic data were analysed by the analysis of variance technique.

Table 3.1 Dates on which tiller and plant counts were made and number of days after sowing on which they occurred.

	1959						1960
Date	4/6	26/6	27/7	21/8	23/9	2/11	27/4
No. of days after sowing	49	71	102	127	160	200	377

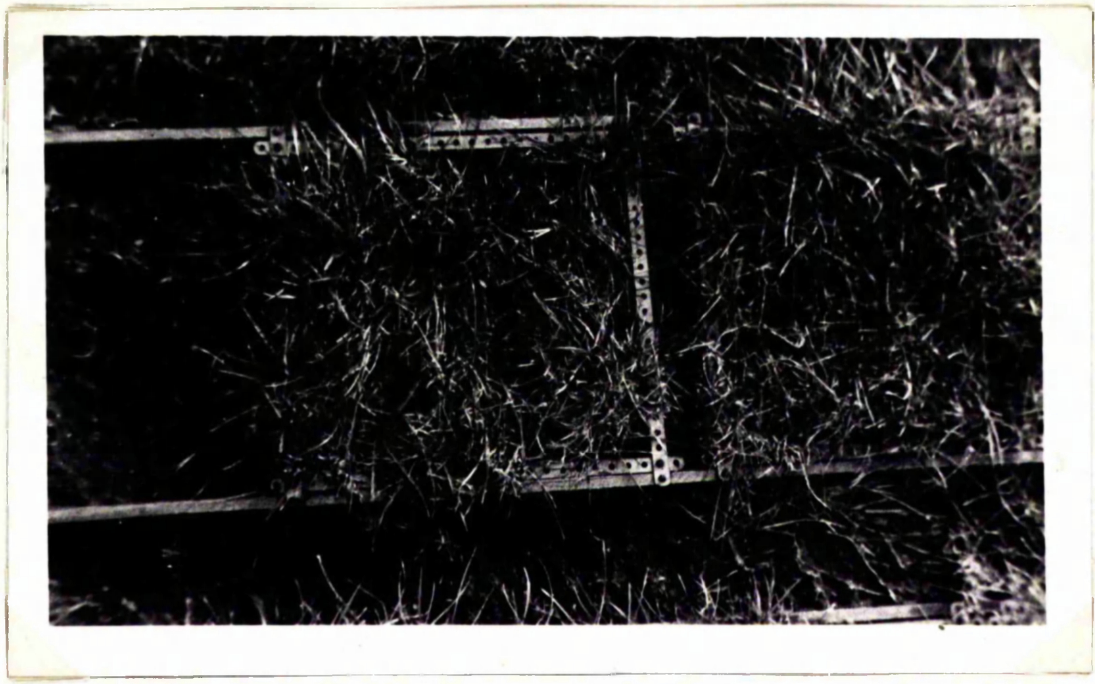


Figure 3.3 Established plants growing in the wire mesh prior to being cut down and counted.

RESULTS

Plant and Tiller Numbers

Plant Survival

The percentage survival of each cultivar growing alone and in mixtures is given in table 3.2 for the period from 49 - 377 days after sowing.

Cultivars growing alone

During the establishment year (1959) there was no noticable difference between the survivals of the cultivars growing alone. There was, however, a marked loss of Irish and New Zealand plants over winter. In April 1960 (377 days after sowing), the survivals of Irish, New Zealand and S.23 were 73%, 79% and 93% respectively.

Cultivars in mixtures

Irish ryegrass The only significant difference between the survival of Irish growing alone and in mixtures occurred at the count made 71 days after sowing when, in company with S.23, the survival had been reduced to 87% compared to 95% for Irish alone. Irish survival in association with S.23 was thereafter always lower than Irish alone, although the difference gradually diminished, until, at the final count there was only 1% between them.

In combination with New Zealand or New Zealand plus S.23 the survival of Irish did not vary greatly from Irish growing alone. The largest difference occurred 377 days after sowing when, in association with New Zealand, the Irish survival was 8% higher than Irish growing alone.

Table 3.2 Percentage survival of cultivars alone and in mixtures. Significant differences were calculated on angularly transformed values which are shown (where appropriate) in parenthesis.

		Days after Sowing						
Cultivar	Treatment	49	71	102	127	160	200	377
	Alone	99	95(80)	93	94	93	91	73
	with N.Z.	100	96(81)	93	93	91	87	81
Irish	" S.23	92	87(69)	83	83	83	82	72
	" N.Z.+S.23	94	94(79)	94	92	86	87	75
	$\bar{x}$	96	93	91	90	88	86	75
	L.S.D.	N.S.	6	N.S.	N.S.	N.S.	N.S.	N.S.
	C.V.%	7.4	3.7	7.5	6.2	12.3	13.5	17.4
	Alone	96	94	93	92	88	89	79
	with Irish	93	87	91	85	80	80	79
N.Z.	" S.23	98	93	93	91	89	89	87
	" Irish+S.23	92	92	89	89	89	86	89
	$\bar{x}$	95	91	91	89	86	86	84
	L.S.D.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	C.V.%	7.1	8.4	8.8	10.5	10.4	11.8	14.5
	Alone	98	96	95	94	94	94	93
	with Irish	94	93	94	93	93	91	92
S.23	" N.Z.	94	91	89	87	87	85	85
	" Irish+N.Z.	97	90	92	92	86	86	83
	$\bar{x}$	96	92	93	91	90	89	88
	L.S.D.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	C.V.%	7.5	12.0	8.2	13.8	15.8	15.7	14.9

New Zealand and S.23 ryegrass Neither the survival of New Zealand nor S.23 was significantly affected by companion cultivars at any period during the investigation. The only apparent trend was a slightly lower survival of S.23 when growing in association with New Zealand or New Zealand plus Irish compared to S.23 growing alone.

Tillers per Plant

The tiller production per plant of each cultivar growing alone and in mixtures is given in table 3.3.

Cultivars growing alone

There were little material differences in tiller production per plant of the three cultivars. All showed a rapid increase until 71 days after sowing and then gradually declined. In the spring of 1960 S.23 was the only cultivar which had a higher tiller number than that recorded in the previous November.

Cultivars in mixtures

Irish ryegrass By 49 days after sowing the peculiar result was recorded that Irish, growing with either New Zealand or S.23, had rather fewer tillers per plant than when growing alone, but, in combination with both cultivars, there were rather more tillers produced. This anomalous situation did not appear again. Over the remainder of the investigational period Irish tended to produce more tillers per plant in association with S.23 than when growing alone. The effect of New Zealand was variable and slight as was New Zealand plus S.23.

New Zealand ryegrass In association with S.23 there was an increase in New Zealand tillering except in November 1959 when only 5.9 tillers were produced per plant compared to 6.9 for New Zealand alone. At

Table 3.3 Mean tiller number per plant.

