Proceedings of the New Zealand Grassland Association 48: 89-92 (1987)

THE DEVELOPMENT OF OUR PASTURE PLANT RESOURCES: THEN AND NOW

ROBERT BURGESS
Grasslands Division, DSIR, Palmerston North

Abstract

This paper honours the contribution of the E.S. Levy to the development of improved pasture plant cultivars in New Zealand by reviewing his work on ecotype development within herbage species.

Starting in the late 1920s, Levy compared at a single site many thousands of seed lines of pasture grass and legume species collected from both within New Zealand and overseas. In several species, including perennial ryegrass, white clover, red clover, cocksfoot and subterranean clover, he showed the existence of genetically distinct strains (ecotypes) which he claimed had developed under the farming practices, climate and soil fertility in their areas of origin.

This work led to the enunciation of pasture plant breeding objectives, the development of improved pasture cultivars and a strategy for grassland improvement. This was based on permanent pasture Hawke's Say perennial ryegrass and New Zealand No. 1 white clover, bred for use in high production forage systems throughout New Zealand. The breeding objectives rejected by Levy, such es the development of improved cultivars for low production systems, must be reconsidered in view of today's changed environment for pastoral farming.

Keywords: ecotypic differentiation, evolution, improved cultivars, plant breeding objectives.

INTRODUCTION

In the first paper read at the inaugural meeting of the New Zealand Grassland Association, E.B. Levy (1931) outlined his investigations of strains (ecotypes) within herbage species. On this first anniversary of the death of Sir E. Bruce Levy, it is appropriate to honour his contribution to the development of improved pasture plant cultivars in New Zealand by reviewing his papers on strain development.

By making collections of seeds or plants of a wild species from different habitats and growing them under uniform conditions, striking genetic differences between populations become apparent. Turesson (1922) termed these differentiated populations "ecotypes", which he claimed came about through the evolutionary response of the species to the particular conditions in the various habitats in which they were found.

Starting in 1928 in New Zealand, Levy used just this approach. With the assistance of Stapledon and William Davies (Empire Grassland Investigator) of the Welsh Plant Breeding Station, Levy set up trials to study an enormous amount of material of different pasture species. Large scale collections were made, principally of commercial seed lines within NZ but also from overseas, and sown at the Plant Research Station, Palmerston North in plots and, for some lines, as single spaced plants.

Over 20,000 single plants, 3,000 lines and 10 herbage species were represented in the sowings between 1928 and 1935. The results of this work were reported in 14 papers published between 1929 and 1936.

Levy's aims were entirely practical: to select and breed improved pasture varieties for farm use. An understanding of ecotype development, whether in the wild or in managed grazing systems, was seen as necessary simply to continue the process with cultivar development by controlled selection and breeding.

THE OBSERVATIONS

Population differences were readily apparent within most species investigated. In perennial ryegrass, cocksfoot, white clover, red clover, browntop, lucerne, chewings fescue and creeping bent, Levy concluded that diverse population types (ecotypes) or a single NZ ecotype had evolved in this country in response to the new farming environments here. In subterranean clover, distinct ecotypes were observed, although these had developed elsewhere, despite each being associated with a particular habitat in NZ.

In perennial ryegrass, 5 different population types were described ranging from the fine leaved, densely tillered, reliably persistent Hawke's Bay/Poverty Bay type to the open, free seeding, short lived type characteristic at the time of South Island sources (Levy & Davies 1930ab). Levy (1932) attributed these population differences to differences in grazing management imposed in the 60-80 years the species had been used in NZ. The development of the elite Hawke's Bay ecotype was ascribed to the influence of close grazing by sheep in a long term pasture system imposing natural selection for a dense, persistent type perennial ryegrass (Levy 1932). This ecotype became the basis of the first certified perennial ryegrass strain in 1930. Certified perennial ryegrass was continuously improved until 1960, when it was named 'Grasslands Ruanui'.

The methods used by Levy were inadequate to establish that ecotypic differentiation had occurred in response to the particular environmental influences claimed. Different strains undoubtedly existed. However, these may simply have come about due to differences between original seed imports. Direct experimental evidence for ecotypic differentiation in response to, for example, close grazing by sheep was lacking. Brougham and Harris (1967) have since provided such evidence, showing that, in response to the experimental application of different grazing managements, very rapid changes can occur to the genetic structure of a mixed ryegrass population. Although compelling, Levy's evidence was, by contrast, circumstantial.

