COMPARISON OF AVAILABLE SOIL MOISTURE AND NITROGEN FOLLOWING WHEAT AND LENTIL

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ABSTRACT

Lentil is generally grown in rotation with cereals, and may benefit the succeeding crop by using less moisture or by increasing the amount of available N. Soil moisture and N depletion was measured for lentil and wheat at five sites in 1985, three sites in 1987 and one in 1988. Lentil depleted soil moisture and mineral N to a similar extent as wheat at most sites. Exceptions occurred due to differences between lentil and wheat in their response to rainfall distribution or in their effectiveness at exploiting moisture and nitrate at deeper soil layers. Lentil residues contained more N than wheat residues, but this did not represent a net gain in N because as much N was removed with the seed as was fixed. Lentil residues had a higher and more variable N concentration than wheat. Thus, net N mineralization will on average be higher following lentil than following wheat, but the magnitude of these differences will be variable.

INTRODUCTION

Approximately 300 thousand hectares of lentil (*Lens culinaris* Medik.) are planted each year in Saskatchewan (Saskatchewan Agriculture, 1988), generally in rotation with cereals. Grain legumes such as lentil often have a beneficial effect on the subsequent cereal crop, although the mechanism for this is unclear (Herridge, 1982). A common suggestion is that because grain legumes such as lentil can fix nitrogen it will either use less soil N and/or residue will contain more N which then improves the N availability for the subsequent crop. However, some work has shown a similar fertilizer N response of cereals on lentil or cereal stubble (Townley-Smith et al., 1987). Other possible reasons for increased yields following lentil include less moisture use by lentil, reduced plant pathogens due to the inclusion of a different crop, or release of growth-promoting allelopathic compounds by lentil residues.

In a number of studies conducted in 1985, 1987 and 1988 soil water and nitrogen levels were monitored for both a lentil and wheat crop. This paper summarizes differences observed between lentil and wheat in the amount of soil moisture, soil mineral N and residue N remaining after harvest.

MATERIALS AND METHODS

Soil moisture and nitrogen depletion was measured for Laird lentil and Columbus or Neepawa wheat at five sites in 1985, three sites in 1987 and one in 1988. Soil moisture was measured gravimetrically to 120 cm at planting and harvest and converted to volumetric moisture using bulk densities obtained from the same soil. Soil samples were also used to measure NO_3^--N in 1985 and NO_3^-- plus NH_4^+-N in 1987 and 1988. Microplots in which ^{15}N-enriched fertilizer was added were included in the 1985 and 1987 experiments. Plant samples were harvested manually at maturity and threshed. The amount of below-ground residues was determined at two sites. In a 1987 experiment on a Sutherland clay loam four 8 cm cores were obtained to 90 cm in each plot at the time of harvest and roots were separated from the soil by washing and by manual

separation. In a 1988 experiment on a Bradwell sandy loam five 8 cm cores were obtained to 120 cm in each plot at the time of harvest and all floatable residues were separated from the soil by washing. All plant samples were weighed, ground and analysed for percent N (Bremner and Mulvaney, 1982). Dinitrogen fixation was estimated by ^{15}N-isotope dilution at all sites; at the 1987 site on the Sutherland clay loam and at the 1988 site ^{15}N dilution was measured relative to natural enrichment (Rennie and Rennie, 1983). Least significant differences ($P < 0.05$) were used to compare values obtained for lentil and wheat within each site.

RESULTS AND DISCUSSION

Lentil and wheat used similar amounts of moisture at all but three sites (Table 1). At a 1985 site less water was used by lentil than wheat at depths greater than 60 cm (Fig. 1). At the 1987 sites wheat used less moisture than lentil because precipitation was received late in the growing season; late precipitation stimulated growth by lentil but had little effect on wheat growth (Fig. 2).

Table 1. Differences between wheat and lentil in water use, soil N uptake and soil mineral N at the end of the growing season.

