THE TANGIER FLATPEA -- A POTENTIAL GREEN MANURE CROP FOR THE PRAIRIES

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INTRODUCTION

The fertility of cultivated prairie soils has greatly decreased under the traditional wheat-fallow rotation. Soil organic matter contents and, more importantly, reserves of mineralizable N have declined so much that N fertilizer must be applied to more and more fallow fields to obtain economic grain yields.

In recent years, rapidly rising fertilizer prices and tillage energy costs have produced renewed interest in the use of legume green manures for soil improvement and have made biological N_2-fixation more attractive. In semiarid regions of the prairies, there is a real need for a high N_2-fixing annual legume in cereal production systems, because biennials, such as sweetclover, compete with the cereal crop and interfere with chemical weed control, and because perennials, such as alfalfa, produce little N in the first year and use too much valuable soil moisture if grown for several years. Annual grain legumes, such as the pulses, are only moderately resistant to drought and thus are grown primarily in the parkland belt rather than the dry Brown and Dark Brown soil zones.

To be effective as fallow substitute-green manure an annual legume should meet the following criteria:

1) Rapid ground cover for soil protection;
2) High rate of N_2-fixation and biomass production;
3) Emergency source of nutritious feed for dry years;
4) High water use efficiency to avoid excessive depletion of moisture reserves in the profile;
5) Remain herbaceous for easy incorporation and decomposition;
6) High seed production in 'leave' strips for harvest of replacement seed;
7) Adequate stand height in 'leave' strips for overwinter snow trapping.

In our search for a suitable annual legume we have screened, since 1980, various species of *Lupinus*, *Lathyrus*, *Trifolium* and *Vicia*; but the results of our initial greenhouse tests were not very encouraging. Early in 1982, Mr. Hugh Campbell, farmer at Qu'Appelle, Saskatchewan, contacted us to report on the rapid growth and high production he had obtained with the Tangier flatpea (*Lathyrus tingitanus* L.) in 1981 at several locations in southern Saskatchewan. He provided us with enough seed for a small field trial.

Since very little is known about the characteristics of this promising annual legume of Mediterranean origin (Usher, 1974), we decided to conduct a more detailed study. Our objectives were (i) to closely monitor the growth of the Tangier flatpea in wheat stubble, (ii) to determine the effect of seed inoculation on yield, quality and N_2-fixation, and (iii) to assess to what extent this exotic legume may meet the afore-mentioned criteria for fallow substitute-green manuring.

MATERIALS AND METHODS

Tangier flatpeas were seeded on May 25, 1982, with a press drill at a rate of 142 kg/ha and a depth of about 5 cm into wheat stubble on a Wood Mountain loam (orthic Brown Chernozem) at Swift Current. The field trial consisted of two flatpea plots, 50 m^2 each, surrounded by an 8 m wide strip seeded to Canuck spring wheat. The flatpea seed for plot "I" was inoculated just prior to seeding with *Rhizobium leguminosarum* using a commercial peat-base inoculant (Nitragin 'C' culture) and sticking agent (Nitragin 'nitra-coat') at a total cost of $1.85/ha. The seed for plot "U" was left uninoculated. On both plots the seedlings did not emerge until about June 9 as germination was delayed by a heavy snowfall on May 29. On June 18, flatpeas and wheat were fertilized with phosphorus by broadcasting 0-45-0 at a rate of 156 kg/ha (70 kg P_2O_5/ha).

Surface soil samples (0- to 15-cm) were collected aseptically, prior to seeding, and analyzed by a modified MPN plant infection technique to test for the presence of indigenous *Rhizobium leguminosarum* strains. For soil moisture, NO_3-N and NH_4-N analyses samples were taken just before seeding and after harvest with a soil coring truck at 0- to 15-, 15- to 30-, 30- to 60-, 60- to 90-, and 90- to 120-cm intervals.

