Annual Legume and Cereal Grain Rotations in Montana

Legumes in rotation with cereal grains can reduce the fertilizer as nitrogen needed for crops. These savings can improve the economic viability of such rotations where indigenous soil nitrogen levels are low and soil moisture levels are adequate.

by Rick Engel, Leon Welty, Ron Lockerman, Jerry Bergman, Greg Kushnak, Art Dubbs, Louise Prestbye, and Jim Sims*

Introduction

Production of cool-season annual legumes (chickpeas, lentil, black pea, green peas) may have application in Montana, in areas of high rainfall or in years of above normal precipitation. Small grain producers and agricultural scientists in Montana are interested in crop management systems which reduce costs while maintaining yields. One of the largest input costs in cereal grain production is fertilizer, particularly nitrogen (N). Including legumes in crop rotations can increase soil N and reduce nitrogen fertilizer requirements for production of a following grain crop (2,3). Forage legumes such as sweet clover or alfalfa were tested in small grain rotations in the Northern Great Plains (1) and Pacific Northwest (4). Though the concept of rotating legumes and grain crops to improve soil N is not new, few studies examined the effect of cool-seasoned legumes on production of a following small grain crop.

* Assistant Professor, Southern Agricultural Research Center, Huntley, Mont. 59037; Associate Professor, Northwestern Agricultural Research Center, Kalispell, Mont., 59901; Associate Professor, Plant and Soil Science Dept., MSU, Bozeman, Mont. 59717; Associate Professor, Western Triangle Research Center, Conrad, Mont., 59425; Professor Emeritus of Agronomy; Associate Professor, Eastern Agricultural Research Center, Sidney, Mont. 59270; Research Assistant; and Professor, Plant and Soil Science Dept., MSU.

Cool-season annual legumes, though not grown extensively in Montana, may be adaptable to our climate. In the Pacific Northwest (northern Idaho, eastern Washington, and northeastern Oregon) about 340,000 acres of dry pea and lentil have been grown annually over the last 10 years (5). Production of these legumes in this region is often done in rotation with winter wheat and spring barley.

A study comprising three categories of crop rotations, annual legume-barley, barley-barley and fallow-barley, was initiated in 1982 at several locations in Montana. The objectives of this study were to:

- determine the production level of several annual legumes (chickpea, lentil, green pea, and black pea) at each location;
- compare the effect of previous crops (legumes vs. barley and fallow) on barley yield-fertilizer N relations in a following year and;
- estimate the value of several annual legumes in terms of reduced need for N fertilizer for a following barley crop.

Materials and Methods

Two-year dryland crop rotations were established in 1982 at five locations in Montana: near Kalispell, Mocassin, Sidney, Conrad, and Bozeman. The same year, an irrigated crop rotation began at Huntley. At Kalispell, the dryland crop rotation was reestablished in 1983.

During the first year 'Clark' barley and four annual legumes ('Chilean-78' lentil, 'Garfield' green pea, 'UC-5' chickpea, and 'Melrose' Austrian winter or black pea) were grown at all sites. In addition, an area was fallowed at the dryland sites. Lentil, green pea, chickpea, and black pea were inoculated with Rhizobia and seeded at rates of 60, 175, 200, and 120 lbs/a, respectively, in rows spaced 12" apart. Annual legumes were harvested for seed, except black pea which was harvested for hay. Chickpea, lentil, and green peas straw material were returned to the plot area after seed harvest.

During the spring of the second year, barley was seeded over the entire study area. Legumes, fallow, and barley main plot areas were divided

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into five subplots with different levels of applied fertilizer N. The experiments were designed as a randomized complete block, strip-plot design with four replications of all treatments. At the dryland sites, N levels of 0, 25, 50, 75, and 100 lbs N/acre were applied. At the irrigated site, N levels of 0, 40, 80, 120, and 160 lbs N/acre were applied. Nitrogen was broadcast as ammonium nitrate (34-0-0) prior to seeding barley. Phosphorus and potassium were applied at a rate sufficient to ensure adequate levels of these nutrients based on soil test results. A portion of each subplot was harvested with a small-plot combine for barley grain yield determination.

