EVALUATION OF NEW HERBAGE CULTIVARS

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Abstract

Some basic principles of herbage cultivar evaluation are outlined. Particular emphasis is placed on the development of procedures which are realistic and relevant to New Zealand farming systems. The importance of regional differences, the grazing animal; level of soil fertility, management factors, compatibility in mixtures and feeding value are illustrated by examples from different sites within New Zealand and overseas. The high cost involved in the detailed evaluation of the large number of new cultivars now being developed illustrates the need for a continual review of the effectiveness of current procedures. Suggestions for improvements are made.

INTRODUCTION

OVER the past 40 to 50 years Grasslands Division has developed 15 herbage cultivars for use in a wide range of farming operations and environments (Table *1).*

TABLE 1: HERBAGE CULTIVARS DEVELOPED BY GRASSLANDS DIVISION

*Present Cultivar Name**	*Common Species Name*	*Breeders' Seed First Produced*
Ruanui	Perennial ryegrass	1936
Huia	White clover	1936
Turoa	Red clover	1937
Paroa	Italian ryegrass	1938
Manawa	Hybrid ryegrass	1943
Hamua	Red clover	1946
Kahu	Timothy	1947
Apanui	Cocksfoot	1953
Ariki	Hybrid ryegrass (perennial type)	1965
Tama	Weaterwolds ryegrass	1968
Matua	Prairie grass	1973
Pawera	Red clover	1974
Nui	Perennial ryegrass	1975
Maku	*Lotus pedunculatus* ***(L. major)***	1975
Pitau	White clover	1975

*The older cultivars were re-named in 1964.

The major features of this list of cultivars are:

(1) The relatively small number of species involved.

(2) The long commercial life of the earlier produced cultivars.

(3) The increasing rate at which new cultivars are now being released.

(4) A trend to increased specialization in cultivar use.

Although the efforts of the early breeders and evaluators in developing, in particular, persistent and high-producing cultivars of perennial ryegrass and white clover cannot be overestimated, there is little doubt that the quality control of seed through the certification scheme operated by the Ministry of Agriculture and Fisheries was a major factor in the widespread adoption of these first New Zealand cultivars by the farming community. The advantages of such standard cultivars as Ruanui perennial ryegrass and Huia white clover over the unreliable short-lived types previously available were obvious, and these plants played a large part in the rapid development of pastoral agriculture from the early 1930s.

However, at present many high-producing pastures are a complex mixture of a large number of improved and unimproved species (Palmer, 1970; Brougham et *al.,* 1973). It has been frequently demonstrated that good permanent pastures can be developed from apparently unpromising material without reseeding through the addition of fertilizer and other management inputs like grazing control and drainage. Thus the question is often asked whether further new species and cultivars have anything to contribute to increasing pasture and animal production.

Naturally occurring grasses like *Poa* spp. appear to contribute markedly to pasture production, improved ryegrasses sometimes lack persistency, reversion of resown pastures to browntop is common, while new sowings are often disappointing, particularly in the early years, compared with old, densely tillered, permanent pastures.

However, the current situation suggests that, at the highest production level where traditional management options like fertilizer application and subdivision have been optimized, the availability of new genetic material for either traditional or novel systems of pastoral agriculture offers a further dimension to the New Zealand agricultural scene (Lancashire, 1977). In addition, the development of new cultivars for the specific requirements of environments like the sand country, dryland and the warm temperate areas of the north should lift the potential of some of the previously neglected areas of the country. These future trends are demonstrated in the list of Grasslands Division's experimental cultivars (Table 2) which are currently being evaluated throughout the country.

TABLE 2: EXPERIMENTAL HERBAGE CULTIVARS UNDER EVALUATION

Grasslands Number	*Common Species Name*
G 4703	*Lotus pedunculatus*
G4708	Hybrid ryegrass
G 4709	Italian ryegrass
G4710	Tall fescue
G4712	Lotus hybrid
G 14	Phalaris
G 15	Paspalum
G 16	Cocksfoot
G 17	Cocksfoot
G 18	White clover
G 19	Serradella

When experimental programmes such as those in ryegrass, white and red clover, lucerne, hill country species, *Lotus corniculntus,* ryegrass-fescue hybrids and pest resistance/tolerance are also considered, it is clear that a greater range of improved species and cultivars will be available to service the specialized needs of different farming systems, managements, regions, and disease and pest resistance.