Plants were sampled at 1, 2, 3, 4, 6, 8, 10 and 12 weeks after emergence by carefully excavating about 20 plants from each plot. To prevent root losses and nodule segregation the entire bulk of rootzone soil for each excavated cluster of 2 to 4 plants was removed *in toto* from the pit and tightly wrapped with nylon window screening to remain intact during transport from the field. The wrapped up bundles of roots, soil and shoots were then placed in metal tubs and the soil was soaked overnight in dilute Na_2CO_3 to effect aggregate disruption and clay dispersion. All soil was gently washed away from roots and nodules and through the nylon screening by repeated spraying with a fine jet of water. After the many old wheat roots, still remaining from the previous crop, were carefully separated from the flatpea root system and removed, the whole washed plants were laid out on a table for inspection. From the range of plants recovered from each plot at each sampling, 12 average plants were selected as representative of that treatment. Shoot and root length of each plant was measured and the number of leaf nodes and root nodules was counted. With the onset of fruiting the number of pods and seeds per plant was also recorded. For dry matter determinations and subsequent chemical analyses (organic matter, C, N and P) plants were bulked into four replicate subsamples of three plants each and separated into roots, shoots and pods before drying at 75°C and weighing.

The amount of plant-N gained through symbiotic N_2-fixation was estimated by substracting total plant-N in uninoculated, i.e., non-nodulated plants from the total plant-N in inoculated, i.e., nodulated plants.

To determine the yield of above-ground plant material at full maturity, six random 1.0 m^2 samples were cut on September 3 in each plot and separated into shoots and pods before drying and weighing. However, these bulk samples grossly underestimated the total above-ground production, especially for the generally more mature inoculated flatpeas, because a large proportion of seeds were lost before harvest due to extensive podshattering and because many leaves had already dropped off from the lower parts of the stems.

Precipitation was assumed to be similar to that recorded at the meteorological site located 0.6 km from the plots (Table 1). During the period of May to the end of September, precipitation was 31% greater than the long-term average for this region.

Table 1. Growing season precipitation at Swift Current during 1982

	Precipitation	
	Actual	L.T. Av.*
	--- mm ---	
May	81.6	42.7
June	42.7	72.5
July	119.2	51.9
August	40.8	42.6
September	30.4	30.5
Total	314.7	240.2

*Long-term average for 97 years (1886-1982).

RESULTS AND DISCUSSION

Successful introduction of green manuring to replace summerfallow in grain production systems in southern Saskatchewan will depend on the adoption of improved snow management in combination with the use of a legume that can produce large quantities of biomass in a relatively short time. A comparison of dry matter production by sweet clovers with that of Tangier flatpeas, when grown under the same climatic conditions, demonstrates the advantage gained from using a fast growing annual instead of biennial or perennial legumes (Table 2). Being seeded into double fallow, the sweetclovers could draw on greater soil moisture and nutrient reserves than the flatpeas seeded into wheat stubble, yet the annual legume, even without the benefit of inoculation, outproduced the biennials severalfold.

Table 2. Sweet Clover vs. Flatpea Production in 1982 at Swift Current

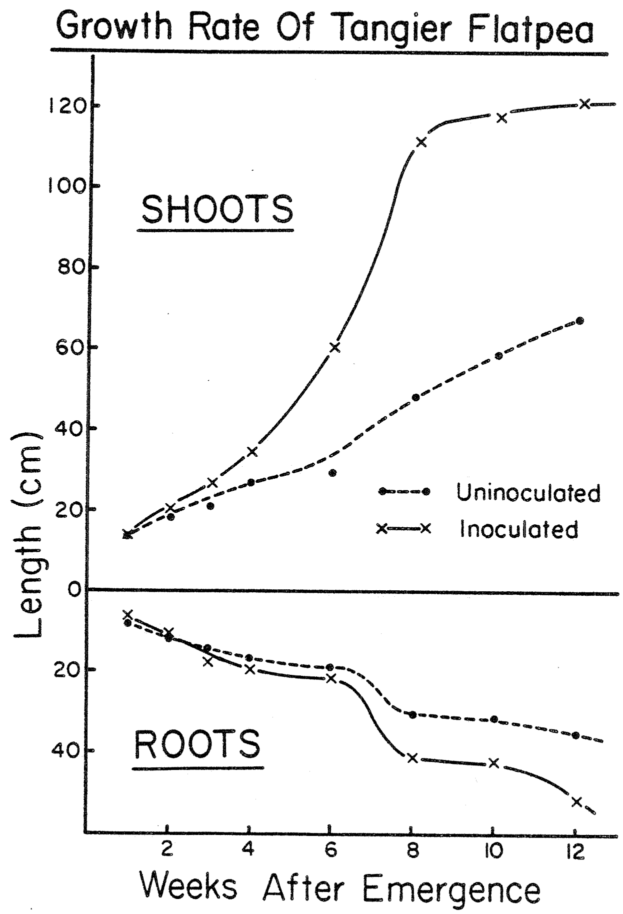
Type of legume and treatment	Dry matter harvested 13 weeks after emergence mean ± S.E.M. (5 reps)
	kg/ha
Common yellow clover in fallow,* inoculated	749 ± 473
Yukon yellow clover in fallow*, inoculated	925 ± 166
Tangier flatpea in stubble, uninoculated	2,530 ± 80
Tangier flatpea in stubble, inoculated	5,050 ± 160