Year	Soil zone	Soil type	------- Difference (wheat - lentil) -------		
			Water use	Soil N uptake	Mineral N
			- cm -	----- kg ha^{-1} -----	
1985	Brown	Fox Valley Silty Clay Loam	-0.1	-1	-9
	Dark Brown	Regina Heavy Clay	4.3**	6	1
	Dark Brown	Elstow-Weyburn Loam	-1.4	-4	-5
	Black	Tisdale Silty Clay Loam	1.4	-22**	-11
	Gray	Whitewood-Waitville Loam	1.7	11	-17*
1985∂	Dark Brown	Elstow Silty Clay Loam	0.4		
	Black	Waitville Loam	0.6		
1987	Dark Brown	Sutherland Clay Loam	-1.1	2	8
	Dark Brown	Bradwell Sandy Loam - irrigated	-3.4**	41**	8
	Dark Brown	Bradwell Sandy Loam - dryland	-6.5**	-12	-13
1988	Dark Brown	Bradwell Sandy Loam - irrigated	1.4	8	-7

* Significantly different from 0 ($P < 0.1$); ** significantly different from 0 ($P < 0.05$)

∂ Data provided by L. Townley-Smith, Agriculture Canada, Melfort Research Station

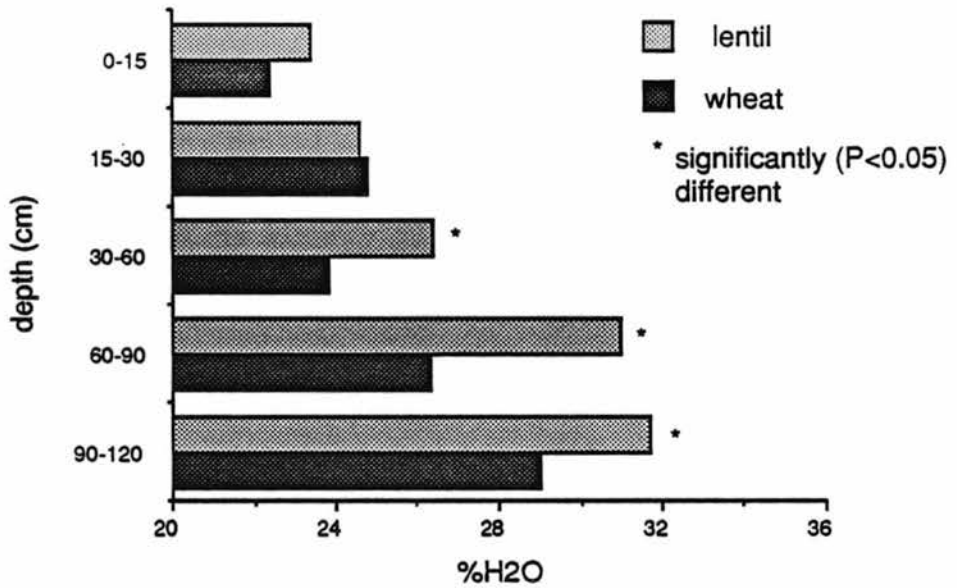

Fig.1 Comparison of gravimetric moisture following wheat and lentil grown on a Regina Heavy Clay in 1985