Results and Discussion

Legume production and price. Production levels of barley and annual legumes differed greatly at each location (Table 1). Black pea-hay production exceeded 4,000 lbs/a at five locations. At Conrad, production was limited by drought. Irrigated legume seed production at Huntley was generally high for all crops except lentil, which had yields reduced by seed shattering and combine difficulties due to its low plant profile.

Green pea production appeared to be the most consistent across the dryland locations. Green pea exceeded lentil and chickpea production at all locations except at Kalispell in 1983. At this site, wet moisture conditions caused excessive vegetative growth and reduced pod set of green pea.

Chickpea production was affected by emergence problems at Mocassin and Conrad due to seed rot caused by Pythium ultimum.

TABLE 1
Annual legume and barley production

Location and precipitation in inches[1]	Chickpea seed	Lentil seed	Yield[2] Green pea seed	Black pea hay	Barley
	lbs/a				bu/a
Kalispell					
1982 (18.6)	1021	2137	3152	4928	68.4
1983 (21.0)	1720	1821	1559	4973	76.2
Bozeman (18.5)	1744	894	1907	4224	18.0
Huntley (14.4)	2178	1583	2929	5286	86.8
Conrad (11.6)	857	1894	2602	2554	39.7
Moccasin (18.5)	651	1056	1436	3258	44.6
Sidney (13.4)	1047	1385	2150	4878	55.0
Average	1317	1539	2247	4300	55.5

1. Crop year precipitation from September 1 of preceding year to August 31 of current crop year. An additional 6" of irrigation was applied at Huntley over three dates.
2. Seed and hay yields expressed at 12% moisture.

Fungicide treatments were not used at these locations. At Kalispell, chickpea production levels in 1982 were 50 percent of the 1983 levels. Captan, which was used in 1982 to control seed rot, inhibited nodulation and induced N deficiencies.

Average grower production levels of green pea, chickpea and lentil from 1983-1986 were 1672, 1116, and 905 lbs/a, respectively, in the Pacific Northwest (5). Average production levels observed in this study were similar to, and in the case of lentils higher than these levels.

The decision by a small grain producer to plant an annual legume will be influenced by the availability of markets, crop prices, and production costs. Markets for lentil, green pea, and chickpea currently can be found in northern Idaho. Precise estimates of cash value based on the product of crop price and yield are difficult to make as grower prices can fluctuate greatly. During the previous five years lentil prices have fluctuated from $12.05/cwt in May 1983 to $46/cwt in January 1986. Green pea prices were more stable during this period ranging from $8.25/cwt in October 1984 to $12.20/cwt in March 1982. Long-range price information on chickpea is not available for the Pacific Northwest. Black pea hay prices will vary with the price and availability of other hay crops.

Barley production as affected by N and previous crop. Barley production in the second year of the rotation was affected by fertilizer N and previous crop (P=0.05 level) at Kalispell (both 1983 and 1984), Bozeman, and Huntley. At these sites, N fertilization improved recrop barley yields indicating that soil N levels were inadequate to maximize barley production during the second year. Evidence of N fixation by Rhizobia-legume symbiosis was apparent from analyses of soil in the fall of 1983, at the end of the first crop-year rotation. Soil NO_3-N levels

TABLE 2
Crop effect on soil NO3-N following the first year of rotation. 1983.

Location[1]	Soil NO_3-N levels (0-48") Crop: Chickpea	Lentil	Green pea	Black pea	Barley	LSD(.05)
	lbs N/acre					
Kalispell	78	65	78	110	46	40
Bozeman	22	58	59	56	21	14
Huntley	82	58	136	68	39	34

[1] Soil analyses from Kalispell-1984 not available.

