Indian Journal of Agronomy **48** (3) : 160–163 (September 2003)

Effect of nitrogen fertilization on productivity and nitrogen balance in soil in *gobhi sarson (Brassica napus)*-based crop sequences

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Received : September 2002

ABSTRACT

An experiment was conducted during 1997–98 to 1999–2000 at the Oilseeds Research Station, Kangra, consisting of 4 rainy-season crops, viz. maize (*Zea mays* L.), *dhaincha* (*Sesbania aculeata* Pers.), soybean [*Glycine max* (L.) Merr.] and blackgram (*Phaseolus mungo* L.), followed by *gobhi sarson* (*Brassica napus* ssp. *oleifera* var *annua*) at 5 levels of N (0, 40, 80, 120 and 160 kg N/ha). *Dhaincha–gobhi sarson* sequence showed the maximum N balance in soil at all levels of N application. This was followed by soybean–*gobhi sarson*, blackgram–*gobhi sarson* and maize–*gobhi sarson* where positive N balance was observed at 40–160 kg N/ha. The balance sheet of N showed that there was gain of N in soybean–*gobhi sarson* and blackgram–*gobhi sarson* sequences, whereas it was negative in *dhaincha–gobhi sarson* and maize–*gobhi sarson* sequences. The gain of N in balance sheet was higher at lower levels of N application. The maximum grain yield of *gobhi sarson* was obtained in *dhaincha–gobhi sarson* sequence. The yield in *dhaincha–gobhi sarson* at 40 kg N/ha, blackgram–*gobhi sarson* at 80 kg N/ha and maize–*gobhi sarson* at 120 kg N/ha also remained at par with one another.

Key words : Crop sequence, *Gobhi sarson*, Soybean, Blackgram, Dhaincha, Productivity, Soil nitrogen

Maize–wheat is the most predominant cropping sequence in Himachal Pradesh. About 80% area is rainfed and the yield of wheat in this system is very low due to dependence on rains which are often missing during the critical growth period. In this situation, *gobhi sarson* has emerged as a potential replacement for wheat because of its higher yield, wider adaptability and suitability for its early planting to exploit residual moisture of the rainy (*kharif*) season. The productivity of cropping system depends on effective utilization of residual and cumulative nutrients. Inclusion of legumes in the cropping system significantly contributes to nitrogen economy and reduces energy inputs. Keeping this in view, the present study was undertaken to know the impact of various *kharif* crops in *gobhi sarson*-based sequence and to study its nitrogen requirement.

MATERIALS AND METHODS

A field experiment was conducted during 1997–98 to 1999–2000 under rainfed conditions at the Oilseeds Research Station, Kangra, Himachal Pradesh. The soil was silty clay loam, having pH 6.4, 6.3 and 6.1; 380, 407 and 415 kg available N/ha; 32.8, 40.2 and 41.8 kg available P_2O_5/ha; and 128.4, 132.8 and 140.6 kg available K_2O/ha, in the 3 years respectively. The treatments in split-plot design with 3 replications consisted of 4 rainy-season (*kharif*) crops grown under recommended doses of nutrients, viz. maize (90 kg N, 60 kg P_2O_5, 40 kg K_2O/ha), *Sesbania* (20 kg N, 40 kg P_2O_5, 40 kg K_2O/ha), blackgram (20 kg N, 60 kg P_2O_5, 40 kg K_2O/ha) and soybean (20 kg N, 60 kg P_2O_5, 40 kg K_2O/ha) in main plot, and *gobhi sarson* in winter (*rabi*) season with 5 levels of nitrogen, viz. 0, 40, 80, 120 and 160 kg/ha, in subplots. Nutrient balance in soil was calculated as: $\hat{Y}$-(X-a)-N, where $\hat{Y}$ is the nutrient removed by crops; X is the initial soil status of the nutrient element; a is the final soil status of the nutrient element and N is the nutrient added through fertilizer, Raghuvanshi *et al.* (1991). The data were pooled for analysis.