Cultivar	Treatment	49	71	102	127	160	200	377
		Days after Sowing						
	Alone	6.2	9.6	7.3	6.4	4.4	5.3	4.9
	with N.Z.	4.5	8.7	6.0	6.7	5.6	4.7	6.4
Irish	" S.23	5.0	10.5	9.8	10.1	8.4	6.6	6.3
	" N.Z.+S.23	7.2	10.7	7.1	7.1	5.1	3.4	5.2
	$\bar{x}$	5.7	9.9	7.6	7.6	5.9	5.0	5.7
	L.S.D.	1.9	N.S.	N.S.	N.S.	N.S.	2.1	N.S.
	C.V.%	16.5	19.7	29.3	25.9	26.4	20.8	42.4
	Alone	4.9	9.2	6.3	7.2	6.3	6.9	5.3
	with Irish	4.3	10.0	8.0	9.2	8.4	9.1	7.2
N.Z.	" S.23	7.4	11.1	8.8	7.8	6.6	5.9	6.7
	" Irish+S.23	6.1	10.0	5.6	5.7	5.5	6.2	7.3
	$\bar{x}$	5.7	10.1	7.2	7.5	6.7	7.0	6.6
	L.S.D.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	1.4
	C.V.%	35.3	17.6	30.7	27.1	44.3	34.6	10.9
	Alone	5.2	9.7	7.8	6.3	5.1	4.6	5.7
	with Irish	4.2	9.1	9.5	7.0	5.8	5.1	9.4
S.23	" N.Z.	5.3	10.9	8.2	6.5	5.2	4.2	7.2
	" Irish+N.Z.	5.8	10.4	8.0	6.8	5.8	5.9	9.7
	$\bar{x}$	5.1	10.0	8.4	6.7	5.5	5.0	8.0
	L.S.D.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	C.V.%	16.3	21.0	19.7	18.2	34.8	31.2	30.5

the final count the increase due to the presence of S.23 just failed to reach significance. Combined with Irish slightly fewer tillers were initially produced but subsequently there were always more than New Zealand alone. The results in combination with both Irish and S.23 were variable and showed an increase up to 71 days after sowing, then a decrease until April 1960 when a significant increase was recorded.

S.23 ryegrass The tillering of S.23 plants was not significantly affected by associated cultivars at any time during the investigation. In most cases, however, there were slightly more tillers produced by each S.23 plant when in mixtures than when in pure sowings.

Competitive Effects

To precisely measure inter-cultivar competition as it affected both plant survival and tillers per plant, the percentage contribution to tiller production per unit area of each cultivar in a mixture was calculated in a similar manner as described in experiment 1 (page 66). By expressing the deviations of actual contribution from potential (as a percentage of potential) values descriptive of the results of inter-cultivar competition were obtained. These values are shown in table 3.4. Three dates, at the first and last counts in the seeding year and at the final count the following April, were chosen to show the trends in the competitive influences.

49 Days after Sowing

In the first growth, from the seedling stage, New Zealand was the most aggressive of the cultivars. Its presence reduced Irish tillering capacity by 7% of its potential and S.23 by 19%. The competitive powers of Irish and S.23 were fairly evenly balanced and only

Table 3.4 Actual percentage contribution to total tillers produced in mixed sowings by each cultivar in the mixture, expressed as percentage deviations from the potential contribution of each cultivar.

Days after sowing	Date	Irish With			N.Z. With			S.23 With		
		N.Z.	S.23	N.Z.+S.23	Irish	S.23	Irish+S.23	Irish	N.Z.	Irish+N.Z.
49	4/6/59	-7	-2	0	+9	+21	0	+2	-19	0
200	2/11/59	-16	+4	-32	+12	-8	0	-4	+12	+34
377	27/4/60	+4	-15	-19	-4	+9	+9	+10	-7	+5

a 2% depression of Irish and a 2% gain by S.23 were recorded. When all three cultivars were together each contributed the exact amount of its potential.

200 Days after Sowing

New Zealand was still exerting a suppressive effect on Irish which now registered -16% of its potential tillering capacity. S.23 had, on the other hand, recovered from its initial setback and was now causing an 8% depression of New Zealand tillering. The balance between Irish and S.23 was still fairly even although it showed a change in direction (in favour of Irish) compared to the 49 day period. The association of all cultivars produced a substantial depression, by 32%, of Irish which was made up by an equally large gain by S.23. The New Zealand tillering capacity remained unaltered; evidently any gain that it made against Irish was offset by the aggressiveness of S.23.

377 Days after Sowing

At the start of what would have been the first harvest year, had the trial been continued, the largest effects of inter-cultivar competition were displayed by Irish. In association with S.23 or S.23 plus New Zealand the Irish contribution to the total tillers produced by these mixtures was reduced by 15% and 19% respectively. Irish made a slight gain when in association with New Zealand.

S.23 showed a small depression of its potential when in competition with New Zealand and a 10% gain in its association with Irish. New Zealand and S.23 gained 9% and 5% respectively in the INS mixture.

DISCUSSION

The spacing chosen - one seed per sq. inch - is roughly equivalent to the space available to ryegrasses sown at 26 lb. of seed per acre. The results obtained were, therefore, closely similar to farm practice. And the cutting frequency (approximately monthly) simulated the management that would normally be given to an establishing sward sown without a "cover" crop.

At a spacing of one inch, it was possible to identify the squares containing the different cultivars but this became increasingly difficult as the season advanced (it would probably have been impossible to have gone beyond the first season). While the technique is satisfactory for the examination of plant development during the seeding year, the spacing was too close to permit the rapid sampling necessary for yield determination.

Plant Survival and Development

Cultivars Growing Alone

The death rate of all cultivars was similar during the seeding year and only over the first winter did the greater persistence of S.23, seen in experiments 1 and 2, manifest itself.

The tiller numbers per plant were also similar for all cultivars although, at the first count (49 days after sowing) Irish did have slightly more than New Zealand or S.23. Davies (1960) who carried out a similar study found S.23 slightly slower in tiller production than Irish or New Zealand initially, but in two trials the relative position of the early maturing cultivars were reversed.

In the spring of the year following seeding, S.23 had rather more tillers than New Zealand or Irish and this finding agrees with the work of Davies (1960). Obviously the inherent high tillering attribute possessed by S.23 was more than able to compensate for the initial advantage of the early maturing cultivars, which resulted from their higher seed weights, and consequent more rapid development, (Davies (1960)).

Cultivars in Competition

Although initially Irish had a slight advantage in terms of tillers per plant this did not effect the ability of associated cultivars to tiller and survive and, in fact, at 49 days after sowing Irish itself was slightly suppressed, especially in the mixture with New Zealand.

New Zealand was, however, more aggressive towards S.23 and did markedly reduce its development as assessed at the first count. S.23 recovered from this position and by November of the seeding year was actually causing a slight depression of New Zealand. The suppression of Irish by New Zealand was still continuing and had increased, but Irish was no longer being suppressed by S.23 and, conversely, showed a gain in its presence. The swing was, however, very small and from a practical viewpoint it could be said that neither Irish nor S.23 were affected by each other's presence.

