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EVALUATION OF ROOT TYPE IN WHITE CLOVER GENOTYPES AND POPULATIONS

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ABSTRACT

A convenient method for assessing root type in white clover (*Trifolium repens* L.) for large numbers of genotypes is described. Plants were grown for 14 weeks in field tiles containing soil. Results were similar to those obtained in earlier field experiments and showed large differences between genotypes. Some populations collected from dryland sites had larger and more numerous taproots than was expected on the basis of their shoot type. They also tended to have a high proportion of root to total plant weight, and a high proportion of taproot to total root weight.

KEYWORDS

Taproot, fibrous root, *Trifolium repens.*

INTRODUCTION

The survival and production of plant species in marginal environments, e.g. on low-fertility soils or in drought-prone areas, have often been related to root types. As a result of interspecific comparisons (Pavlychenko and Harrington, 1934; Jeffery, 1967; McLachlan, 1976) it is assumed that a frequently branched, fine root system is more effective in absorbing nutrients (Vose, 1963; Clarkson and Hanson, 1980). Taprooted and more deeply rooted species are considered to be more drought tolerant (May and Milthorpe, 1962; Turner, 1979), although it is also accepted that a greater root mass, of any type, is beneficial for plants subjected to periodic moisture stress (Hurd, 1974).

Root systems of white clover vary from large taprooted forms (taproots are defined here as vertically penetrating roots), with only a small proportion of fibrous root, to those with no large taproots but a high proportion of fibrous root (Caradus, 1977, 1981). However, the former are generally found on large-leaved plants and the latter on small-leaved plants. Since smaller leaved types are more persistent under close grazing (Williams and Caradus, 1979) it was considered that selection for taprooted, medium to small-leaved types for drought-prone areas may be beneficial. Selection of genotypes with similar shoot types but with different root types would also provide experimental material to determine the importance of root type for survival and production in drought-prone areas and in low-fertility soils. The aim was to examine a large number of white clover genotypes of varied origin for differences in root type relative to shoot type.

METHOD

A total of 600 white clover genotypes (20 genotypes of 30 lines) were evaluated. Names and numbers assigned to populations that were evaluated are given in Table 1. They were grown in field tiles (9 cm diameter × 37 cm deep) containing a B horizon Egmont loam to which had been added potassic superphosphate at a rate of 1 g P/kg of soil. The tiles were arranged in a randomised block design with two replicates.

Genotypes were propagated from stolon tips and pre-rooted in potting mix before being transplanted to tiles on 30 April, 1985. Plants were harvested after 14 weeks on 6 August. At harvesting most plants had no stolon hanging over the edge of tiles and none of the plants had become root-bound. Measurements were made of leaflet width, diameter of the largest taproot, and number of taproots with a proximal diameter greater than 1 mm. Shoots (leaves, petioles, and stolons) were weighed fresh, and roots were separated into taproot and fibrous root components and weighed fresh and dry.

RESULTS AND DISCUSSION

Inter-line comparisons

As in previous field studies (Caradus, 1977, 1981) there was a strong tendency for the larger leaved lines to be most taprooted, particularly when root type was determined by diameter of the largest taproot (r = +0.78***) (Fig. 1). This trend was also apparent when root type was determined by taproot number (Fig. 2) (r = +0.53**). In field-grown spaced plants the correlations between leaf size and taproot number were higher (e.g. r = +0.80 Caradus, 1977, r = +0.89 Caradus, 1981).

Table 1. Description of populations and mean total fesh weight after 14 weeks growth in field tiles.