Evaluation procedures will have to take these changes into account and the collaborative role of the breeder and evaluator in assessing new plant material and setting clearly defined breeding objectives must be strongly emphasized. If there is good interaction between the two, then much of the information required to plan a rational, broadly based evaluation programme will be available. If not, resources are likely to be wasted on unnecessary trials.

FACTORS AFFECTING AN EVALUATION PLAN

SOIL FERTILITY

Many evaluations are run at high levels of soil fertility so that the genetic potential of the improved cultivar can be best expressed. However, a uniformly high level of fertility is rarely seen in all paddocks on the farm and even in ryegrass, the preeminent high fertility grass, important cultivar differences in response to nitrogen have been demonstrated. In New Zealand the hybrid ryegrasses Manawa and Ariki showed a greater response to increased nitrogen supply than Ruanui (Table 3) in laboratory experiments (J. L. Brock and J. H. Hoglund, pers.

TABLE 3: LEAF GROWTH AT TWO NITROGEN LEVELS
(J. L. Brock and J. H. Hoglund, pers. comm.)

	ppm N 20	100	*Percentage Increase*
Ruanui	210	295	40
Ariki	225	395	75
Manawa	255	495	95

comm.) while in the field Bascand (1963) found that trials in which Ariki was inferior to Ruanui were generally on "infertile" soils. In the U.K. S321 perennial ryegrass was 26% superior to three other ryegrass cultivars at low nitrogen levels but slightly inferior at high nitrogen levels (Wilman *et* al., 1976), while cultivars bred in environments where high inputs of nitrogen fertilizer are used tend to be more responsive and persistent at high nitrogen regimes (Aldrich, 1971; Lee et al., 1977). Conversely, in New Zealand both Manawa ryegrass and Apanui cocksfoot suffered widespread tiller death at high nitrogen levels in hot, dry weather compared with Ruanui and Ariki ryegrass which were unaffected (Lancashire, unpublished; Lancashire and Latch, 1969).

The ability of other grass species such as browntop, Yorkshire fog and red fescue to grow as well as or better than ryegrass on low-fertility soils is well documented (Cowling and Lockyer, 1965; Levy, 1970; Haggar, 1976) so cultivars of these species should not generally be evaluated under fertility conditions which are optimum for ryegrass. Similarly, although Maku lotus responds well to phosphate, its primary role as a replacement legume for white clover is on low-fertility acid soils and these requirements should determine most of the evaluation sites. As more specialized cultivars become available for more efficient use of plant nutrients, soil fertility considerations must clearly play a greater role in the determination of evaluation procedures .

Finally, the influence of soil type must also be considered. For example, red clover has demonstrated better potential than lucerne on some soil types (R. J. M. Hay, pers. comm.), while sainfoin, a possible non-bloating alternative to lucerne, and G19 Serradella, an annual legume for sand country, will not tolerate waterlogged soils in winter.

CLIMATE

It is easy to demonstrate major climatic variation in New Zealand, although a considerable potential for higher animal production per hectare from standard perennial ryegrass/white clover pastures than normally seen in commercial farming can still be demonstrated in such diverse environments as Kaikohe, Palmerston North, Canterbury, and Core (Brougham, 1977). The areas where pastures are based on improved species and cultivars share two major climatic restrictions — low winter temperatures and/or insufficient soil moisture in the summer and early autumn. This explains the use of cultivars broadly adapted to a wide range of apparently diverse environments (Table 4) — e.g., Nui (Baars *et* al., 1976; Harris *ef* al., 1977; Armstrong, 1977).

TABLE 4: PERCENTAGE YIELD INCREASES OF NUI OVER ARIKI (Harris *et al.,* 1977)

Kaikohe	17
Palmerston North	17
Lincoln	19
Gore	14

However, as animal production levels more nearly approach the genetic potential of the available plants in a given environment, a greater emphasis on regional adaptability will give opportunities for further increases. For example, Pitau white clover has shown increased production over Huia in the warmer parts of the country (Brougham, 1974), while Manawa hybrid ryegrass is best suited to areas of evenly distributed rainfall with low soil moisture stress in summer. It is therefore essential that any new cultivars with broad application — e.g., perennial ryegrass and white clover — be evaluated at least in the main climatic regions of the country. Conversely, there would probably be little to be gained at present from evaluating paspalum south of Hamilton (Percival, 1977), while the potential of tall fescue may well be outside the major agricultural production areas of the country — e.g.,, peat soils and the high country (F. C. C. Hupkens, van der Elst, pers. comm.; D. Scott, pers. comm.).