In April of 1960 (377 days after sowing) Irish was no longer being suppressed by New Zealand but was producing 15% less than its potential in association with S.23. The position of relative aggressiveness between New Zealand and S.23 had again changed and S.23 was slightly suppressed, but not to nearly the same degree as it had been 49 days after sowing. As S.23 rapidly recovered from its original suppression there is good reason to assume that it would do so again, especially as the effect was less severe.

When all three cultivars were growing together Irish was the only one which was suppressed and overall S.23 showed the largest gain.

It is therefore apparent that, although initially suppressed by New Zealand, S.23 can compete favourably with early maturing ryegrass cultivars of upright habit in the seeding year of a sward. Charles (1961) showed how the tiller population of S.23 was greatly reduced by the presence of Italian ryegrass (S.22) during the establishment year and that S.24 ryegrass was also reduced but to a lesser degree than S.23. He also showed that the suppression of S.23 was less when the grasses were established under a cover crop.

The investigations of Charles (1960) further indicated that, after the establishment year, the late maturing cultivar will eventually dominate the sward despite its initial suppression.

This latter finding lends support to the results of experiment 3 and also experiments 1 and 2. It can therefore be confidently stated that, inter-cultivar competition in the establishment phase of a sward between Irish, New Zealand and S.23, will not alter the relative populations or plant development in a manner likely to influence the subsequent effects of competition which were so markedly displayed in experiments 1 and 2.

SUMMARY OF EXPERIMENT 3

1. The use of a fine wire mesh, allowing 1 sq. inch per plant, was satisfactory for the identification of the cultivars. Much greater care had to be taken to ensure accurate identification of the plants than was necessary at the wider spacing used in experiments 1 and 2 and was, consequently, slower. Due to the spread of plants it is doubtful if the trial could have been carried on for a longer period than was done. It is considered that, at 1 inch spacing, it would be well-nigh impossible to make rapid and accurate yield determinations of the components of cultivar mixtures.
2. The effects of inter-cultivar competition were apparent 49 days after sowing when the most marked effect was the suppression of S.23 by New Zealand. This, however, did not last and by the end of the seeding year S.23 was suppressing New Zealand. The competitive effects between Irish and S.23 were very slight in the seeding year. Irish was slightly suppressed by New Zealand. The largest suppression recorded was of Irish when in association with both New Zealand and S.23.
3. In the spring of the year following sowing the largest effect of competition was again on Irish which was being suppressed when in association with S.23 and S.23 plus New Zealand. The presence of New Zealand caused a slight depression of S.23 growth.
4. The experiment showed that, although competition did take place between the contrasting cultivars during the seeding year, the initially slower-developing S.23 was not suppressed to a degree which would change the inter-cultivar relationships noted in experiments 1 and 2.

GENERAL SUMMARY

TECHNIQUES EMPLOYED

(i) The competition - within mixed sowings of Irish, New Zealand and S.23 perennial ryegrass - was measured in terms of plant survival and development and the effect on the seasonal and total yield of the cultivars, by the use of a technique which permitted rapid and accurate identification and sampling under simulated sward conditions (experiment 1). The identification technique was also applied to a study of the effects of competition on plant development and survival when the swards were subjected to two intensities of sheep grazing or cut for hay and aftermath production (experiment 2). By a modification of the technique used in experiments 1 and 2 an investigation was also made of the competition between the selected cultivars during the establishment phase of a sward (experiment 3).

(ii) Basically, the technique employed in experiments 1 and 2 consisted of growing the plants within the squares of a wire mesh placed permanently at ground level. Each square of the mesh was painted in a distinctive colour to indicate the positions of the cultivars, and by this and other physical aids, the grasses were easily identified and sampled. In experiments 1 and 2 the plants were grown at two inch centres but in experiment 3, to more closely simulate field conditions, a smaller mesh was used and the seeds were sown at one inch centres. While this latter method was adequate to evaluate the plant development over a period of one year, the close spacing would have made cutting for yield determinations extremely difficult.

(iii) In experiment 1, each plant was individually cut and in this way the yields of the components of cultivar mixtures were determined over the three years of the trial. Supporting evidence in the form of plant and tiller counts was also recorded. In experiments 2 and 3 no yield data were recorded and competition between the cultivars was assessed by plant and tiller counts.

EFFECTS OF COMPETITION IN CULTIVAR MIXTURES

(i) Under sheep grazing, or when cut at approximately grazing height, the late maturing, prostrate cultivar S.23 dominated both of the early maturing upright cultivars, Irish and New Zealand by virtue of its greater persistence and tillering capacity.

(ii) Irish was more severely affected by competition from S.23 than was New Zealand. By the third treatment year of experiment 1 (defoliated by hand shears) and the end of the first treatment year of experiment 2 (defoliated by sheep grazing), Irish was making only a very small contribution to the tiller production of the mixture with S.23. Where yield assessment was made, Irish was seen to be contributing less than 10% of the total production of the mixture. The suppression of Irish by S.23 was progressive, the Irish contribution to yield and tillers produced falling gradually over the years. The more rapid dominance of S.23 under grazing was due, in part, to the selective action of the sheep which removed most of the upright growing top growth of Irish, while leaving the basal prostrate tillers of S.23 untouched.

(iii) New Zealand made a substantially higher contribution to yield and tiller numbers in association with S.23 than did Irish. An important feature of the mixture of New Zealand and S.23 was the fact that, although considerably suppressed in the summer and autumn of each year, New Zealand recovered each spring to contribute nearly as much as S.23 to the total yield of the mixture (experiment 1). In the final years of both the cutting and grazing experiments, New Zealand was still making up between 25 - 30% of the tiller population.

(iv) In mixture with Irish, New Zealand gradually became dominant and produced the major portion of the yield. Irish was never suppressed to the same degree as it was in association with S.23 and, under grazing conditions, simulated or actual, gave around 20% of the yield and tiller production in the final years.

(v) When Irish, New Zealand and S.23 were growing together S.23 became dominant mainly by suppression of Irish. The New Zealand contribution to yield and tiller production was little affected by competition due to the compensating effects of the aggressiveness of S.23 and the lack of vigour in Irish.

(vi) By delaying the first cut each spring until Irish and New Zealand had reached ear emergence the aggressiveness of S.23 was reduced. Both of the early cultivars continued to be, on average, suppressed under this management but the contribution that they were able to make to yield was noticably increased (except that of Irish in the final year when S.23 suppressed it to much the same degree under all managements). Similarly the suppression of Irish by New Zealand was less when a longer uninterrupted growth period was allowed in spring.

(vii) By allowing the grasses to mature to the hay stage before cutting (experiment 2), the suppressive influence of S.23 on New Zealand was completely overcome and S.23 itself was suppressed. Irish continued to be suppressed but to a much less degree in the second year of the trial. S.23 initially maintained the dominant role in combination with both of the early cultivars under hay and aftermath management; any tendency for its suppression by New Zealand being counter-balanced by its suppression of Irish. After two years of this management, the early cultivars were jointly producing over 50% of the tillers in the mixture and the aggressiveness of S.23, although still functioning, was markedly reduced.