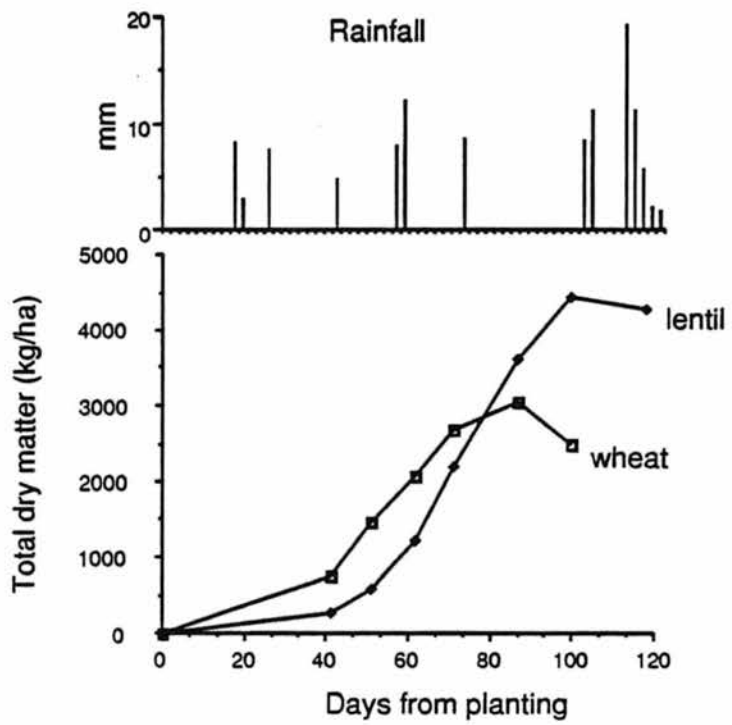

Fig. 2 Rainfall distribution and dry matter accumulation of lentil and wheat on a dryland Bradwell Sandy Loam, 1987.

Lentil assimilated similar amounts of soil N as wheat at all but two sites (Table 1). Mineral N levels were not significantly different following wheat and lentil except at the 1985 site on a Whitewood-Waitville soil, where wheat was more effective than lentil in taking up soil nitrate at depths greater than 60 cm (Fig. 3). At the 1985 site on a Tisdale soil lentil apparently assimilated more soil N than wheat, but also had a higher amount of mineral N left in the soil at the end of the growing season. It is likely that the difference in soil N depletion was actually quite small, despite the significant difference in soil N uptake. Similarly, at the 1987 site on an irrigated Bradwell soil lentil apparently took up 41 kg soil N ha^{-1} less than wheat, but also had 8 kg ha^{-1} less mineral N at the end of the growing season. At this site it is likely that the amount of N_2 fixed was overestimated because lentil assimilated more soil N late in the growing season than wheat (Swerhone et al., 1989), which would lead to an overestimate of N_2 fixed with the use of the ^{15}N-isotope dilution method (Witty, 1983). Thus, although some reports have indicated that some grain legumes assimilate less soil N than cereals (Senaratne and Hardarson, 1988; Evans and Taylor, 1987), lentil apparently takes up as much soil N as wheat. This agrees with other reports which show that legumes utilize existing supplies of mineral N before utilizing more C-expensive fixed N_2 (Ryle et al., 1978) and that mineral N inhibits N_2 fixation (Gibson, 1977).