DEFOLIATION

The mowing trial generally offers the first opportunity to assess the influence of frequency and intensity of defoliation on the performance of a new cultivar. It may also be possible to relate this to the farming situation where, because of stock demands in periods of feed shortage, it will not always be feasible to apply the optimum management required by a particular cultivar. Therefore, it is important that the effects of frequent, severe defoliation treatments on persistency and production should be evaluated at an early stage. However, there is little point in applying such treatments to erect-growing types like lucerne and Italian ryegrass, when information is already available from agronomic trials or the breeder's prescription that show these plants will not survive or will produce only very poorly under this sort of management. Conversely, it is important that defoliation treatments are also imposed that allow the cultivar to express its maximum genetic potential. This may not always involve a "lax" treatment as it has been demonstrated in the U.K. that the persistency of the perennial ryegrass S23 is adversely affected by excessive spells between defoliations (Jackson, 1974) .

There arc many cases of seasonal factors interacting with frequency and intensity of defoliation (Brougham, 1968) and so it is important that trial design allows this information to be obtained for each cultivar. Although cultivars are often produced which appear to combine very high production with high persistency — e.g., Pawera red clover and Nui perennial ryegrass — there is frequent emphasis on the dual role of many species — i.e., cultivars which show relatively high production and low persistency or relatively low production and high persistency. Examples are Hamua and Turoa red clover, Ladino and Kent wild white clover, and Manawa and Ariki hybrid ryegrass. Thus, with the move towards more specialized management prescriptions for new cultivars, the task of the evaluator in designing relevant defoliation procedures should become easier.

MIXTURES

The end use of most new pasture cultivars in New Zealand is in grazing systems on farms, where they are nearly always grown in mixtures with other species and cultivars. For example, Harris (1968) in a survey of seed sales in the southern North Island showed that most mixtures contained at least two grasses and two legumes (Table 5).

TABLE 5: SEEDS MIXTURES (%) IN SOUTHERN NORTH ISLAND
(Harris, 1968)

98.7	contained white clover
73.2	contained red clover
54.5	contained two ryegrasses
28.8	contained three ryegrasses

Thus it is extremely important in the assessment of new plant material that a grass/legume association is used for evaluation under grazing, or, at least, an experimental technique is provided which gives a valid simulation of the relationship.

It appears that the growth of grasses as pure swards under cutting can be used to predict quite well their performance in a mixture of other grasses (Harris and Sedcole, 1974), but of course this does not take into account factors like inhibition of germination by seed of one cultivar on another as shown by Norrington-Davies and Harries (1977), or the possibility of selective grazing when animals are present. In the case of white clover, correlations between growth in monoculture and in mixtures have often been low, although correlations between the best lines in monoculture and mixtures were higher for the better lines than the poorer lines (Dijkstra and de Vos, 1972). Therefore, it would appear that, in general, the potentially best lines of both grasses and clovers can be identified under mowing in pure swards.

However, the inclusion of legumes, particularly clover, in mixtures with grasses under mowing must be treated with great caution, Although this technique may appear to give a more realistic evaluation, the competitve relationships between grass and clover in a grazing situation are extremely complex and many experiments show that white clover content is higher in mown plots than comparable grazed treatments (Sears, 1951; Frame, 1965; Wolton et al., 1970). Important factors in this difference are selective grazing of white clover (Taylor et *al.*, 1960; Lancashire and Keogh, 1968; Alder, 1969; Wolton et *al.*, 1970), differences in nitrogen recirculation by grazing animals (Wolton and Brockham, 1970), and the removal of stolons and their terminal growing points by the grazing animal (particularly sheep) from below a height which can be effectively defoliated by any mower (Lancashire and Keogh, 1968) (Table 6).