(viii) Competition between the cultivars was shown to take place during the establishment phase of a sward (experiment 3). The inter-cultivar effects were, however, variable. There was no evidence to suggest that S.23 was suppressed to such a degree as to affect its subsequent rise to the dominant position demonstrated in experiments 1 and 2.

PRODUCTION OF MIXTURES RELATIVE TO CULTIVARS GROWING ALONE

(i) The similarity in the early spring yield of the late maturing cultivar (S.23) and the early maturing cultivars (Irish and New Zealand) before the early cultivars entered their rapid growth phase, precluded any advantage being gained (in terms of more level production) by the combination of an early and a late cultivar. Only when stem elongation of the early-maturing cultivars commenced was any smoothing of the growth curve observed in mixtures with S.23. The mixture of Irish and S.23 hardly showed this at all due to the rapid suppression of Irish.

(ii) Although the distribution of seasonal growth was improved slightly by combining early and late maturing cultivars, the effect was very small compared to the change in distribution which resulted by altering the time of taking the first cut in spring; the later the cut the greater the percentage of total production produced in it.

(iii) In the case of the New Zealand and S.23 mixture, the growth-rate and total yield of the mixture was considerably greater than either of its components growing alone. This may have been due to the upright and prostrate growth habits of these two cultivars which enabled better use to be made of the available growth space and sunlight (it was easily noticable in spring that New Zealand and S.23 occupied the upper and lower layers of the sward respectively). This positive interaction did not occur in the first harvest year and only under certain cutting frequencies in the second and third harvest years. Apart from one instance, where no positive interaction occurred, the higher yield displayed by this mixture only took place when the yield was divided approximately in the ratio 30/70 from New Zealand and S.23 respectively.

(iv) In the third harvest year of experiment 1, the Irish in mixture with New Zealand also gave a higher yield than its components separately. Examination of the individual yields of the cultivars in the mixture showed that the major portion of the yield was being produced by the New Zealand component. The New Zealand yield in association with Irish was, in fact, greater than that from New Zealand growing alone and was being produced from a smaller number of tillers. Evidently the greater space afforded the New Zealand plants in the mixture (due to the poor survival and tillering capacity of Irish) permitted a higher yield per tiller than was possible from the more closely spaced plants in the pure New Zealand swards. This positive interaction between New Zealand and Irish occurred only under one frequency of cutting and there was no indication that a particular balance between the cultivars was necessary for its expression (as seemed to be required in the mixture of New Zealand and S.23).

(v) In general the evidence was in favour of the use of cultivar mixtures compared to the same cultivars growing alone.

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APPENDIX 1

Table A1.1 Weekly Soil Temperature and Rainfall for the Period of the Experiment.

Week	Temperature 1 ft. below ground °F.	Mean Temperature/ Month	Inches Rain	Total Rain/ Month
July 1957				
30 - 6	60.9		0.66	
7 - 13	60.5		0.67	
14 - 20	59.4	59.9	0.59	3.25
21 - 27	59.7		1.31	
August				
28 - 3	58.6		0.02	
4 - 10	61.1		1.41	
11 - 17	59.7	58.7	0.61	4.95
18 - 24	58.3		2.17	
25 - 31	55.6		0.78	
September				
1 - 7	56.2		0.90	
8 - 14	54.6		0.97	
15 - 21	53.1	53.9	2.02	4.16
22 - 28	52.4		0.27	
October				
22 - 5	50.4		0.36	
6 - 12	51.9	50.4	0.11	4.1
13 - 19	51.2		1.43	
20 - 26	48.8		1.59	
November				
27 - 2	49.9		1.49	
3 - 9	44.4		0.37	
10 - 16	43.7	45.0	0.06	1.89
17 - 23	44.9		0.51	
24 - 30	46.1		0.1	
December				
1 - 7	43.9		1.05	
8 - 14	41.8		0.18	
15 - 21	40.5	42.1	0.93	2.76
22 - 28	41.8		0.41	
January 1958				
29 - 4	40.5		0.36	
5 - 11	39.8		2.49	
12 - 18	40.0	39.3	0.21	3.93
19 - 25	37.6		0.72	

Table A1.1 continued.

Week	Temperature 1 ft. below ground °F.	Mean Temperature/ Month	Inches Rain	Total Rain/ Month
February				
26 - 1	40.0		0.35	
2 - 8	39.5		0.95	
9 - 15	38.2	38.9	1.8	3.22
16 - 22	39.8		0.82	
March				
23 - 1	38.4		0.31	
2 - 8	40.3		0.1	
9 - 15	36.2	38.0	0.0	0.71
16 - 22	36.6		0.0	
23 - 29	37.9		0.56	
April				
30 - 5	40.6		0.21	
6 - 12	41.0		0.0	
13 - 19	43.6	43.7	0.4	1.18
20 - 26	46.8		0.56	
May				
27 - 3	48.5		0.06	
4 - 10	49.6		0.9	
11 - 17	49.8	50.1	0.06	2.64
18 - 24	50.0		1.41	
25 - 31	50.8		0.27	
June				
1 - 7	54.1		0.61	
8 - 14	54.7		1.0	
15 - 21	56.2	55.2	0.29	2.72
22 - 28	55.4		0.56	
July				
29 - 5	58.1		0.31	
6 - 12	60.7		0.77	
13 - 19	59.0	59.2	0.93	4.44
20 - 26	59.1		0.89	
August				
27 - 2	58.5		2.73	
3 - 9	58.3		0.76	
10 - 16	59.1	58.7	1.44	4.24
17 - 23	58.9		0.80	
24 - 30	58.1		0.29	
September				
31 - 6	59.3		1.67	
7 - 13	58.9		0.21	
14 - 20	58.4	57.6	0.44	3.91
21 - 27	55.3		0.77	

Table Al.1 continued.