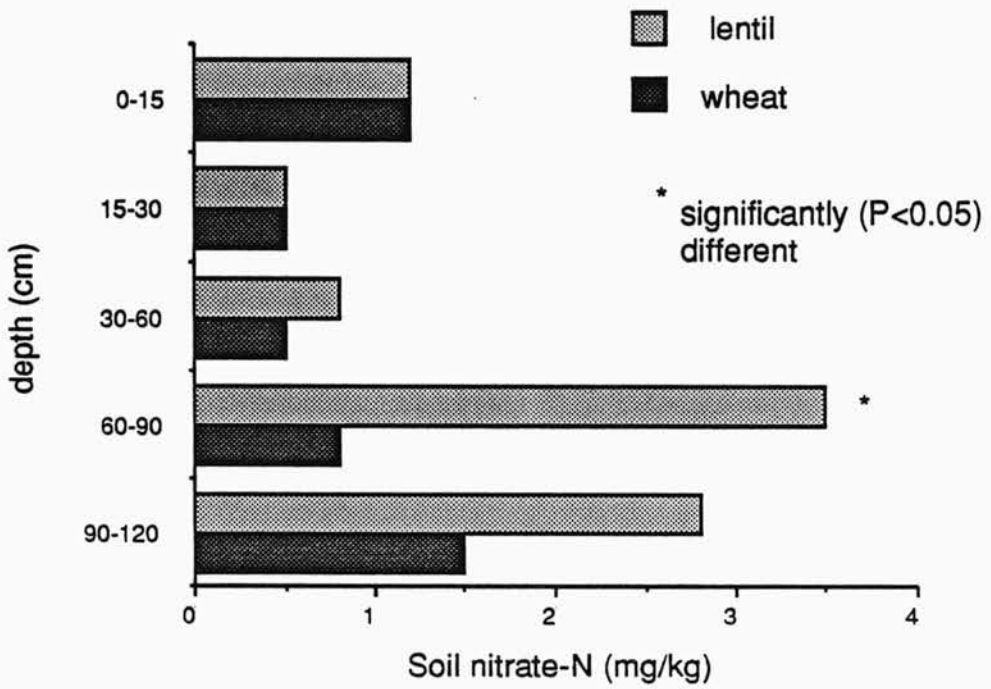

Fig. 3. Comparison of nitrate-N concentrations following lentil and wheat grown on a Whitewood-Waitville Loam in 1985.

Differences in subsequent N availability following wheat and lentil may be due to differences in the amount and N concentration of crop residues. Lentil had similar or greater amounts of above-ground residue compared to wheat in this study (Table 2), although average yields in Saskatchewan for lentil (1981 to 1985) were only half of those of wheat (Saskatchewan Agriculture, 1987). Differences in the amount of below-ground residues were less than those of above-ground residues at the two sites for which below-ground residues were measured. The N concentration of lentil was always significantly higher than that of wheat but was also more variable, ranging from 0.7 to 1.7% (Table 2). The high N concentration of lentil residues under

irrigation in 1987 was due to the wet conditions which favored vegetative growth and limited translocation of N to the seed. Differences in N concentration for below-ground residue were less than those for above-ground residues. The amount of N in crop residues was always much higher for lentil than for wheat due to the higher N concentration and the similar or greater amounts of residue.

Table 2. Comparison of the amount and N content of wheat and lentil residues.

Year	Site	Crop	Total dry matter	%N	Total N
			kg/ha		kg/ha
			Above-ground residues		
1985	Fox Valley SCL	Wheat	660	NA‡	NA
		Lentil	1050	NA	NA
	Regina HC	Wheat	1920	NA	NA
		Lenril	1420	NA	NA
	Elstow-Weyburn L	Wheat	2020	NA	NA
		Lentil	3790	NA	NA
	Tisdale SCL	Wheat	7410	NA	NA
		Lentil	6510	NA	NA
	Whitewood-Waitville L	Wheat	4170	NA	NA
		Lentil	3910	NA	NA
1987	Sutherland CL	Wheat	1620	0.3	5
		Lentil	3010	0.7	22
	Bradwell SL - Dryland	Wheat	1290	0.7	9
		Lentil	2790	1.2	34
	Bradwell SL - Irrig.	Wheat	2590	0.6	15
		Lentil	4810	1.7	80
1988	Bradwell SL - Irrig.	Wheat	3550	0.5	19
		Lentil	3520	1.0	35
			Below-ground residues		
1987*	Sutherland CL	Wheat	1500	1.0	15
		Lentil	1660	1.5	25
1988†	Bradwell SL - Irrig.	Wheat	4510	1.4	62
		Lentil	3950	1.8	71

* root residue
† floatable residue
‡ Not Available

Although lentil returned more N in the form of crop residues, this did not represent a net gain in N due to N_2 fixation. At all but two sites as much or more N was removed in the grain as was fixed by lentil (Table 3). At the 1987 site on an irrigated Bradwell soil lentil fixed 54 kg N ha^{-1} more than was removed in the grain; this can be attributed to more vegetative growth and possibly to overestimation of fixed N_2. At the 1988 site lentil removed 43 kg N ha^{-1} more than it fixed because high mineral N levels limited N_2 fixation. Thus, a lentil should not be expected to add significant amounts of N to a soil.

Table 3. Net N additions of lentil.