*Sweetclovers were seeded into land fallowed for two years.

It must be noted that the bulk sample yields of Tangier flatpeas, cut at 13 weeks after emergence (Table 2), do not represent the true total above-ground dry matter production. In fact, these yields markedly underestimate total production because they include neither the weight of seeds lost due to extensive pod shattering prior to harvest nor the weight of leaves dropped from the lower nodes as plants approached maturity. The yield loss through seed ejection was considerable because at early maturity (i.e., 12 weeks after emergence) seeds and pods accounted for 62% and 58% of the above-ground matter of uninoculated and inoculated plants, respectively. Based on a post-harvest ground survey, indicating a seed loss of about one quarter from uninoculated and about one-third from the more mature, inoculated plants, we have estimated the actual amount of total dry matter produced to be about 3,100 kg/ha for uninoculated and about 6,800 kg/ha for inoculated Tangier flatpeas. These adjusted bulk sample yields represent more realistic production estimates than the curves for total production shown in Figure 3. Since the latter are based on periodic excavation of a small number of plants and extrapolation to a per hectare scale by means of an assumed average plant density, they apparently tended to overestimate actual production.

However, excavation, root washing and subsequent measurements of individual plants produced average shoot and root growth rates that indicate when and to what extend growth was enhanced as a result of seed inoculation (Figure 1).