Week	Temperature 1 ft. below ground °F.	Mean Temperature/ Month	Inches Rain	Total Rain/ Month
October				
28 - 4	54.1		1.77	
5 - 11	52.1		1.12	
12 - 18	50.2	51.6	0.78	3.36
19 - 25	51.3		0.14	
November				
26 - 1	50.9		1.13	
2 - 8	49.3		0.48	
9 - 15	45.7	46.8	0.22	1.43
16 - 22	47.6		Trace	
23 - 29	44.5		Trace	
December				
30 - 6	41.7		0.02	
7 - 13	40.1		1.55	
14 - 20	38.7	40.4	1.06	3.69
21 - 27	40.8		1.01	
January 1959				
28 - 3	41.1		1.17	
4 - 10	36.5		0.03	
11 - 17	34.4	35.7	0.06	1.41
18 - 24	34.6		0.56	
25 - 31	34.9		0.08	
February				
1 - 7	34.3		0.01	
8 - 14	34.1		0.51	
15 - 21	39.0	37.4	0.23	1.54
22 - 28	42.9		0.79	
March				
1 - 7	43.1		0.23	
8 - 14	41.9		0.98	
15 - 21	41.8	42.7	Trace	1.90
22 - 28	43.2		0.53	
April				
29 - 4	45.1		0.23	
5 - 11	43.7		0.78	
12 - 18	47.4	46.6	0.13	1.83
19 - 25	48.5		0.48	
May				
26 - 2	47.4		0.49	
3 - 9	48.2		0.16	
10 - 16	54.7	53.4	0.72	1.41
17 - 23	55.2		0.08	
24 - 30	56.7		-	

Week	Temperature 1 ft. below ground °F.	Mean Temperature/ Month	Inches Rain	Total Rain/ Month
June				
31 - 6	55.8		0.78	
7 - 13	54.6		0.85	
14 - 20	56.8	56.6	0.01	3.50
21 - 27	58.6		1.74	
July				
28 - 4	58.0		1.01	
5 - 11	59.4		0.92	
12 - 18	57.6	59.1	0.82	4.41
19 - 25	60.0		0.07	
August				
26 - 1	60.3		2.05	
2 - 8	59.4		0.12	
9 - 15	60.3	59.7	0.17	0.57
16 - 22	59.2		0.06	
23 - 29	60.1		0.22	
September				
30 - 5	57.7		-	
6 - 12	57.2		-	
13 - 19	56.0	56.1	-	1.46
20 - 26	55.3		1.46	
October				
27 - 3	54.4		Trace	
4 - 10	55.0		-	
11 - 17	53.8		1.85	
18 - 24	52.3	52.8	1.77	5.53
25 - 31	49.1		1.91	
November				
1 - 7	48.8		0.15	
8 - 14	44.8		1.41	
15 - 21	44.3	46.3	0.35	3.67
22 - 28	47.4		1.58	
December				
29 - 5	43.6		0.62	
6 - 12	42.5		0.33	
13 - 19	42.9	42.7	1.39	4.49
20 - 26	42.5		1.08	
January 1960				
27 - 2	43.3		1.27	
3 - 9	41.0		0.23	
10 - 16	38.8	39.9	0.06	3.7
17 - 23	39.3		1.65	
24 - 30	40.0		1.66	

Table A1.1 continued.

Week	Temperature 1 ft. below ground °F.	Mean Temperature/ Month	Inches Rain	Total Rain/ Month
February				
31 - 6	41.5		0.96	
7 - 13	37.7		0.07	
14 - 20	36.4	38.3	0.64	2.62
21 - 27	36.8		0.80	
March				
28 - 5	42.4		0.98	
6 - 12	40.4		0.04	
13 - 19	42.4	42.0	0.62	1.70
20 - 26	42.6		0.31	
April				
27 - 2	42.1		0.12	
3 - 9	45.3		1.40	
10 - 16	46.5	46.7	0.61	2.16
17 - 23	47.3		0.03	
24 - 30	48.8		-	
May				
1 - 7	50.1		0.16	
8 - 14	52.1		0.62	
15 - 21	53.6	52.6	-	1.44
22 - 28	53.6		0.65	
June				
29 - 4	56.0		0.13	
5 - 11	57.6		1.0	
12 - 18	56.1	57.9	0.41	1.68
19 - 25	59.3		-	
July				
26 - 2	59.5		0.15	
3 - 9	58.7		1.11	
10 - 16	56.7	58.6	0.63	2.66
17 - 23	58.6		0.65	
24 - 30	38.7		0.21	
August				
31 - 6	59.1		0.46	
7 - 13	58.9		0.23	
14 - 20	57.6	58.5	0.61	3.38
21 - 27	58.3		2.12	
September				
28 - 3	58.3		0.31	
4 - 10	56.6		0.56	
11 - 17	56.6	55.4	1.63	2.78
18 - 24	54.5		0.21	
October				
25 - 1	52.4		0.01	
2 - 8	52.6		0.83	
9 - 15	50.0	50.5	Trace	2.13
16 - 22	49.2		0.56	
22 - 29	50.0		0.06	

Table A1.2 Minimum Temperature at Soil Level for January, February, March and April in 1958-59-60 and Number of Days when Temperatures of 32°F. or Under were Recorded.

	Minimum Temperature on Soil Surface		Mean Temperature/Week
January 1958			
1	22		
2	14		
3	16		
4	28		25
5	35		
6	30		
7	29		
8	29		
9	35		
10	33		
11	30		26
12	18		
13	16		
14	23		
15	42		
16	42		
17	35		
18	29		28
19	17	Thermometers	
20	18	covered in	
21	16	snow.	
22	8		
23	9		
24	13		
25	14		23
26	34		
27	39		
28	45		
29	32		
30	29		
31	29		
February 1958			
1	39		28
2	20		
3	21		
4	28		
5	31		
6	19		
7	8		
8	21	Thermometers	22
9	17	in snow.	
10	27		
11	30		

Table A1.2 continued.

	Minimum Temperature on Soil Surface	Mean Temperature/Week
12	35	
13	32	
14	33	
15	37	29
16	34	
17	17	
18	14	
19	28	
20	37	
21	39	
22	28	30
23	-	
24	30	
25	20) Snow	
26	8	
27	27	
28	34	
March 1958		
1	40	28
2	22	
3	25	
4	39	
5	40	
6	25	
7	27	
8	20) Snow	20
9	10	
10	10	
11	9	
12	17	
13	24	
14	17	
15	30	22
16	21	
17	24	
18	18	
19	21	
20	9	
21	18	
22	19	21
23	26	
24	25	
25	30	
26	30	
27	35	
28	35	
29	35	34

Table A1.2 continued.

	Minimum Temperature on Soil Surface	Mean Temperature/Week
30	34	
31	34	
April 1958		
1	35	
2	15	
3	21	
4	26	
5	32	25
6	23	
7	29	
8	32	
9	24	
10	32	
11	19	
12	20	25
13	20	
14	28	
15	31	
16	30	
17	36	
18	39	
19	42	36
20	40	
21	36	
22	31	
23	41	
24	38	
25	32	
26	33	37
27	32	
28	39	
29	44	
30	39	
January 1959		
1	31	
2	28	
3	20	20
4	20	
5	15	
6	12	
7	17	
8	13	
9	17	
10	12	
11	13	15
12	18	
13	19	
14	15	

Table A1.2 continued.

	Minimum Temperature on Soil Surface	Mean Temperature/Week
15	10	
16	14	
17	21	
18	29	23
19	37	
20	29	
21	20	
22	20	
23	10	
24	18	
25	12	17
26	17	
27	21	
28	20	
29	26	
30	27	
31	18	
February 1959		
1	11	18
2	17	
3	13	
4	13	
5	15	
6	29	
7	17	
8	16	19
9	16	
10	26	
11	16	
12	25	
13	29	
14	36	
15	26	30
16	29	
17	40	
18	28	
19	30	
20	37	
21	34	
22	40	38
23	40	
24	41	
25	42	
26	35	
27	43	
28	40	
March 1959		
1	27	34
2	25	
3	39	
4	27	

Table A1.2 continued.