In red clover, two major types, attributed to contrasting systems of management, were recognised (Levy & Davies 193Oc). The early flowering, typically short lived, broad red type developed under a temporary pasture system, whereas the later flowering, longer lived Montgomery type developed under a longer rotation system. The NZ broad red clover, grown in pastures left down for 3-4 years, was more persistent and productive than introduced lines (Levy & Davies 193Oc). 'Grasslands Hamua' broad red clover is the result of breeding with this NZ material. By contrast, introduced lines formed the basis of the first certified Montgomery red clover in 1932, from which 'Grasslands Turoa' developed.

Levy also attributed ecotypic differences to the influence of climate and soil fertility. In parts of Hawke's Bay and North Canterbury, populations of white clover were found which were considerably more productive, particularly in winter and under high fertility conditions, than any introduced lines (Davies & Levy 1931b). The evolution of these dense, larger leaved, persistent white clover populations (grouped as NZ No. 1) was attributed to the milder climate and more fertile soils of the permanent grassland areas in parts of NZ compared with equivalent areas in the UK. The significance of the winter activity of NZ No. 1 white clover for overcoming the winter feed supply bottleneck in farm production was well recognised by Davies and Levy.

Selections within NZ No. 1 white clover, for even greater production and seasonal spread of growth, stood out from all other strains, particularly under lenient, rotational grazing (Table 1).

Lower production ecotypes such as ordinary NZ white clover and NZ No. 2 were

Table 1: Yields of pure white clover wards relative to NZ No. 1, sown in spring (Data from Levy and Gorman, 1934).

	Summer	Winter	Spring	Autumn
Selection	128	211	101	147
NZ No. 1	100	100	100	100
NZ No. 2	83	64	80	29
Ordinary NZ	57	37	69	21
Kentish	47	26	65	15
Ladino	96	147	82	29

identified with less fertile soils and close grazing (Table 2), reinforcing the concept of ecotypes within a species, each ecotype evolving to suit the particular conditions of the habitat (Davies & Levy 1931b).

The single spaced plant trials set up by Levy exposed the extreme variability within lines, in all species investigated. For example, in cocksfoot and Italian ryegrass, the variation within NZ lines was so great that no differentiation between distinct ecotypes could be found (Levy & Davies 1929b, Levy & Saxby 1933). In cocksfoot unlike Italian ryegrass, however, NZ lines were superior to imported material. The best of the NZ sources of cocksfoot were first certified in 1932, and subsequent breeding in the 1930s (in Canterbury) and 1940s (in Palmerston North) was aimed to improve the persistence and recovery from grazing of this NZ material.

Table 2: Population type classification of old pasture and roadside collections of white clover from sites of high, medium and low soil fertility (From Davies and Levy 1931b).

	Percentage of lines		
	Soil fertility		
Population type	High	Medium	Low*
NZ No. 1	38		
NZ No. 2	8	11	
Ordinary NZ (with traces of NZ No. 1 and 2)	46	36	
Ordinary NZ	8	53	100

* Includes South Island tusaock country

DISCUSSION

The seed certification scheme developed in NZ in the late 1920s involved the identification and maintenance of seed of particular types. Sources of variable and inferior seed were soon recognised and avoided. The scheme was seen as crucial to the commercial exploitation of the high quality genetic strains recognised by Levy, such as Hawkes Bay perennial ryegrass and NZ No. 1 white clover. The economic potential of superior ecotypes of herbage species, including the amenity grasses, was clear. Levy and Saxby (1931) quote the £100,000 pa export of fine lawn seeds. Such financial returns to the nation were used as ample justification for the continuation of plant breeding, to further enhance the reputation of NZ as an exporter of high quality seed.

Whatever the cause of population differences within herbage species in NZ, the task set by Levy was apparent: first, to apply the appropriate species and ecotype to the appropriate environment and second, to select and breed improved pasture cultivars. Levy outlined three plant breeding options:

1. High production populations within high production species.
2. Improved populations within low production species.
3. Stress tolerant populations of high production species.

Levy became the evangelist of the first option. He discounted the breeding both of low production varieties of high quality grasses and legumes and of high production lines of low production species. He believed that the more efficient way

to high production came through increasing soil fertility, cultivation, drainage and subdivision, so that the potential of high production lines of perennial ryegrass and white clover would be realised. The testimony to this strategy can be seen in the pre-eminence of ryegrass and white clover in today's improved pastoral systems, and in the continuing efforts of plant breeders to develop even better cultivars within these species.

