Fenugreek (*Trigonella foenum-graecum*) compared to five temperate legume species in Wimmera farming systems.

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ABSTRACT

Field experiments in the Victorian Wimmera compared growth, yield and nitrogen (N) inputs of fenugreek with field pea, faba bean, lentil, vetch and medic. Four fenugreek accessions flowered at a similar time to faba bean, but earlier than other species. Faba bean produced the highest grain yield. Fenugreek yields ranged from 1.4 to 1.7 t/ha. The relative N fixation efficiency was highest for faba bean, field pea and vetch (21-23 kg N/t). Fenugreek accession 150265 had the highest RNFE for fenugreek (19.4 kg N/t). Medic and fenugreek accessions 150000 and 150292 had significantly lower RNFE values (<15 kg N/t). There were no significant differences in pre-sowing soil nitrate and water content, grain yield, grain size, or grain protein for wheat sown on the sites in the following year. Thus, fenugreek performed similarly to other legumes grown in Wimmera farming systems. Differences among fenugreek accessions suggest that significant improvements in agronomic performance of fenugreek can be made by selection within current germplasm.

KEY WORDS

Fenugreek, legumes, pulses, nitrogen fixation, *Trigonella foenum-graecum*, rotations.

INTRODUCTION

Fenugreek *(Trigonella foenum-graecum*) has been grown in Australia since the mid 1980s. The area sown to fenugreek in the Victorian Wimmera has increased since 1998 due to high grain prices (>$400/t) and the occurrence of *Ascochyta rabei* in chickpea. Interest in fenugreek has increased as grain growers seek alternative crops to extend the diversity of their farming systems. The demand for new crops has been driven by more intensive rotations and high disease pressure on pulses such as chickpea and lentil. Furthermore, green manuring is becoming an integral part of sustainable cropping practice as a compromise between traditional fallow and continuous cropping to overcome problems with declining soil fertility, soil borne diseases and herbicide resistant weeds. Fenugreek has potential to be included in a crop rotation as green manure, for seed production for niche markets such as the Asian condiment market, or as forage. This paper reports the growth, yield and N contribution of several fenugreek accessions and compares their performance to that of other legumes commonly grown in south-eastern Australia. The subsequent concentrations of soil nitrate, and the N uptake, growth, grain yield and quality of a following wheat crop is also described.

MATERIALS AND METHODS

Legume comparison

Field experiments were conducted on grey cracking clay soil (Ug 5.2) in the Victorian Wimmera at Longerenong (1998 and 1999) and Dimboola (1998 only). This paper presents data from four fenugreek accessions and faba bean (*Vicia faba* cv. Fiord), field pea (*Pisum sativum* cv. Dundale), lentil (*Lens culinaris* cv. Digger), vetch (*Vicia sativa* cv. Morava) and medic (*Medicago trunculata* cv. Mogul). The fenugreek accessions include a check variety (150000), and three potential releases (150212, 150265, and 150292), that were selected on the basis of maturity, growth and yield. The experiment was replicated three times in a randomised complete block design (plot size 1.71m x 10m, row spacing 21.4cm). Seed was inoculated with the commercial *Rhizobium* strain recommended for each species.

Faba bean was not included in the Dimboola trial. Observations included flowering date (when 50% of plants had commenced flowering), flowering duration, shoot dry matter (DM) at mid grain fill, late grain fill and harvest, grain yield and grain nitrogen.

Nitrogen fixation studies

Nitrogen fixation was estimated at Longerenong in 1998 and 1999. Plant material was harvested at mid-grain fill, which is the approximate time of peak DM and N accumulation (3). The proportion of plant N derived from atmospheric N_2 (%Ndfa) and the amount of N_2 fixed (ANF kg N/ha) were estimated using the ^{15}N natural abundance technique (1,3,4). The amount of N_2 fixed was adjusted to include a contribution from nodulated roots by assuming that 33% of total plant N was partitioned below ground based (5,6) and that %Ndfa in the roots is the same as that in the shoots. The relative N_2 fixation efficiency (RNFE) was calculated as the amount of shoot N fixed per tonne of DM produced. This enables comparisons of N_2 fixation to be made independent of dry matter production.

Effects on the subsequent wheat crop

Wheat was sown over each site in the following growing seasons (1999 and 2000). Soil water content and soil NO_3 were determined from 1m soil cores taken four weeks prior to sowing at the Longerenong sites. Crop measurements included: shoot density at Z30 (Zadoks growth stage 30: first node present at base of stem), shoot N uptake at Z30, grain yield, grain protein and grain size at Longerenong and Dimboola in 1999. Only early season data from Longerenong 2000 is presented.