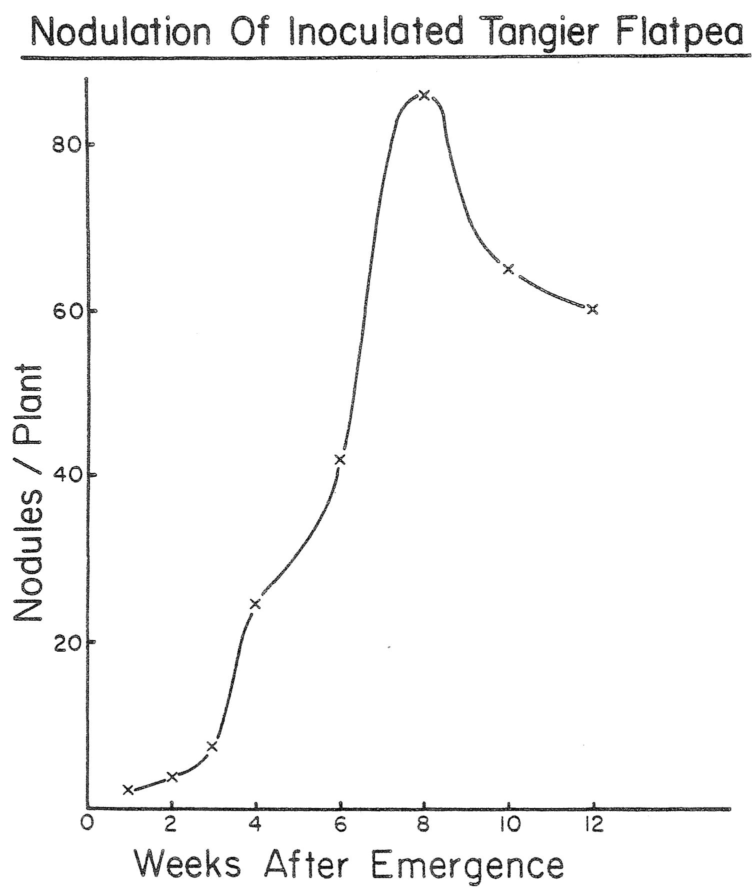
Figure 1



For inoculated plants the rate of shoot extension resulted in a sigmoidal curve, typical for plant growth under nutrient-non-limiting conditions. By contrast, shoot growth of uninoculated plants followed more of a straight line than a curve. Although the final shoot lengths were 68 cm and 122 cm for uninoculated and inoculated plants, respectively, maximum stand heights in the field were only 55 cm and 100 cm because of the herbaceous nature of this annual legume. Differences in the growth rate of roots due to inoculation, were considerably less pronounced, especially during the first six weeks (Figure 1).

The first marked increase in shoot growth of inoculated plants over that of uninoculated plants occurred between three and four weeks after emergence and that was also the time when nodulation of the inoculated plants underwent a sudden large (3.4-fold) increase (Figure 2).

Figure 2

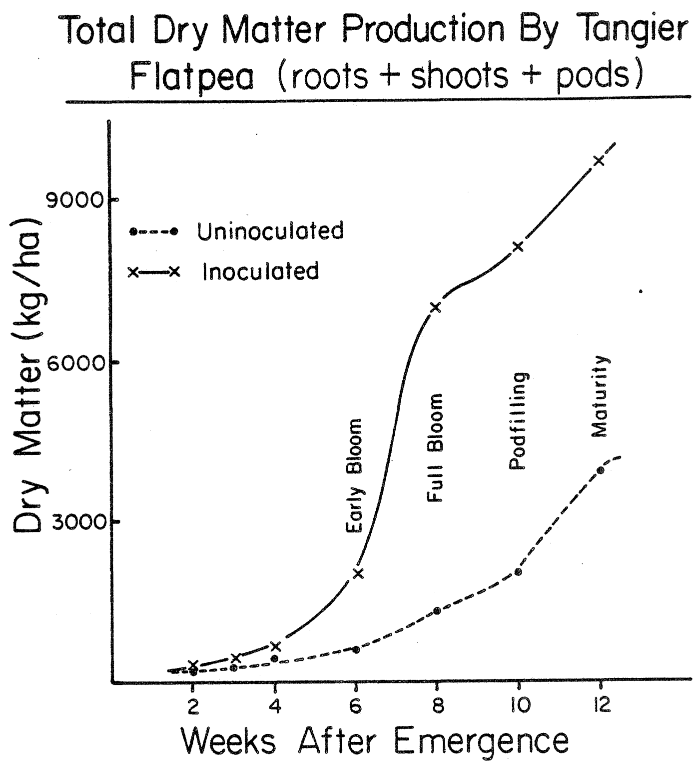


Although 60%, 83% and 100% of the inoculated plants were found to be nodulated one, two and three weeks after emergence, respectively, the number of nodules per plant during this period (i.e., <7) was too small to significantly boost the N supply of nodulated plants. Thereafter, nodulation increased very rapidly, not only in terms of number but also in size and distribution within the crown region. Nodulation appeared to reach a maximum of about 86 nodules/plant at eight weeks, i.e., when the plants were in full bloom and had just gone through very rapid vegetative growth (cf. Figures 1, 2 and 3). The subsequent decrease was due to progressive senescing and sloughing off of many large crown nodules as the plants shifted from primarily vegetative to more reproductive growth. However, during this time of podfilling and high N demand, a considerable number of new, and actively N_2-fixing, nodules appeared on secondary roots and on deep roots down to a depth of at least 50 cm.

The observed nodulation was attributed exclusively to seed inoculation because there were no Rhizobium leguminosarum cells present in any of the soil samples taken just prior to seeding and analyzed by the plant infection technique using Tangier flatpeas as host plants, and because not one of more than 200 uninoculated flatpeas, that were excavated during the growing season, was nodulated. Thus the growth of the uninoculated flatpeas was completely dependent on the supply of available N from the soil and was, therefore, used as a natural and valid control for assessing the time course and extent of symbiotic N_2-fixation.