	Minimum Temperature on Soil Surface	Mean Temperature/Week
5	37	
6	38	
7	27	
8	28	32
9	26	
10	32	
11	39	
12	38	
13	24	
14	37	
15	31	29
16	24	
17	24	
18	22	
19	33	
20	22	
21	23	
22	29	29
23	29	
24	27	
25	37	
26	35	
27	32	
28	32	
29	35	33
30	31	
31	26	
April 1959		
1	38	
2	26	
3	42	
4	22	
5	30	29
6	26	
7	27	
8	33	
9	21	
10	19	
11	29	
12	38	32
13	37	
14	40	
15	40	
16	35	
17	35	
18	28	
19	22	29

Table A1.2 continued.

	Minimum Temperature on Soil Surface	Mean Temperature/Week
20	34	
21	23	
22	30	
23	29	
24	24	
25	27	
26	35	28
27	29	
28	31	
29	27	
30	18	
January 1960		
1	39	
2	24	
3	24	
4	30	30
5	33	
6	30	
7	28	
8	22	
9	27	
10	17	
11	22	23
12	20	
13	27	
14	23	
15	21	
16	26	
17	29	
18	30	25
19	33	
20	17	
21	22	
22	35	
23	44	
24	31	
25	27	31
26	28	
27	26	
28	28	
29	24	
30	30	
31	32	
February 1960		
1	40	34
2	30	
3	40	
4	40	

Table A1.2 continued.

	Minimum Temperature on Soil Surface	Mean Temperature/Week
5	31	
6	26	
7	26	
8	20	23
9	20	
10	21	
11	19	
12	12	
13	14	
14	14	
15	24	19
16	30	
17	15	
18	23	
19	30 } Snow	
20	21 } Snow	
21	23	
22	30	27
23	22	
24	28	
25	34	
26	26	
27	31	
28	40	
29	43	37
March 1960		
1	46	
2	38	
3	37	
4	25	
5	37	
6	36	
7	30	30
8	28	
9	24	
10	33	
11	36	
12	34	
13	32	
14	38	37
15	42	
16	41	
17	39	
18	33	
19	37	
20	40	
21	36	34
22	34	
23	28	
24	29	

Table A1.2 continued.

	Minimum Temperature on Soil Surface	Mean Temperature/Week
25	28	
26	32	
27	29	
28	31	28
29	22	
30	20	
31	36	
April 1960		
1	30	
2	41	
3	29	
4	44	39
5	45	
6	45	
7	38	
8	42	
9	45	
10	37	
11	39	40
12	36	
13	45	
14	38	
15	38	
16	24	
17	27	
18	31	31
19	36	
20	34	
21	29	
22	45	
23	29	
24	38	
25	31	35
26	31	
27	35	
28	37	
29	42	
30	35	

Table A1.2 continued.

Number of Days when Temperature was 32°F. or Under.

1958			
	January	22	
	February	20	Total 83
	March	23	
	April	18	
1959			
	January	30	
	February	17	Total 87
	March	21	
	April	19	
1960			
	January	26	
	February	23	Total 71
	March	13	
	April	9	

APPENDIX 2

SPECIMEN ANALYSIS OF VARIANCE

TOTAL DRY MATTER PRODUCTION FOR 1958

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE	VARIANCE RATIO
REPLICATES	3	8356	2785	6.99 *
CUTTING SECTIONS	2	8268	4134	10.39 *
ERROR (a)	6	2388	398	
MAIN PLOT TOTAL	11	19012		
CULTIVAR COMBINATIONS	6	3995	666	2.19 N.S.
INTERACTION	12	6238	520	1.71 N.S.
ERROR (b)	54	16447	304	
SUB PLOT TOTAL	72	26680		
EXPERIMENT TOTAL	83	45692		

A2.1 Summary of "F" values from analyses of yield data in tables 1.1, 1.16 and 1.30.

Source of variation	D.F.	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Cut 8	Cut 9	Total
1958											
Cutting sections	2:6	102.8 ***	6.36 *	3.02 n.s.	7.99 *	35.0 ***	30.67 ***	11.1 **	8.3 *	<1	10.39 *
Cultivar combinations	6:54	4.31 **	9.47 ***	8.76 ***	4.53 **	4.34 **	2.51 *	<1	1.29 n.s.	1.04 n.s.	2.19 n.s.
Interaction	12:54	1.88 n.s.	<1	1.40 n.s.	1.43 n.s.	2.39 *	2.54 **	1.47 n.s.	1.94 *	<1	1.71 n.s.
1959											
Cutting sections	2:6	296.1 ***	11.15 **	11.28 **	1.98 n.s.	65.1 ***	11.24 **	97.3 ***	7.78 *	-	14.8 **
Cultivar combinations	6:54	4.62 **	1.31 n.s.	2.56 *	12.6 ***	10.73 ***	7.54 ***	10.7 ***	9.13 ***	4.64 ** †	7.1 ***
Interaction	12:54	3.77 ***	2.12 *	1.72 n.s.	2.05 *	2.72 **	1.60 n.s.	2.56 *	2.26 *	-	2.31 *
1960											
Cutting sections	2:6	65.02 ***	4.05 n.s.	35.08 ***	10.57 *	18.28 **	60.93 ***	-	-	-	9.56 *
Cultivar combinations	6:54	12.18 ***	16.59 ***	12.04 ***	12.38 ***	8.81 ***	7.91 ***	-	-	-	12.3 ***
Interaction	12:54	2.64 **	3.61 ***	2.37 *	1.76 n.s.	2.06 *	1.79 n.s.	-	-	-	1.66 n.s.
Σ 1958-59-60											
Cutting sections	2:6	6.89 *									
Cultivar combinations	6:54	8.2 ***									
Interaction	12:54	2.0 *									

† D.F. associated with this value 6:18.

A2.2 Summary of "F" values from analyses of percentage contribution of Irish ryegrass in tables 1.4, 1.19 and 1.33.