RESULTS AND DISCUSSION

Growth and yield of Gobhi sarson

Plant height siliquae/plant and 1,000-seed weight of *gobhi sarson* were significantly influenced by the preceding crops in rainy season (Table 1). Significantly taller plants with higher number of siliquae/plant and 1,000-seed weight were obtained when *gobhi sarson* was preceded by *Sesbania* green manure, followed by maize and blackgram. Among rainy-season crops, the total biomass was maximum from *Sesbania* green manure. This was followed by soybean> maize> blackgram. Beri *et al.* (1989) also reported higher biomass production with

Table 1. Effect of cropping systems and nitrogen levels on growth, yield and economics of *gobhi sarson* (mean data of 3 years)

Treatment	Plant height (cm)	Primary branches	Secondary branches	Seeds/ siliqua	1,000-seed weight (g)	Seed yield of *gobhi searson* (kg/ha)	Net returns (R/ha)	Benefit : cost ratio
Cropping system								
Maize–*gobhi sarson*	155.5	6.1	1.1	18.8	3.07	1,372	16,336	1.63
Sesbania–gobhi sarson	176.5	6.9	1.7	19.7	2.23	1,791	17,083	2.44
Soybean–*gobhi sarson*	148.1	5.2	1.6	19.6	2.78	1,300	28,754	3.19
Blackgram–*gobhi sarson*	149.2	5.7	2.1	19.7	2.98	1,459	17,165	2.45
CD (P=0.05)	9.9	NS	NS	NS	0.17	272		
N (kg/ha)								
0	138.3	4.6	0.5	15.7	2.81	813	7,969	1.53
40	155.1	5.6	1.0	17.1	2.86	1,248	13,076	2.20
80	159.3	6.2	1.8	19.7	3.09	1,631	17,458	2.67
120	164.3	6.7	1.8	20.5	3.14	1,827	20,002	2.76
160	169.4	7.0	3.2	21.5	3.18	1,889	20,836	2.59
CD (P=0.05)	5.9	1.4	0.8	1.9	0.14	140		

The yields of *kharif* crops were: maize grain (1,926 kg/ha) and stover (5,370 kg/ha), *Sesbania* biomass (32,099 kg/ha), soybean grain (3,309 kg/ha) and stover (8,404 kg/ha), blackgram seed (346 kg/ha) and stover (4,568 kg/ha)

Sesbania. The highest seed yield of *gobhi sarson* was obtained in *Sesbania–gobhi sarson* cropping system. The other 3 systems, viz. maize–*gobhi sarson*, blackgram–*gobhi sarson* and soybean–*gobhi sarson*, were statistically at par with one another. Sharma and Mittra (1988) also reported higher yields of winter season crops after green manuring.

The number of primary and secondary branches/plant increased significantly with application of 80 kg N/ha over the control. However, the number of branches at 40 kg N/ha application were at par with 80 kg N/ha and no N application. The number of siliquae/plant increased with the increase in N application up to 120 kg/ha, while seeds/siliqua and 1,000-seed weight increased significantly up to 80 kg N/ha. Effect of N on yield-attributing characters was reflected on seed yield. The seed yield of *gobhi sarson* increased significantly with the increase in N application up to 120 kg N/ha. The increase in yield over the control with first 40 kg N/ha was 53.51%, which decreased to 30.69, 12.02 and 3.39% at 80, 120 and 160 kg N/ha respectively. Thakur and Chand (1998) also reported a response up to 100 kg N/ha in *gobhi sarson.*

Gobhi sarson grown after maize responded up to 120 kg N/ha, while after *Sesbania*, blackgram and soybean the response was only up to 80 kg N/ha (Table 2). *Gobhi sarson* crop preceded by *Sesbania* green manure gave the higher seed yield, irrespective of the levels of N application. The seed yield after blackgram also remained at par with it at all the levels of N except 40 kg N/ha. As level of N increased, the seed yield of *gobhi sarson* after maize also came at par with *Seabania* and blackgram. Thus, at higher levels of N to *gobhi sarson*, the effect of rainy-season cropping was less marked. Soybean preceded *gobhi sarson* gave lower yield at higher level of N. This may partly be attributed to higher N uptake by this crop, leaving less residual N for *gobhi sarson.* The highest yield of *gobhi sarson* (2,108 kg/ha) realized in *Sesbania–gobhi sarson* sequence at 160 kg N/ha. However, it was statistically at par with *Sesbania* 40 kg N/ha (1,720 kg/ha), blackgram with 80 kg N/ha (1,784 kg/ha) and maize with 120 kg N/ha (1,913 kg/ha).