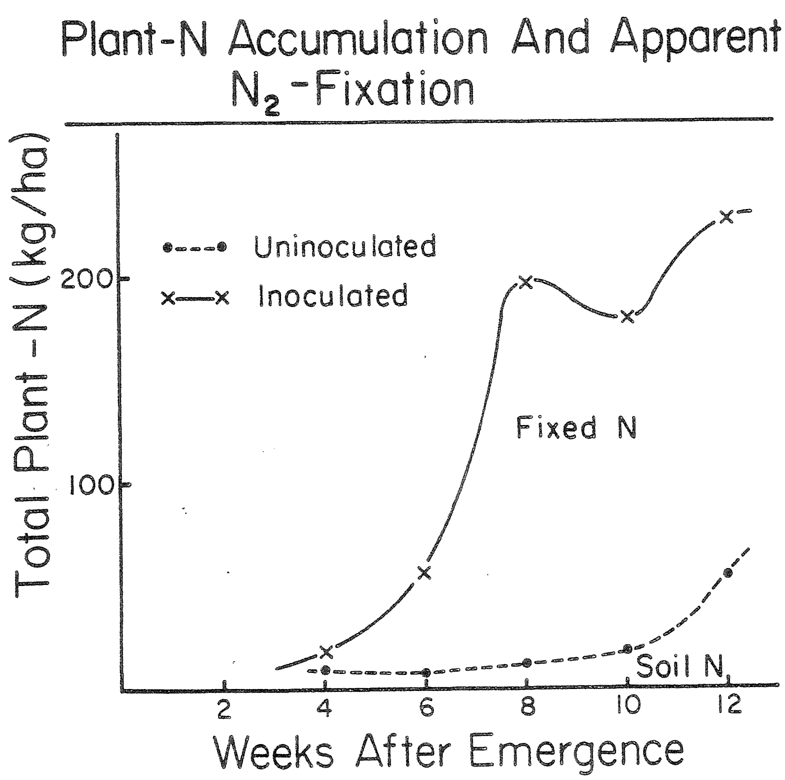
Differences in total dry matter production between uninoculated and inoculated plants were very small during the first four weeks (Figure 3).

Figure 3



Then the production by inoculated plants increased very rapidly, as nodulation also underwent its largest increase, until the maximum difference in total dry matter was reached at full bloom. At this stage the inoculated plants had outproduced the uninoculated and non-nodulated plants by 540%. During the primarily reproductive growth, after full bloom, the uninoculated plants increased dry matter at a slightly faster rate than did the inoculated plants thus effecting some reduction of treatment differences. This was particularly evident during the late podfilling stage when the total dry matter of uninoculated plants doubled within two weeks. Figure 4 indicates that this large, late increase in dry matter production by uninoculated plants was facilitated by a greatly increased uptake of soil N. By mid- to late August much more mineral N had become available to the roots, as leaching of NO_3-N due to the heavy July rains had ceased by early August, and as more N was being mineralized and moving upward within the gradually drying rootzone soil.

Figure 4



Symbiotic N_2-fixation, as estimated by subtracting total plant-N in non-nodulated plants from total plant-N in nodulated plants, increased very rapidly between early and full bloom (Figure 4), indicating a net gain of about 135 kg N/ha within this two-week period. The proportion of total N in the inoculated plants obtained through fixation accounted for 50%, 88% and 94% at four, six and eight weeks, respectively. What appeared to be a net decrease of N in inoculated plants and hence in N_2-fixation, was not real, but was simply due to progressive N loss from the plants (i.e., the plant material recovered after excavation and washing) via sloughing off large senescing crown nodules and early dropping of lower leaves in the very dense inoculated stand. Thus the curve for cumulative total N_2-fixation within the soil-plant system should never actually decline also it will flatten off as the nodulated legume approaches maturity.

The levels of available nitrogen present at seeding and at harvest in the 0- to 60-cm depth under the flatpeas did not change markedly (Table 3). This suggests that the total N uptake by uninoculated flatpeas, i.e., 55 kg N/ha based on tissue analyses, was roughly equal to the amount of N mineralized from soil organic reserves during the growing season. The adjacent wheat did use more N from the top 60 cm, and, as indicated by N-analyses of the 60- to 120-cm depth, the wheat with its much deeper root system had taken up a considerable proportion of its plant-N from below 60 cm.