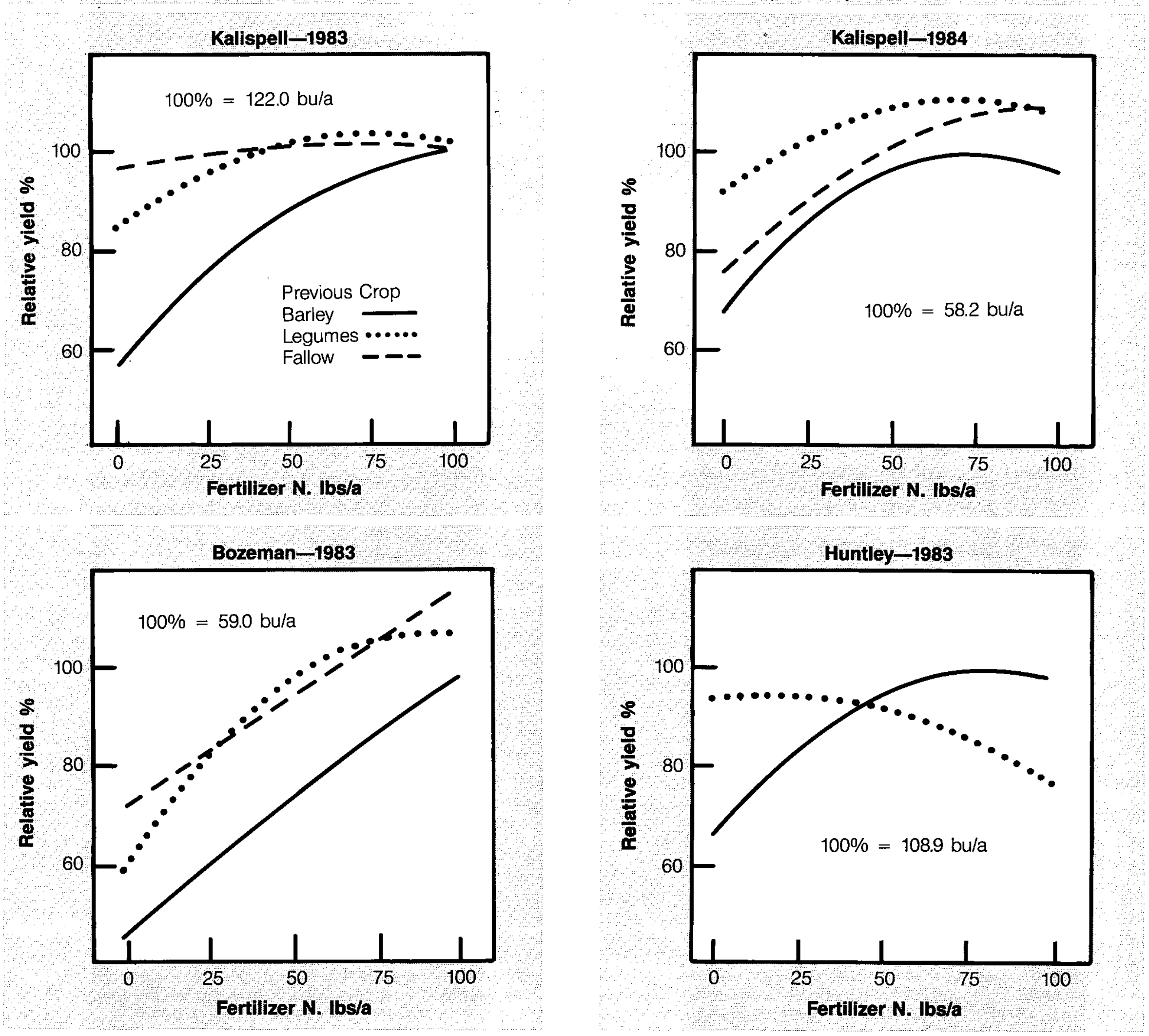
from the 0-48" layer revealed significantly higher ($P = 0.05$ level) plant available N for many of the legumes compared to barley (Table 2).

Fertilizer N did not improve barley yield at Sidney and Mocassin due to high indigenous soil N levels (288 lbs NO_3-N/a in 0-48" soil layer in spring of 1982) and drought, respectively. At these sites, previous crop had little effect on barley production during the second year. Yield data from Conrad was not obtained due to crop damage from a hail storm.

Regression analyses were used to develop equations relating barley yield in the second year of the rotation to fertilizer N and previous crop at the N responsive sites. That data is available upon request. Curves depicting the relationship between yield and fertilizer N for recrop barley, fallow-barley, and legume-barley (mean of chickpea, lentil, green pea and black pea) rotations are illustrated in Figure 1. Yield is expressed as a percentage of the maximum yield observed under the recrop barley rotation. Regression analyses revealed that barley yield-fertilizer N relations among the four legume crops did not differ at Huntley and Kalispell-1984 ($P = 0.05$ level), but did at Bozeman. Barley yield-fertilizer N relations following chickpea differed from the other legume rotations at Kalispell-1983. Poor chickpea nodulation and growth at this site, resulting in less N fixation, may explain why barley yield was lower following chickpea compared to the other legumes.