Table 2. Interaction effect of rainy-season crops and N levels on seed (kg/ha) of *gobhi sarson* (mean data of 3 years)

Rainy-season	N(kg/ha)				
crop	0	40	80	120	160
Maize	626	979	1,279	1,913	2,063
Sesbania	1,081	1,720	2,019	2,028	2,108
Soyben	715	1,076	1,481	1,622	1,605
Blackgram	829	1,190	1,622	1,746	1,781
CD (P=0.05)					
N levels at same rainy-season				254	
Rainy-season crops at same or different N levels				442	

Economics

The highest net returns and benefit : cost ratio were obtained from soybean–*gobhi sarson* crop sequence (Table1). *Sebania-gobhi sarson* and blackgram–*gobhi sarson* sequence gave almost equal returns. The lowest

returns were from maize–*gobhi sarson* sequence. The higher returns from soybean–*gobhi sarson* were owing to higher yield from soybean during rainy reason which added to total income. Beri *et al.* (1989) also reported higher returns of oilseed crops after soybean. The lower returns from maize–*gobhi sarson* were due to higher cost of cultivation of maize and *gobhi sarson*.

Nitrogen balance in soil

Pooled data revealed that treatments with maize, soybean and blackgram during rainy season recorded reduction in the N status of the soil when no fertilizer was given to *gobhi sarson*, whereas with *Sesbania*, it was positive even no N application (Table 3). However, when *gobhi sarson* was given increasing levels of N, the available N status increased in all treatments. The maximum increase was with *Sesbania* (7–54 kg/ha), followed by soybean and blackgram. Further, the treatments given higher dose of N had more N status regardless of crops taken during the rainy season. The higher gain in N status of soil under *Sesbania*, blackgram and soybean can be ascribed to nitrogen fixation by these crops.

Unaccountable N did not find proportionate exhibition in the balance sheet in the form of available N in the soil. The maximum negative N balance was observed in *Sesbania* and maize treatments, indicating that N removed by the crop was less than that applied. However, soybean–*gobhi sarson* and blackgram–*gobhi sarson* sequences showed the maximum gain of N and this was more at lower levels of N application in *gobhi sarson*. This showed that the nutrients removed by them were more than the applied ones. The unaccountable N can be explained on the phenomenon of continuous exchange of N from available to unavailable pool and vice versa (Ressel, 1963). Other factors like leaching, volatilization and denitrification also explain unaccountable N.

It was concluded that *gobhi sarson* crop taken after maize responded up to 120 kg N/ha, while after *Sesbania*, blackgram and soybean the response to N was only up to 80 kg N/ha. The balance sheet showed that there was gain

Table 3. Balance sheet of available N in soil under different cropping sequences (mean data of 3 years)

Treatment	Total N applied (kg/ha)			N uptake (kg/ha)			Residual N after harvest of *gobhi sarson* (kg/ha)	Change in N status (kg/ha)	N balance (kg/ha)
	Kharif crop	*Gobhi sarson*	Total	*Kharif* crop	*Gobhi sarson*	Total			
Maize–gobhi sarson									
No N	270	0	270	183.12	62.83	245.95	384	–17	–41
40 kg N/ha	270	120	390	183.12	108.44	291.56	402	1	–97
80 kg N/ha	270	240	510	183.12	148.41	331.53	416	15	–163
120 kg N/ha	270	360	630	183.12	232.98	416.10	420	19	–195
160 kg N/ha	270	480	750	183.12	257.79	440.91	428	27	–282
Sesbania–gobhi sarson									
No N	340.2	0	340.2		143.14	143.14	408	7	–190
40 kg N/ha	340.2	120	460.2		243.45	243.45	426	25	–192
80 kg N/ha	340.2	240	580.2		298.48	298.48	428	27	–255
120 kg N/ha	340.2	360	700.2		314.62	314.62	444	43	–343
160 kg N/ha	340.2	480	820.2		333.30	333.30	455	54	433
Seybean–gobhi sarson									
No N	60	0	60	331.52	90.76	422.28	292	–9	353
40 kg N/ha	60	120	180	331.52	142.80	474.32	420	19	313
80 kg N/ha	60	240	300	331.52	203.39	534.91	428	27	262
120 kg N/ha	60	360	420	331.52	236.90	568.42	436	35	183
160 kg N/ha	60	480	540	331.52	234.46	565.98	440	39	65
Blackgram–gobhi sarson									
No N	60	0	60	136.64	108.66	245.30	390	–11	174
40 kg N/ha	60	120	180	136.64	167.05	303.69	411	10	134
80 kg N/ha	60	240	300	136.64	270.74	407.38	420	19	126
120 kg N/ha	60	360	420	136.64	282.80	419.44	424	23	22
160 kg N/ha	60	480	540	136.64	280.63	417.27	431	30	-93

of N in soybean–*gobhi sarson* and blackgram–*gobhi sarson* sequences, whereas it was negative in *Sesbania*–*gobhi sarson* and maize–*gobhi sarson* sequences.

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