TABLE 6: PERCENTAGE INTAKE OF HERBAGE COMPONENTS BY GRAZING SHEEP AT TWO HEIGHTS
(Lancashire and Keogh, 1968)

	8-10 on	2.5-5.0 cm
Live ryegrass	41	30
Live white clover leaf and petiole	44	14
White clover stolon	0	18
Dead	14	37

FEED QUALITY

There is little point in producing 30 000 to 40 000 kg of dry herbage per hectare if the material is only suitable for the building industry. Thus it is important that the herbage obtained from cutting trials is sampled for simple feed quality characteristics like digestibility and screened for possible deleterious substances like alkaloids or oestrogens so that some guidance can be given on the likely animal response to such material. Unfortunately, the relationship between digestibility and voluntary intake and potential animal production probably does not operate consistently in many pastures in New Zealand where relatively high levels of digestibility of over 70% are frequently recorded (Hutton, 1962; Ulyatt, 1970) . Thus, in the absence at this stage of any more meaningful single parameters of feed quality than digestibility, there is little alternative but to feed or preferably graze productive animals on pure swards of the more important new cultivars (Lancashire and Ulyatt, 1975; Wilson, 1966).

STAGES OF EVALUATION

The evaluation process is simplified below into several distinct stages, although it is recommended that these be telescoped as Car as possible, because it is important to make new, improved material available to the user as quickly as is responsibly possible.

INITIAL SCREENING

Visual scores of vigour, disease, and growth habit on single spaced plants are an economical and effective method of initially comparing a large number of genotypes or cultivars with standard types, particularly to eliminate poor or non-persistent lines. Although grown in a very artificial situation with little competition (normal spacings are 60 cm) from others for space, light, nutrients, and moisture, it has generally been the experience at Grasslands Division that cultivars distinctly superior as spaced plants are also better in swards, although the margin is often reduced (Rumball and Armstrong, 1974). Single spaced plants are generally mob-stocked with wethers so that there is limited scope for selective grazing. However, it is advisable to grow different species, sub-species, and classes of cultivars — *i.e.*, diploid or tetraploid, early or late flowering types — in separately fenced blocks because differences in growth habit, flowering time, and acceptability *per* se may induce different severities of defoliation which will subsequently affect regrowth.

It is not proposed to review in detail the many apparently conflicting results obtained between the performance of cultivars as spaced plants or swards (Knight, 1960; Lazenby and Rogers, 1964; Sedcole and Clements, 1973; England, 1975). What is important is that spaced plant data are interpreted carefully and not extrapolated too far. For example, the Welsh Plant Breeding Station found that large differences in digestibility between two cocksfoot lines grown as spaced plants (Breese and Thomas, 1967) were greatly seduced under sward conditions because their morphology reacted quite differently to the different growing conditions (Davies, 1974). Also, an important determinant of the success or failure of a new cultivar is its rate of establishment from seed in the field and this is not generally evaluated under spaced plant conditions. Finally, alternative possibly more realistic techniques of evaluating very large numbers of genotypes or cultivars (microswards under grazing) must continually be assessed in order to achieve a more realistic initial screening.

MOWING TRIALS

The next stage in evaluation is generally a standard defoliation technique with a mower under controlled conditions in a sward. The dry weight yields of the sown and invading species are generally measured, and with the need for a range of defoliation treatments, fertilizer return, botanical separation of samples, chemical analysis and general plot maintenance, these trials can be expensive to run, particularly when they reach the size and complexity of the "peg cemeteries" seen in some European countries, where over 200 cultivars may be assessed at any one time. However, mowing trials are more realistic than single spaced plants and generally less costly than grazing trials.

GRAZING TRIALS

Major differences between cutting and grazing not already mentioned are treading effects (Brown and Evans, 1973), varying defoliation patterns by different types and classes of livestock (Calder, 1970; Aldrich and Elliott, 1974) and the uneven return of nutrients by grazing animals (Sears, 1951). Nevertheless, recent trials in the U.K. have shown quite good correlations between the yield rankings of grass cultivars obtained under mowing and grazing (Aldrich and Elliott, 1974; Camlin and Stewart, 1975) (Table 7). However, as there were notable exceptions to this generalization, it was recommended that a limited number of grazing trials were required before final cultivar release.