RESULTS

Table 1. Mean flowering time, seed yield and harvest index for different legumes species at Longerenong in 1998-1999 and Dimboola in 1998.

Species-Genotype	Flowering commencement (days after sowing)	Flowering duration (days)	Seed yield (t/ha)	Harvest index
Fenugreek-150000	95	32	1.35	0.31
Fenugreek-150212	86	34	1.73[2]	0.38
Fenugreek-150265	98	31	1.50	0.30
Fenugreek-150292	97	38	1.43	0.27
Faba bean -Fiord[1]	89	38	2.35	0.41
Field pea-Dundale	104	33	2.07[2]	0.32
Lentil-Digger	109	33	1.27[2]	0.29
Medic-Mogul	102	35	-	-

Vetch-Morava	124[3]	18	0.80[2,3]	0.18
LSD (P<0.05)	*5.4*	*7*	*0.8*	*0.09*

[1] Data from Longerenong sites only; [2] Greater than 30% frost damage at one or more sites

[3] Maturity delayed and plant growth and yield reduced by herbicide damage in 1998

Table 2. Estimation of the N_2 fixation capacity of different legume species at Longerenong in 1998 and 1999.

Species-Genotype	Dry matter at mid grain fill (t/ha)	Shoot N (%)	Ndfa (%)	Amount N fixed[1] (kg/ha)	Relative nitrogen fixation efficiency (kg N/t)
Fenugreek-150000	4.8	2.36	71	122	16.8
Fenugreek-150212	5.1	2.53	72	141	18.2
Fenugreek-150265	4.5	2.46	79	130	19.4
Fenugreek-150292	5.7	2.40	67	142	16.2
Faba bean -Fiord	6.1	2.63	81	200	21.2
Field pea-Dundale	6.9	2.50	87	226	21.9
Lentil-Digger	4.0	2.40	85	124	20.5
Medic-Mogul	4.7	2.15	74	109	16.0
Vetch-Morava	5.1	2.74	84	174	22.9
Species LSD (P<0.05)	*1.5*	*0.15*	*8.5*	*47*	*2.6*
Mean of all species 1998	4.3	2.3	75	116	18.0
Mean of all species 1999	6.2	2.5	81	188	20.4
Year LSD (P<0.05)	*0.7*	*0.07*	*4.0*	*22.0*	*1.2*

[1] Includes estimate of N contributed by nodulated roots

Both 1998and 1999 and 2000 were difficult growing seasons. In 1998, both sites received average growing season rainfall (GSR of Decile 5) but were severely frosted on October 28. The 1999 GSR was below average (Decile 2). In October 2000, the GSR was in Decile 3.

The fenugreek accessions flowered at a similar time to faba bean and before other species (Table 1). There was significant variation in flowering time among fenugreek accessions. It is difficult to compare grain yields, as they were frost affected in 1998. Lentil and vetch were the worst affected at both sites, with faba bean and the fenugreek accessions being least affected. Vetch growth in 1998 was also inhibited by herbicide damage. Faba bean and field pea were the highest yielding species, with the earlier maturing 150212 being the highest yielding fenugreek accession in all three experiments.

Field pea produced the most DM and fixed the highest proportion of N, and consequently fixed the largest amount of N per hectare (Table 2). Vetch and faba bean also had ANF values significantly higher than fenugreek, lentil and medic. Estimates of fenugreek N_2 fixation were between that of lentil and medic. There were no significant differences in fenugreek DM production, or ANF, but accession 150265 had the highest RNFE and had a significantly higher %Ndfa than that of 150000 and 150292. The amount of N fixed was closely related to DM (Table 3), but also influenced by shoot N content and %Ndfa. Shoot N content and %Ndfa both significantly influence RNFE. All species consistently produced more growth and fixed a higher proportion of N in 1999 than in 1998 (Table 2 and 4). The only species-year interaction was for AFN, where vetch and faba bean showed greater improvements than other species in 1999, but field pea and 150265 did not change.

The amount of N remaining after the legume harvest was greatest for field pea and vetch (Table 4). Fenugreek accessions and lentil all left similar amounts of residual N. There were no significant differences in pre-sowing soil NO_3 concentration following the various legume treatments at Longerenong, in either May 1999 or April 2000 (data not shown), and there were no significant differences in N uptake and DM at Z30. Furthermore, there were no statistically significant differences in grain yield or grain protein at Dimboola or Longerenong wheat plots in 1999 (Table 5).