Table 3. Available Soil Nitrogen under Tangier Flatpeas and Canuck Wheat

	Uninoc. flatpea	Adjacent wheat	Inoc. flatpea	Adjacent wheat
		kg N/ha*		
At seeding	--- 59 (NO_3-23) ---		--- 67 (NO_3-37) ---	
At harvest	61	48	60	52

*Nitrate plus exchangeable ammonium in 0 to 60-cm depth.

We noted that the farily high soil nitrate level under the inoculated seedlings (i.e., 37 kg N/ha) did not, as could have been expected, inhibit or reduce nodule formation and subsequent efficient symbiotic N_2-fixation. This apparent capacity for effective nodulation in the presence of considerable soil nitrate could be an important positive attribute of the Tangier flatpea.

The amounts of soil nitrogen available within the shallow rootzone of the flatpeas were obviously insufficient to meet the needs of non-nodulated plants because visible symptoms of N deficiency could be easily recognized in the uninoculated stand as early as six weeks after emergence. In contrast to the normal signs of N deficiency among legumes, viz. stunted growth and pale green to yellowish appearance of the foliage, the foliage of non-nodulated flatpeas assumed initially a slight reddish coloration that changed to a distinctly red appearance as the plants became severely N deficient at about eight weeks. Thereafter, the stems also showed a reddish tinge while the foliage was gradually losing its reddish coloration to a progressive yellowing. All nodulated flatpeas displayed very vigorous growth with leaves and stems being slightly larger and consistently dark green until podfilling, when they became pale green as more and more tissue-N was translocated to the seeds.

Inoculation was also effective in getting more protein into the forage portion of the flatpeas (Table 4).

Table 4. Effect of Inoculation on Protein Content and *in vitro* Digestibility of Tangier Flatpea Stems and Leaves

Weeks after emergence	% Protein		% Org. matter digestible	
	Uninoc.	Inoc.	Uninoc.	Inoc.
4	14.1	17.1	76	76
6	6.8	17.5	66	69
8	5.3	17.1	63	65
10	4.7	9.1	58	56
12	4.1	8.0	48	55

While the protein content of uninoculated plants declined very sharply after four weeks of growth, protein in the herbage of inoculated plants remained consistently high (>17%) until full bloom, and although it declined thereafter it still remained about twice as high as in non-nodulated plants. However, inoculation had very little effect on the *in vitro* digestibility of flatpea herbage. This index of the potential for digestion by ruminants was, initially, equally high in both treatments and then decreased at similar rates until podfilling (Table 4), but at maturity the herbage of inoculated plants was significantly more digestible.

These results indicate that the Tangier flatpea may provide a nutritionally adequate emergency source of feed, particularly if cut at full bloom when the herbage still contains about 17% protein and about two-thirds of the organic matter appears to be digestible. To properly evaluate the nutritive quality of Tangier flatpeas, these preliminary indications should be followed up be feeding trials with sheep or cattle.

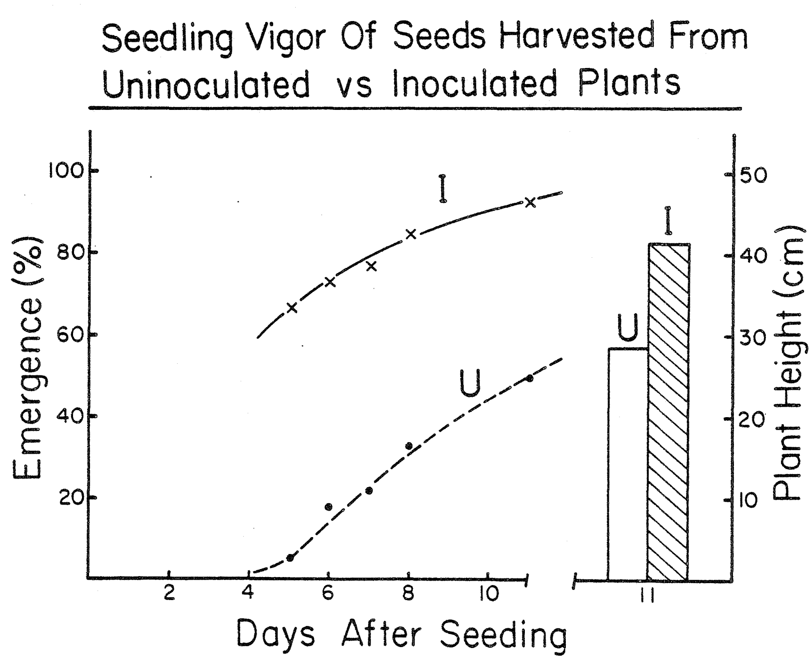
The extent of soil moisture depletion is a key criterion in the initial assessment of annual legumes for fallow replacement cropping. Thus soil water reserves were determined at the beginning and the end of the growing season (Table 5). The results indicate that inoculated flatpeas depleted soil moisture to the same extent as did spring wheat, and suggest that flatpeas may have a slightly higher water use efficiency because they produced more dry matter than the adjacent wheat.