TABLE 7: YIELD RANKINGS OF PERENNIAL RYEGRASS CULTIVARS
(Aldrich and Elliott, 1974)

	Cut	Grazed
Premo	2	4
Ruanui	1	2
S 24	3	3
Devon Eaver	5	1
Verna Pajbjerg	4	5
Oriel	6	6

As stated earlier, it is extremely important during the assessment of new plant material for New Zealand grassland agriculture that the grass/legume relationship is evaluated under grazing, or, at least, in a valid simulation of the process. The "cafeteria" system, where small plots containing various grass/legume mixtures are grazed in common by an on-off system, offers an effective method of evaluating relatively large numbers of cultivars (Harris, 1977) . If plants of similar growth habit and "acceptability" are grouped together and the problem of localized fertility effects from animal returns can be overcome, the technique has considerable potential as a realistic primary screen.

Generally the most promising material has been identified in mowing trials and is then included in a pasture mixture in a grazing trial of standard factorial design with on-off grazing where large numbers of stock are used to graze paddocks over 1 to 3 days. Preconditioning or holding paddocks (non-measurement areas) are generally used to graze stock for 24 hours prior to grazing the experimental paddocks in order to reduce fertility transfer on and off the area. The design and analysis of these trials are straightforward and a range of managements can be easily applied, although they are expensive to run and no realistic animal measurements can be made.

The small, self-contained block system where the same set of grazing stock remains permanently on one treatment (Sears, 1951) requires fewer stock, but in a rotational grazing system different replicates are grazed at different times and special techniques of pasture measurement and statistical analysis have to be developed (Hoglund and Brock, 1977).

Larger self-contained block systems (effectively a mini-farm) also form the basis for measuring the ultimate objective of any new pasture cultivar which is to produce more animal products per hectare. Here sufficient animals are maintained on each treatment so that the effects of particular plant and animal management strategies on pasture and animal production can be measured (Harris and Hickey, 1977). These trials may continue for a number of years so that the long-term effects of cultivar persistency and seasonal variation on the production of the system can be assessed.

ON-FARM TRIALS

Despite the usefulness of these larger scale grazing trials, it is clear that, as the number of cultivars for evaluation increases and as the cost of any more than a minimum number of experimental "management" treatments becomes prohibitive, particularly under grazing, alternative approaches are needed for larger scale evaluations. In addition, there is no way an evaluator or research station can cover any more than a small proportion of all the conceivable management permutations, regions, soil types, etc., and, even if this was possible, it is still the farmer who will finally decide whether a new cultivar is widely adopted. Thus it is obvious that, during the final stages of any assessment, on-farm evaluations should be carried out. The techniques used in these evaluations vary from a series of small replicated plots measured periodically for yield after being sown in the centre of a paddock which is managed as part of the normal grazing rotation (Aldrich, 1971), to simple measurements and observations of the cultivar sown in part or all of a single paddock (Brock and Charlton, 1978). Regardless of the technique, these on-farm evaluations will play an increasingly important role in the evaluation of new cultivars. Also they may prove particularly useful as an early screen in specific disease situations — *i.e.,* lucerne in the pumice country (H. S. Easton, pers. comm.).

CONCLUSIONS

It is essential that new improved pasture cultivars reach the farmer as quickly as possible. However, the inherent complexity of soil-plant-animal relationships in grassland farming means that responsible evaluation is necessarily a more involved and lengthier procedure than that for most crops where only relatively simple yield and quality measures are required.

Also it is vital that resources devoted to evaluation are not excessive because the country cannot afford to emulate the U.K., where recently over 100 perennial ryegrasses were being evaluated under a fairly elaborate mowing technique on a widespread regional basis. This situation, which has arisen because of excessive commercial competition induced by Plant Variety Rights legislation and because of the intrusion of bureaucrats into technical areas, must be avoided at all costs in New Zealand.

To ensure real progress and cost-effective procedures, it is essential that clear breeding objectives are set for new pasture cultivars and that sufficient information is available for relevant evaluation techniques to be adopted. In this way it will be possible to utilize effectively a limited number of improved types and with the correct management information ensure that they are integrated positively into New Zealand grassland farming to increase animal production on a national basis.

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