Source of variation	D.F.	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Cut 8	Cut 9	Total
1958											
Cutting sections	2:6	<1	<1	2.06 n.s.	3.93 n.s.	2.83 n.s.	6.0 x	1.60 n.s.	5.34 x	7.21 x	3.11 n.s.
Cultivar combinations	2:18	11.32 xxx	11.0 xxx	46.18 xxx	27.42 xxx	31.89 xxx	60.11 xxx	12.82 xxx	21.32 xxx	11.28 xxx	26.17 xxx
Interaction	4:18	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
1959											
Cutting sections	2:6	4.38 n.s.	<1	<1	3.15 n.s.	3.04 n.s.	3.18 n.s.	<1	2.32 n.s.	-	4.54 n.s.
Cultivar combinations	2:18	<1	1.96 n.s.	4.62 x	5.23 x	7.96 xx	7.95 xx	6.55 xx	8.2 xx	<1 †	7.05 xx
Interaction	4:18	<1	1.0 n.s.	1.30	<1	<1	<1	1.38 n.s.	1.48 n.s.	-	1.28 n.s.
1960											
Cutting sections	2:6	<1	2.91 n.s.	2.21 n.s.	1.39 n.s.	2.61 n.s.	1.07 n.s.	-	-	-	2.10 n.s.
Cultivar combinations	2:18	3.84 x	11.22 xxx	15.7 xxx	15.67 xxx	10.5 xxx	20.28 xxx	-	-	-	12.06 xxx
Interaction	4:18	3.69 x	1.97 n.s.	4.16 x	3.11 x	3.25 x	6.0 xx	-	-	-	4.22 xx
Σ 1958-59-60											
Cutting sections	2:6	3.5 n.s.									
Cultivar combinations	2:18	24.7 xxx									
Interaction	4:18	1.72 n.s.									

† D.F. associated with this value 2:6.

A2.3 Summary of "F" values from analyses of percentage contribution of New Zealand ryegrass data in tables 1.5, 1.20 and 1.34.

Source of variation	D.F.	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Cut 8	Cut 9	Total
1958											
Cutting sections	2:6	1.14 n.s.	<1	<1	<1	1.07	<1	<1	<1	2.27 n.s.	<1
Cultivar combinations	2:18	15.46 xxx	25.32 xxx	42.59 xxx	40.97 xxx	61.13 xxx	55.96 xxx	62.5 xxx	46.57 xxx	39.33 xxx	43.5 xxx
Interaction	4:18	<1	<1	<1	<1	1.56 n.s.	2.68 n.s.	1.64 n.s.	1.36 n.s.	1.43 n.s.	<1
1959											
Cutting sections	2:6	1.40 n.s.	3.64 n.s.	1.26 n.s.	<1	<1	2.2 n.s.	1.52 n.s.	<1	-	1.43 n.s.
Cultivar combinations	2:18	36.94 xxx	35.66 xxx	70.72 xxx	84.0 xxx	91.3 xxx	65.6 xxx	49.4 xxx	90.8 xxx	19.4 xx †	85.4 xxx
Interaction	4:18	5.01 xx	2.53 n.s.	4.78 xx	2.68 n.s.	2.75 n.s.	1.89 n.s.	<1	5.3 xx	-	4.03 x
1960											
Cutting sections	2:6	<1	3.31 n.s.	<1	<1	<1	<1	-	-	-	<1
Cultivar combinations	2:18	48.39 xxx	62.6 xxx	102.6 xxx	164.81 xxx	163.85 xxx	215.4 xxx	-	-	-	158.0 xxx
Interaction	4:18	4.91 xx	1.31 n.s.	3.88 x	3.06 x	5.7 xx	6.0 xx	-	-	-	5.38 xx
Σ 1958-59-60											
Cutting sections	2:6	<1									
Cultivar combinations	2:18	11.8 xxx									
Interaction	4:18	3.09 x									

† D.F. associated with this value 2:6.

12.4 Summary of "F" values from analyses of percentage contribution of S.23 ryegrass data in tables 1.6, 1.21 and 1.35.

Source of variation	D.F.	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Cut 8	Cut 9	Total
1958											
Cutting sections	2:6	1.10 n.s.	< 1	< 1	< 1	< 1	1.72 n.s.	1.88 n.s.	1.14 n.s.	< 1	1.81 n.s.
Cultivar combinations	2:18	9.78 **	9.66 **	10.96 ***	13.21 ***	10.03 **	19.65 ***	9.75 **	13.78 ***	15.04 ***	17.47 ***
Interaction	4:18	1.06 n.s.	< 1	< 1	< 1	1.24 n.s.	2.04 n.s.	< 1	1.43 n.s.	1.62 n.s.	< 1
1959											
Cutting sections	2:6	< 1	2.16 n.s.	< 1	< 1	15 - NS	< 1	2.47 n.s.	2.45 n.s.	-	< 1
Cultivar combinations	2:18	13.62 ***	7.15 **	18.96 ***	22.89 ***	32.61 ***	23.9 ***	25.25 ***	30.91 ***	9.52 * †	26.86 ***
Interaction	4:18	2.58 n.s.	1.63 n.s.	3.33 *	2.26 n.s.	1.61 n.s.	1.17 n.s.	< 1	1.23 n.s.	-	2.34 n.s.
1960											
Cutting sections	2:6	4.58	6.77 *	1.54 n.s.	< 1	1.25 n.s.	1.34 n.s.	-	-	-	3.18 n.s.
Cultivar combinations	2:18	32.47 ***	17.12 ***	33.1 ***	43.2 ***	37.17 ***	42.58 ***	-	-	-	42.38 ***
Interaction	4:18	< 1	1.85 n.s.	< 1	1.21 n.s.	< 1	1.25 n.s.	-	-	-	1.28 n.s.
Σ 1958-59-60											
Cutting sections	2:6	< 1									
Cultivar combinations	2:18	33.6 ***									
Interaction	4:18	1.28 n.s.									

† D.F. associated with this value 2:6.

Table A2.5 Summary of "F" values from analyses of percentage survival and tillers per plant data for Irish, New Zealand and S.23 ryegrass in tables 1.10, 1.12, 1.25, 1.26, 1.39 and 1.40.

Source of variation	D.F.	Autumn 1958	Spring 1959	Autumn 1959	Spring 1960	Autumn 1960	Autumn 1958	Autumn 1959	Autumn 1960
		Irish Ryegrass % Survival					$\bar{x}$ Tillers/Plant		
Cutting sections	2:6	< 1	8.58 x	7.02 x	4.6 n.s.	6.54 x	< 1	1.68 n.s.	2.35 n.s.
Cultivar combinations	3:27	1.74 n.s.	4.97 xx	3.97 x	8.1 xxx	15.28 xxx	7.42 xxx	15.05 xxx	15.23 xxx
Interaction	6:27	< 1	< 1	< 1	1.1 n.s.	1.62 n.s.	< 1	< 1	< 1
		N.Z. Ryegrass % Survival					$\bar{x}$ Tillers/Plant		
Cutting sections	2:6	1.02 n.s.	< 1	< 1	1.26 n.s.	1.45 n.s.	6.04 x	1.01 n.s.	1.66 n.s.
Cultivar combinations	3:27	1.04 n.s.	2.25 n.s.	5.23 xx	5.69 xx	8.19 xx	4.84 xx	6.6 xx	8.76 xxx
Interaction	6:27	1.34 n.s.	1.73 n.s.	1.64 n.s.	2.25 n.s.	1.97 n.s.	1.63 n.s.	1.5 n.s.	1.8 n.s.
		S.23 Ryegrass % Survival					$\bar{x}$ Tillers/Plant		
Cutting sections	2:6	3.54 n.s.	1.55 n.s.	3.11 n.s.	1.49 n.s.	< 1	< 1	< 1	2.41 n.s.
Cultivar combinations	3:27	< 1	< 1	< 1	2.28 n.s.	3.49 x	< 1	10.18 xxx	3.48 x
Interaction	6:27	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2.95 x

Table A2.6 Summary of "F" values from analyses of mean tillers per plant at July 1957 data in table 1.11.