This approach is dependent upon the continuation of costly inputs which in today's environment are increasingly difficult to meet. Levy accepted that where it was not possible to cultivate, drain or apply fertiliser, low production species such as *Danthonia pilosa*, browntop, Yorkshire fog, ratstail, suckling clover and lotus were valuable. Many pastoral farmers find themselves in this situation today, unable to cope with costs of farm inputs.

It is appropriate therefore to reconsider Levy's second two options: improved populations of the lower producing species, or stress tolerant varieties of the high quality grasses and legumes that would blend into low production swards. Such populations would enable economic use of situations that cannot be exploited by use of ryegrass and white clover cultivars adapted to high fertility lowland soils. Plant breeders have proceeded in this direction. There are today improved lines of some lower production species, specifically bred for high country conditions ('Grasslands Tiki' *Bromus inermis* and 'Grasslands Hakari' *B. marginatus*), well suited to wet, acid and infertile high country soils ('Grasslands Maku' Lotus *pedunculatus*), or having a specific management role in this region ('Massey Basyn' Yorkshire fog, Scott *et* al. 1985).

These options rejected by Levy are not only valid today but essential to the survival of the pastoral industry over the next 20 years. Given the environment in which pastoral farming now finds itself, improvement and use of herbage species, in addition to the high fertility clovers and ryegrasses, must be strenuously pursued.

References

Brougham R.W., Harris W. 1967. Rapidity and extent of changes in genotypic structure induced by grazing in a ryegrass population. NZ ***Journal of*** Agricultural ***Research 10: 56-65.***

Davies W., Levy E.B. 1931a, b. Strain investigation of grasses and clovers 4. White clover (*Trifolium repens*). NZ ***Journal of Agriculture*** 42: 75-89, 151.164.

Levy E.B. 1931. Strain developments in herbage plants. ***Proceedings NZ Grassland Association 1:*** 1.

Levy E.B. 1932. New Zealand pasture plants. What the dominion has to offer. NZ ***Journal of Agriculture 44:*** 253-260, 309-315, 379.366.

Levy E.B. 1933. Strain development in herbage plants. ***Proceedings NZ Grassland Association 2:*** 72-75.

Levy E.B., Davies W. 1929a. Strain investigation relative to grasses and clovers. 1. Perennial ryegrass. ***NZ Journal of Agriculture 39:*** 1-8.

Levy E.B., Davies W. 1929b. Strain investigation relative to grasses and clovers. 2. Cocksfoot (*Dactylis glomerata*). ***NZ Journal of Agriculture 39: 363-373.***

Levy E.B., Davies W. 1930a. Perennial ryegrass strain investigation. Data from trials at the Plant Research Station. ***NZ Journal of Agriculture 40:*** 363-385.

Levy E.B., Davies W. 1930b. Perennial ryegrass strain investigation. Single plant trials at the Plant Research Station. ***N.? Journal of Agriculture 41: 147-163.***

Levy, E.B., Davies W. 193Oc. Strain investigation of ***grasses*** and clovers ***3.*** Red clover (*Trifolium pratense*). ***NZ Journal of*** Agriculture 41: 377.367.

Levy E.B., Gorman L.W. 1933. Strain investigation of white clover. Finalised results of trials at Plant Research Station. ***NZ Journal of Agriculture 46: 76-69.***

Levy E.B., Gorman L.W. 1934. Strain investigation in white clover. ***NZ Journal of Agriculture 49:*** 86-104.

Levy E.B., Gorman L.W. 1936. Strain In subterranean ***clover. Proceedings NZ Grassland Association 5:*** 19-32.

Levy E.B., Saxby S.H. 1931. Strain investigation of grasses and clovers. 5. Browntop ***(Agrostis tenuis). NZ Journal of Agriculture 43:*** I-10.

Levy E.B., Saxby S.H. 1933. Strain investigation of grasses and clover8 Italian, western wolths and Wimmera ***ryegrasses. NZ Journal of Agriculture 47:*** 366-375.

Scott D., Keoghan J.M., Cossens G.G., Maunsell L.A., Floate M.J.S., Wills B.J., Douglas G. 1965. Limitations to pasture production and choice of species. ***In: Burgess*** R.E., Brock J.L. (Eds). ***Using herbage cultivars.*** Grassland Research and Practice Series No. 3. NZ Grassland Association.

Turesson G. 1922. The genotypical response of the plant species to the habitat. *Hereditas 3:* 211-350.