No.	Name	C - cultivar S - selection E - ecotype	Description	Total fresh weight (g)
1	Huia	C	Medium leaf size; adapted to a wide range of pastoral conditions	14.9
2	Tahora	C	Small leaf size, highly branched stolons	13.8
3	G18	S	Large leaf size; improved summer yields	18.2
4	G23	S	Large leaf size; improved yields in Northland	15.6
5	Dusi	C	Large leaf size; selected in an acid, dryland soil, South Africa	15.7
6	Root knot	S	Large leaf size; tolerant to root knot nematode Northland	20.6
7	Southland	S	Improved yields in Southland	10.4
8	Kaikohe — sheep	E	Sheep farms in Northland	14.4
9	Kaikohe — dairy	E	Dairy farms in Northland	7.5
10	Whata HC	E	Whatawhata hill country research station	14.6
11	Whata EF	S	Early flowering at Whatawhata	13.0
12	Ballantrae	E	Ballantrae hill country research station	5.6
13	Devon	E	Old pastures in Devon, England	6.2
14	Cheviot Downs	E	Unfertilised pastures in Cheviot Downs, Canterbury	12.9
15	High (HLP)	S	High yields at low-P in glasshouse trials	6.1
16	Low (LLP)	S	Low yields at low-P in glasshouse trials	5.2
17	Pukewhinau	E	Southern Hawke's Bay, ASMD[1] 50 mm	14.0
18	Horoeka	E	Southern Hawke's Bay, ASMD 50 mm	13.3
19	Akitio	E	Southern Hawke's Bay, ASMD 50 mm	15.5
20	Ruakawa	E	Hawke's Bay, ASMD 100 mm	11.9
21	Castlepoint	E	Wairarapa, ASMD 100 mm	19.5
22	Summerhill	E	Wairarapa, ASMD 100 mm	11.3
23	Weber	E	Southern Hawke's Bay, ASMD 50 mm	15.3
24	Hawarden	E	North Canterbury, ASMD 50 mm	8.3
25	Cheviot 1	E	North Canterbury, ASMD 100 mm	8.0
26	Cheviot 2	E	North Canterbury, ASMD 100 mm	8.1
27	Wither Hills 1	E	Marlborough, ASMD 100 mm	7.3
28	Wither Hills 2	E	Marlborough, ASMD 100 mm	5.9
29	Tara Hills	E	Central Otago, ASMD 200 mm	11.2
30	Mt Stoker	E	Central Otago, ASMD 50 mm	11.2
				$MSR^{2}_{0.05} \times 1.90$

[1]ASMD - average annual soil moisture deficit.
[2]MSR - minimum significant ratio.

The two dryland populations Hawarden (24) and Cheviot 2 (26) had larger taproots, and G18 (3) had smaller taproots than was assumed from their leaf sizes (Fig. 1). The large-leaved cultivars Dusi (5), G18 (3), and G23 (4) had fewer taproots, and the populations from Mt Stoker (30), Cheviot 2 (26), Hawarden (24), and Southland (7) had more taproots than their leaf sizes would have suggested (Fig. 2).

There was no linear relationship between proportion of root to total plant weight and proportion of taproot to total root weight (Fig. 3). Four populations with a high proportion of root and a high proportion of taproot were collected from dryland sites (Summerhill (22), Hawarden (24), Cheviot 2 (26), and Mt Stoker (30)). Populations with a low proportion of root and a low proportion of taproot were LLP (16), G18 (3), Whata EF (11), Kaikohe — sheep (8), and Ballantrae (12) from wetter sites.

Dusi (5), a cultivar bred for dryland areas of South Africa (Smith and Morrison, 1983), had the highest proportion of root to total plant weight but only a moderate proportion of taproot to total root weight (Fig. 3). Similarly, Dusi (5) was no more taprooted than other populations of equivalent shoot type (e.g. G23 (4) and Root knot (4)) (Fig. 1 and 2). Although Smith and Morrison (1983) have shown that at a dryland site the number of nodal taproots produced per unit stolon length by Dusi was double that of Huia, in the present study there was no difference between Huia and Dusi for taproot number.

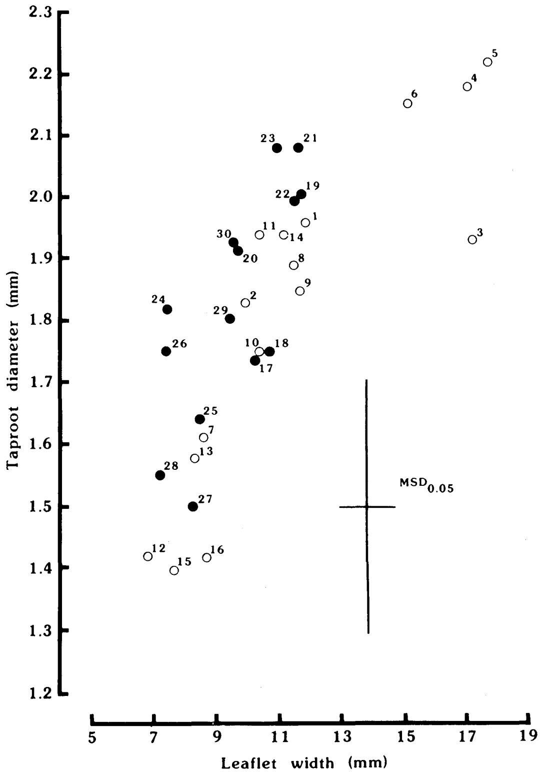

Figure 1. The relationship between leaf size and diameter of the largest taproot of 30 white clover populations. Populations collected from dryland sites are denoted by ●; other populations by ○ (r = +0.78*).**