Source of variation	D.F.	
Between cultivar	2:429	< 1

Table A2.7 Summary of "F" values from analyses of total tillers per sq. ft. data in tables 1.13, 1.27 and 1.41.

Source of variation	D.F.	Autumn 1958	Autumn 1959	Autumn 1960
Cutting sections	2:6	2.38 n.s.	< 1	5.73 *
Cutting combinations	6:54	3.3 **	2.04 n.s.	1.91 n.s.
Interaction	12:54	1.47 n.s.	< 1	< 1

Table A2.8 Summary of "F" values from analyses of percentage contribution to total tillers per sq. ft. data in tables 1.14, 1.28 and 1.42.

		Irish Ryegrass			N.Z. Ryegrass			S.23 Ryegrass		
Source of variation	D.F.	1958	1959	1960	1958	1959	1960	1958	1959	1960
Cutting sections	2:6	1.00 n.s.	4.50 n.s.	3.94 n.s.	1.94 n.s.	< 1	< 1	< 1	2.49 n.s.	3.79 n.s.
Cultivar combinations	2:18	10.89 ***	8.48 **	18.33 ***	18.00 ***	90.30 ***	191.48 ***	13.65 ***	54.26 ***	34.11 ***
Interaction	4:18	< 1	2.09 n.s.	5.24 **	< 1	3.70 *	7.48 ***	< 1	1.55 n.s.	1.08 n.s.

Table A2.9 Summary of "F" values from analyses of percentage survival at July and November 1959 and April, July and November 1960 data in tables 2.2 and 2.3.

Source of Variation	D.F.	1959 July	1959 November	1960 April	1960 July	1960 November
Irish Ryegrass						
Management	2:6	$3.45^{N.S.}$	< 1	< 1	< 1	< 1
Cultivar combinations	3:27	$2.01^{N.S.}$	< 1	$1.05^{N.S.}$	< 1	< 1
Interaction	6:27	< 1	< 1	$1.88^{N.S.}$	$1.02^{N.S.}$	< 1
New Zealand Ryegrass						
Management	2:6	< 1	23.86^{***}	28.3^{***}	16.92^{**}	25.29^{**}
Cultivar combinations	3:27	$1.64^{N.S.}$	$1.88^{N.S.}$	3.28^{*}	3.62^{*}	$2.92^{N.S.}$
Interaction	6:27	< 1	$1.82^{N.S.}$	$1.59^{N.S.}$	$1.21^{N.S.}$	$1.70^{N.S.}$
S.23 Ryegrass						
Management	2:6	$2.13^{N.S.}$	21.47^{**}	35.2^{***}	28.6^{***}	58.6^{***}
Cultivar combinations	3:27	< 1	< 1	< 1	$1.03^{N.S.}$	$1.12^{N.S.}$
Interaction	6:27	< 1	< 1	< 1	< 1	< 1

Table A2.10 Summary of "F" values from analyses of mean tillers per plant at November 1958, 1959 and 1960 data in tables 2.4 and 2.5.

November 1958

Source of Variation	D.F.	Irish Ryegrass	N.Z. Ryegrass	S.23 Ryegrass
Cultivar combinations	3:33	$1.93^{N.S.}$	< 1	$1.70^{N.S.}$

		Irish Ryegrass		N.Z. Ryegrass		S.23 Ryegrass	
Source of Variation	D.F.	Nov. 1959	Nov. 1960	Nov. 1959	Nov. 1960	Nov. 1959	Nov. 1960
Management	2:~~11~~ 6	$1.86^{N.S.}$	$4.58^{N.S.}$	< 1	9.79^{*}	6.06^{*}	$1.52^{N.S.}$
Cultivar combinations	3:27	4.31^{*}	$1.56^{N.S.}$	$1.52^{N.S.}$	5.89^{**}	4.10^{*}	$2.62^{N.S.}$
Interaction	6:27	< 1	< 1	3.58^{**}	3.66^{**}	1.23	< 1

Table A2.11 Summary of "F" values from analyses of tillers per sq. ft. produced at November 1959 and 1960 data in table 2.6.

Source of Variation	D.F.	Nov. 1959	Nov. 1960
Management	2:~~11~~ 6	17.45^{xx}	13.3^{xx}
Cultivar combinations	6:54	5.09^{xxx}	11.05^{xxx}
Interaction	12:54	2.74^{xx}	3.76^{xxx}

Table A2.12 Summary of "F" values from analyses of percentage contribution to total tillers per sq. ft. at November 1959 and 1960 data in table 2.7.

Source of Variation	D.F.	Irish Ryegrass Nov. 1959	Irish Ryegrass Nov. 1960	N.Z. Ryegrass Nov. 1959	N.Z. Ryegrass Nov. 1960	S.23 Ryegrass Nov. 1959	S.23 Ryegrass Nov. 1960
Management	2:6	$3.00^{N.S.}$	11.71^{**}	$1.88^{N.S.}$	< 1	11.15^{**}	8.54^{*}
Cultivar combinations	2:18	8.16^{**}	$3.16^{N.S.}$	29.23^{***}	51.82^{***}	17.88^{***}	18.09^{***}
Interaction	4:18	$1.58^{N.S.}$	< 1	$2.58^{N.S.}$	3.80^{*}	$1.22^{N.S.}$	$1.71^{N.S.}$

Table A2.13 Summary of "F" values obtained from analyses of percentage survival data in table 3.2.

Source of variation	D.F.	Days after sowing 49	71	102	127	160	200	377
				Irish Ryegrass				
Cultivar combinations	3:6	3.73^{NS}	10.37***	3.08^{NS}	4.69^{NS}	< 1	< 1	< 1
				N.Z. Ryegrass				
Cultivar combinations	3:6	1.88^{NS}	1.87^{NS}	< 1	1.16^{NS}	1.34^{NS}	< 1	< 1
				S.23 Ryegrass				
Cultivar combinations	3:6	1.14^{NS}	< 1	< 1	< 1	< 1	< 1	< 1

Table A2.14. Summary of "F" values obtained from analyses of tiller number per plant data in table 3.3.

Source of variation	D.F.	49	71	102	127	160	200	377
				Days after sowing				
				Irish Ryegrass				
Cultivar combinations	3:6	5.15*	< 1	1.56NS	2.32NS	3.96NS	5.09*	< 1
				N.Z. Ryegrass				
Cultivar combinations	3:6	1.38NS	< 1	1.34NS	1.50NS	< 1	1.09NS	5.13*
				S.23 Ryegrass				
Cultivar combinations	3:6	1.88	< 1	< 1	< 1	< 1	< 1	1.82NS