Table 3. Correlation coefficients between factors affecting nitrogen fixation.

Parameter	Amount N fixed[1] (kg/ha)	Relative nitrogen fixation efficiency (kg N/t)
Dry matter at mid grain fill	0.92 P<0.001	0.21 NS
Shoot N (%)	0.54 P<0.001	0.76 P<0.001
%Ndfa	0.41 P<0.01	0.89 P<0.001

[1] Includes estimate of N contributed by nodulated roots

Table 4. Nitrogen balance at the end of the legume season (Longerenong data only).

Species-Genotype	Amount N fixed[1] (kg/ha)	Seed yield (t/ha)	Seed N (%)	N removed by seed (kg/ha)	N balance (kg/ha)

Fenugreek-150000	122	1.51	4.15	62	61
Fenugreek-150212	141	1.80	4.60	81	60
Fenugreek-150265	130	1.59	4.32	67	63
Fenugreek-150292	142	1.61	4.37	69	73
Faba bean -Fiord	200	2.35	4.00	94	106
Field pea-Dundale	226	2.22	4.08	89	137
Lentil-Digger	124	1.56	3.98	61	63
Medic-Mogul	109	NH	NH	-	-
Vetch-Morava	174	1.00	4.50	45	129
Species LSD (P<0.05)	*46.6*	*0.43*	*0.13*	*17.8*	*53*
Mean of all species 1998	116	1.00	4.44	45	75
Mean of all species 1999	188	2.40	4.06	97	98
Year LSD (P<0.05)	*22.0*	*0.20*	*0.06*	*8.4*	*NS*

[1] Includes estimate of N contributed by nodulated roots

DISCUSSION

Fenugreek did not produce seed yields as high as field pea or faba bean, but its current high price ($450/t compared to $200/t for field pea and $270/t for faba bean) makes it economically attractive. However, inelastic demand and market volatility means that fenugreek production for grain is high risk. The incidence of bacterial blight in Wimmera fenugreek crops (2) also increases the risk. While vetch is the major green manure species used in Wimmera farming systems, medic is still used as a short duration annual pasture, or green manure fallow, by growers who are concerned by vetch contamination. Fenugreek could have role as a vetch or medic replacement for green manuring.

The amount of N_2 fixed by legume crops was primarily influenced by DM production. Nitrogen fixation estimates indicate that two fenugreek accessions fixed similar amounts of N per tonne of DM to faba bean, field pea and vetch, but were more efficient at fixing N than medic (Table 2). Despite significant differences in N fixation estimates, no differences were detected in subsequent wheat growth. This was most likely due to the dry growing seasons experienced by the wheat crops.

Fenugreek accessions varied in flowering time, grain yield and N fixation. The variation exhibited by all accessions in the trial indicated that significant improvement could be made by selection.

Table 5. Effect of previous crop on wheat growth in the following season.

Previous crop	Z30 dry matter[1] (t/ha)	Z30 N uptake[1] (kg/ha)	Grain yield[2] (t/ha)	Grain protein[2] (%)	100 grain weight[2] (g)	N removal by grain[2] (kg/ha)
Fenugreek-150000	1.3	45.6	2.76	11.4	4.1	57
Fenugreek-150212	1.59	58.3	3.13	12.4	4.2	58
Fenugreek-150265	1.58	56.3	2.42	11.1	4.1	52
Fenugreek-150292	1.49	54.8	2.93	11.3	4.0	55
Faba bean -Fiord[3]	1.59	59.0	3.33	11.3	4.1	55
Field pea-Dundale	1.52	53.8	3.07	11.0	4.1	58
Lentil-Digger	1.47	55.9	2.63	12.2	4.1	60
Medic-Mogul	1.51	52.9	2.78	11.6	4.2	56
Vetch-Morava	1.59	59.4	2.90	12.2	4.2	55
LSD (P<0.05)	NS	NS	NS	NS		NS

[1] Pooled data from 1999 and 2000 at Longerenong; [2] Pooled data from 1999 at Longerenong and Dimboola

[3] Data from Longerenong only

CONCLUSION

The phenology, DM production and seed yields of fenugreek accessions indicate that this species was agronomically similar to other legumes used in Wimmera farming systems. Fenugreek had comparable N_2 fixation capacity to other species. Fenugreek's effect on the growth of subsequent wheat crops was not significantly different to that of the other legumes in the dry seasons of 1999 and 2000. Therefore,

fenugreek could have a similar rotational role to other legumes in Wimmera farming systems where legumes are often included in two out of five seasons either as a cash crop, pasture or green manure.

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