Table 5. Net Change in Root Zone Moisture due to Stubble Cropping to Tangier Flatpeas and Canuck Wheat

	H_2O as cm/120 cm soil under	
	Inoculated flatpea	Adjacent Wheat
	--- mean ± S.E.M. ---	
At seeding	--- 21.01 ± 0.67 ---	
At harvest	13.58 ± 0.40	13.78 ± 0.61
Net change	-7.43	-7.23

After the harvest, seeds from nodulated and from non-nodulated plants were tested separately for germination and it was discovered that some beneficial effects of the original seed inoculation and subsequent N_2-fixation were definitely carried over into the next generation of flatpea plants. Seeds harvested from inoculated plants and then seeded, without inoculation, into soil flats emerged much more rapidly and produced much taller and healthier seedlings than did the seeds harvested from uninoculated plants (Figure 5).

Figure 5



In three consecutive tests the effect on seedling vigor was quite remarkable. The improved emergence by seeds originating from nodulated plants should be attributed to their higher protein content and 22% greater dry weight per seed.

Through our initial field trial and examination of the rather meager literature pertaining to Lathyrus species, we have, as yet, become aware of the following four problems or negative attributes of the Tangier flatpea that could reduce the potential usefulness of this annual legume:

1) The plants are susceptible to attack by blister beetles when in bloom. In areas where the infestation was heavy we eliminated these beetles very effectively by spraying the plants once with carbaryl.
2) The progressive twisting of pods that causes very extensive seed shattering as the plants reach maturity could present a major problem for the efficient harvesting of replacement seed from 'leave' strips.
3) Another negative attribute is the reported presence of a toxic compound, i.e., β-glutamyl-aminopropionitrile (BAPN), in the seeds of Tangier flatpeas (Kingsbury, 1964). The seeds harvested from our inoculated plot had a very high protein content that averaged 38% of dry weight. However, the potential use of such seeds for animal or human consumption is rather unlikely, unless future breeding programs can genetically eliminate the toxic seed component.
4) As the flatpea stems and foliage remain herbaceous, even after pod maturity, flatpea stands have the tendency to lodge badly during late fall rains or early snowfalls. This compacting would make 'leave' strips much less effective for snow trapping. We suggest that this problem could be resolved by simply drilling in some seed of a tall and 'stemmy' annual legume (e.g., fababeans) with the flatpea seeds to provide a rigid support for the flatpea vines in 'leave' strips.

CONCLUSIONS

This initial, albeit small and unreplicated field trial, did nevertheless provide some insight into the growth habit, the performance on wheat stubble and the inoculation response of Tangier flatpeas. This annual legume established ground cover early and did nodulate abundantly in response to seed inoculation, despite the presence of considerable soil nitrate. It proved capable of fixing very large amounts of atmospheric N_2 to facilitate rapid and extensive production of herbaceous biomass, that could serve as nutritious feed in emergencies. This legume used soil moisture very efficiently and did not cause 'excessive' depletion of water reserves within the profile.

From the results of our short, but intensive, study we have concluded that the Tangier flatpea may be able to meet most of the criteria we consider to be essential for the effective use of legumes as fallow substitute-green manure in support of grain production in a semiarid climate. This new and exotic legume seems to have sufficient potential for future soil improvement and savings of fertilizer and energy to warrant more interdisciplinary research and the implementation of a cooperative field testing program across the Prairies.

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