FIGURE 1

Effect of previous crop and fertilizer N on relative barley yield at Kalispell—1983, Kalispell—1984, Bozeman—1983 and Huntley—1983. At each site 100% yield = Maximum production of recrop barley.



Relative yield-fertilizer N curves indicate that where barley was preceeded by an annual legumes, response to fertilizer N was smaller and maximum yields occurred at lower N rates compared to recrop barley. At Huntley, N fertilization above 40 lbs/a resulted in lodging and depressed yield where barley followed annual legumes. These observations, plus soil N analyses during the fall following the first year of the rotation, indicate annual legumes increased soil N levels and reduced fertilizer N requirements needed to obtain to a specific yield level.

Yield differences between the legumes and recrop barley in the second year were greatest at the 0 N fertilizer level. Under the high moisture conditions at Huntley and Kalispell-1983 this difference was 27 and 32 bu/a, respectively. As fertilizer N increased the curves for the different rotations tended to converge, suggesting that most of the yield differences in this study could be accounted for by differences in N status of the soil.

Barley yields following legumes were generally equal to or greater than yields following fallow at the dryland locations. Exceptions were for chickpea at Kalispell-1983 and chickpea and black pea at Bozeman. Barley yield following legumes compared favorably with fallow because precipitation received during the winter was sufficient to replenish the soil profile, and because legumes were able to improve soil N status.

Fertilizer N requirements for maximum barley production. Optimal economic yields, where fertilizer N no longer increased yield sufficiently to recover its material cost of application, are equal to approximately 95 percent of the maximum yield. These levels for recrop barley were 115.9, 55.3, 56.0, and 105.4 bu/a for Kalispell 1983, Kalispell 1984, Bozeman, and Huntley respectively.

The N fertilizer required to achieve optimal economic yields was reduced when barley followed annual legumes (Table 3). The reduction averaged 51, 58, 39, and 45 lbs N/a at Huntley, Kalispell-1983 (chickpea not included), Kalispell-1984, and Bozeman, respectively. Assuming fertilizer N costs $25/cwt, this would translate into a substantial fertilizer N savings ranging from $9.75 to $14.50/acre.

In general, differences in fertilizer N requirements among the legumes at given locations were not as great as the differences observed between the locations. The results of this study could not confirm any advantage of one legume over another in terms of fertilizer N savings.

Summary and Conclusions

With the exception of Conrad, growing season moisture conditions were generally good at the test site locations. Thus, production levels reported here may be somewhat optimistic relative to typical Montana dryland conditions. Seed production levels of chickpea, lentil, and green pea averaged 1,068, 1,411, and 1,975 lbs/a, respectively, across seven locations in Montana. Black pea-hay production averaged 4300 lbs/a across these same sites.

Barley production during the second year was affected by N fertilization and previous crop at four sites ($P = 0.05$ level). At these sites, barley was typically less responsive to fertilizer N, and lower N rates were required to achieve similar yield levels when the preceding crop was an annual legume. Fertilizer N requirements at the 95 percent maximum yield level were reduced by an average of 51, 58, 39, and 48 lbs N/a at Huntley, Kalispell-1983 (chickpea not included), Kalispell-1984, and Bozeman. These fertilizer N savings may not be the overriding factor in a decision to include an annual legume into a cereal grain rotation. However, they can improve the economic viability of such a rotation where indigenous soil N levels are low and where soil moisture levels are replenished during winter.

TABLE 3
Fertilizer N required to reach 95 percent of maximum barley production level

	Site			
	Kalispell		Bozeman	Huntley
	1983	1984	1983	1983
	95% Maximum Yield Level, bu/a			
Previous crop	(116)	(55)	(56)	(103)
	fertilizer N, lbs/a			
Barley	72	49	93	81
Chickpea	56	9	56	30
Lentil	14	9	64	30
Green pea	14	9	40	30
Black pea	14	9	57	30
Fallow	0	37	52	

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