Year	Soil	Fixed N	Seed N	Net addition
		---------- kg N / ha ----------		
1985	Fox Valley SCL	8	12	-4
	Regina HC	21	29	-8
	Elstow-Weyburn L	73	68	-15
	Tisdale SCL	63	67	-4
	Whitewood-Waitville L	40	24	+16
1987	Sutherland CL	106	104	+2
	Bradwell SL - irrigated	124	70	+54
	Bradwell SL - dryland	47	56	-9
1988	Bradwell SL - irrigated	36	79	-43

A rough comparison of the net amount of N mineralized in the following year can be made if the following assumptions are made: crop residues contain 45% C; 75% of the C from both lentil and wheat residues decomposes with a half life of 0.5 year and 25% decomposes with a half life of 8 years (Juma and McGill, 1986), and the critical C/N for the decomposing substrate to release N is 25 (Harmsen and Van Schreven, 1955). More N is immobilized than mineralized after wheat (Fig. 4) because microbes decomposing wheat residues require more N than is available from the residue. Lentil residues vary widely in N concentration, and therefore net N mineralized may either be negative or positive. At the 1987 site on a Sutherland soil lentil may immobilize more N than wheat despite having a higher N concentration because it had twice the amount of crop residues. Differences in subsequent N mineralization following wheat and lentil are likely to vary widely between sites, primarily due to wide variation in the N concentration of lentil residues.

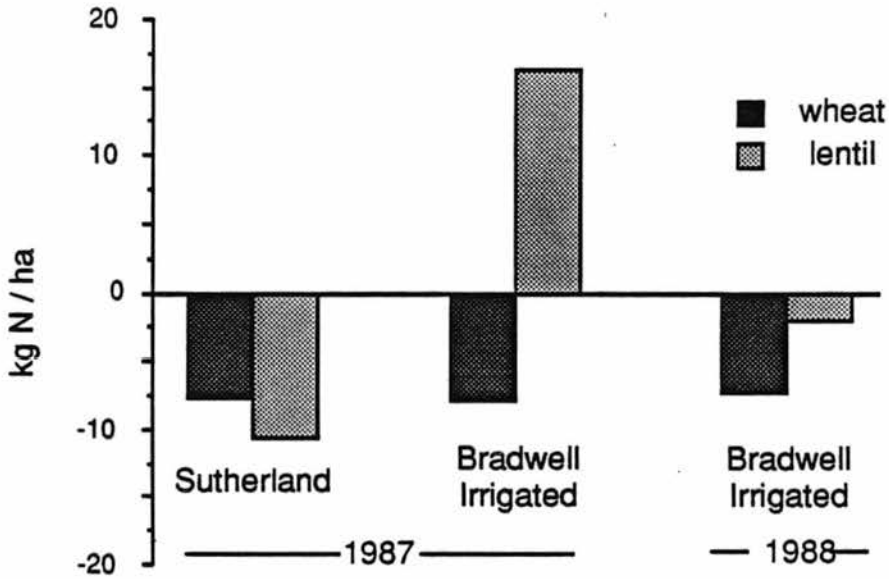

Fig. 4. Comparison of the amount of net N mineralized (predicted) in the following year after wheat and lentil.

CONCLUSIONS

Lentil generally uses similar amounts of water and soil N as wheat. If precipitation is received late in the growing season, lentil may use more moisture (and possibly soil N) than wheat because they are able to respond to this moisture due to their indeterminate growth habit whereas wheat cannot. There was some indication in this study that lentil may occasionally be less effective at exploring deeper soil depths for moisture or soil mineral N. Lentil residues may lead to greater net N mineralization in the following year because they contain higher concentrations of N. However, the N concentration of lentil residues was also more variable, and therefore differences in net N mineralization following wheat and lentil may also vary widely.

ACKNOWLEDGEMENTS

Special thanks to George Swerhone, Garth Parry, Bob Anderson and Lynn Gray for their help in carrying out field and laboratory measurements. This work has been financially supported by Esso Chemical Canada, Saskatchewan Agricultural Development Fund and NSERC.

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