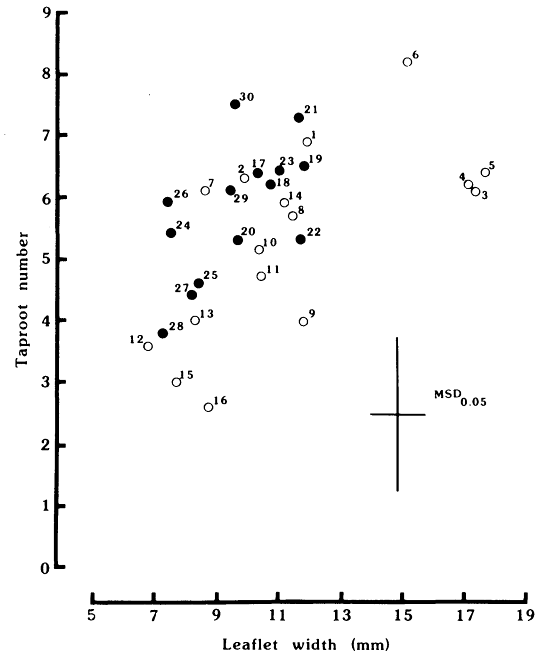

Figure 2. The relationship between leaf size and the number of taproots (proximal diameter >1 mm) of 30 white clover populations. Populations collected from dryland sites are denoted by ●; other populations by ○ (r = +0.53).**

Root knot nematode selection (6) and the dryland population collected from Castlepoint (21) had the highest total fresh weights; significantly higher ($P<0.05$) than that of the populations collected from dairy farms near Kaikohe (9), Ballantrae (12), Devon (13), Hawarden (24), Cheviot 1 and 2 (25 and 26), Wither Hills 1 and 2 (27 and 28), and the high (15) and low (16) yielding selections (Table 1). Dryland populations from Pukewhinau (17), Horoeka (18), Akitio (19), and Weber (23) had yields similar to those of Huia (1). There was a significant correlation between leaf size and total plant fresh weight (r = +0.77***).

Inter-genotype comparisons

Correlations between leaf size, taproot diameter, and number of taproots were lower when all 600 genotypes were considered (r = +0.49** and +0.39** respectively). This variation allowed selections to be made of small-leaved genotypes with a large number of thick taproots, and large-leaved genotypes with a small number of thin taproots. Selections have also been made for a high degree of taprootedness and either a high or low root to shoot ratio.

CONCLUSION

The culture of white clover genotypes in soil in field tiles produces plants with root systems that can be easily described. It is possible to evaluate large numbers of genotypes. The ability to manipulate root and shoot type concurrently by selection will be evaluated in future studies.

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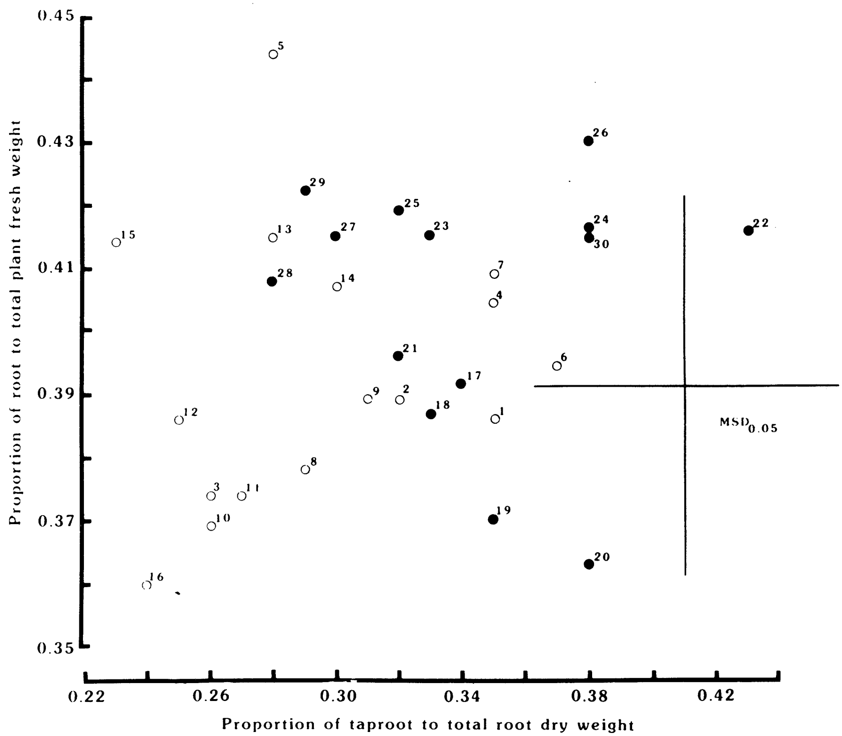

Figure 3. The relationship between proportion of taproot to total root dry weight and proportion of root to total plant fresh weight of 30 white clover populations. Populations collected from dryland sites are denoted by ●; other populations by○.

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