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Comparative performance of oleiferous *Brassica* species in intercropping with potato (*Solanum tuberosum*), staggered sowing and fertility levels

D. S. RANA AND GANGA SARAN

Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012

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ABSTRACT

In a field experiment during 1995-96 and 1996-97 at New Delhi, three oleiferous brassicas were grown in 3:1 replacement series with potato (*Solanum tuberosum* L.) i.e. every fourth row of potato was replaced either with *Brassica juncea* L. or *B. carinata* A. Braun or *B. napus* L., to compare their performance under staggered sowing and combination of nitrogen and sulphur. *Brassica carinata* consistently recorded the maximum plant-height (232 cm), number of primary (11.2) and secondary branches (35.5)/plant, siliquae/plant (613) and seed yield (16.24 q/ha), whereas, siliquae length (7.13 cm) and seeds/siliqua (24.71) were maximum in *Brassica napus* and 1000-seed weight (4.5 g) in *Brassica juncea*. Mean seed yield recovery(%) in the intercropped stand was 42.6% in *Brassica juncea*, 60.3% in *Brassica carinata* and 52.1% in *Brassica napus* of the respective mean seed yield recorded under sole stand. Delayed sowing resulted in reduced growth and yield attributes and seed yield. Except siliquae/plant and seed yield (1996-97) of *Brassica carinata*, these species did not respond to N beyond 75 kg/ha. Application of N + S increased most of the parameters over N alone.

Key words: *Oleiferous brassicas*, Potato, Intercropping, Staggered sowing, N, S

Intercropping of Indian mustard (*Brassica juncea* L.) with potato (*Solamum tuberosum* L.) has been recommended in the north-west part of India for stabilizing farmer's income from potato cultivation and increasing oilseed production (Narwal and Prakash, 1991; Rathi *et al.*, 1992 and Ganga Saran *et al.*, 1994). In addition to Indian mustard, cultivation of *gobhi sarson* or winter rape (*Brassica napus* L.) and karan rai or Ethiopian mustard (*Brassica carinata* A. Braun) is also being done by the farmers of this region to boost the production of winter oilseeds. These two new introductions, exhibit entirely different growth rhythm than cultivated cultivars of Indian mustard. Both of them show a slow growth and flower between 80-110 days after sowing while Indian mustard between 40-60 days after sowing. Thus, there stand a possibility of increasing the spatial and temporal complementarity of the potato based intercropping system which can be manipulated further by resorting to staggered sowing of component crops. These species are likely to show differential response to nitrogen and sulphur application due to variation in their growth rhythm and yield potential.

There is practically no information available on the comparative performance of these species in intercropping system with potato and under different combinations of nitrogen and sulphur. Looking to these aspects, the present experiment was undertaken to screen *Brassica* species for intercropping with potato and response of the emerging cropping systems to nitrogen and sulphur.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* seasons of 1995-96 and 1996-97 at the Division of Agronomy, Indian Agricultural Research Institute, New Delhi. The soil of

Table 1. Gist of field operations including growth stages

Field operation/Growth stages		Date of occurrence	
		1995–96	1996–97
1. Basal application of 1/2 nitrogen + sulphur as per treatment + 80 kg P_2O_5/ha + 100 kg K_2O/ha; plot-wise on the demarcated lines		01.11.95	19.10.96
2. Planting of potato		04.11.95	22.10.96
3. Sowing of *Brassica* species		05.11.95	23.10.96
1st date (D_1)		05.11.95	23.10.96
2nd date (D_2)		24.11.95	12.11.96
4. 1st irrigation		06.11.95	24.10.96
5. Top dressing of remaining 1/2 dose of N		18.12.95	09.12.96
6. 50% flowering:			
B. juncea	D_1	04.01.96	31.12.96
	D_2	20.01.96	15.01.97
B. napus	D_1	26.01.96	13.01.97
	D_2	06.02.96	27.01.97
B. carinata	D_1	20.02.96	12.02.97
	D_2	08.03.96	26.02.97
7. Harvesting of potato		15.03.96	01.03.97
8. Harvesting of:			
B. juncea	D_1	21.03.96	12.03.97
	D_2	06.04.96	26.03.97
B. napus	D_1	04.04.96	22.03.97
	D_2	19.04.96	05.04.97
B. carinata	D_1	22.04.96	15.04.97
	D_2	03.05.96	27.04.97

the experimental field was sandy loam with pH 7.2 and analysing low in available nitrogen and medium in available phosphorus, potassium and sulphur. The experiment was laid in the split-plot design with three replications. The main-plot treatments comprised seven cropping systems, whereas five fertility levels were allocated to sub-plots. Of the seven cropping systems, sole crop of potato was sown in rows interspaced at 60 cm while the remaining six cropping systems were created by replacing every fourth row of potato with one row of either *Brassica juncea* L. (Indian mustard cv. Pusa Jaikisan) or *Brassica napus* (winter rape or *gobhi sarson* cv. ISN 706) or *Brassica carinata* (Ethiopian mustard or Karan rai cv. DLSC 1) and doing staggered sowing of the *Brassica* species i.e. sowing at the time of potato planting (D_1) and 20 days after potato planting (D_2). Five fertility levels were created by adopting 0, 75 and 150 kg N/ha and combining 30 kg S/ha with 75 and 150 kg N/ha. The main plot size was 15 × 6 m and sub plot size was 3 × 6 m. Both potato and brassicas were planted on ridges. In sole potato 60 × 20 cm spacing was adopted and same population of potato was maintained in

Table 2. Plant height (cm) and primary and secondary branches/plant of *Brassica* species at harvest as influenced by cropping systems, staggered sowing and fertility levels.

Treatment	Plant height (cm)		Number of branches/plant			
	1995-96	1996-97	Primary		Secondary	
			1995-96	1996-97	1995-96	1996-97
Cropping system						
Potato + *B. juncea*	153.0	156.0	5.91	5.43	14.64	15.45
Potato + *B. carinata*	229.0	234.6	10.81	11.52	34.70	36.51
Potato + *B. napus*	156.0	158.3	5.33	5.30	10.39	10.62
CD (P = 0.05)	7.9	6.0	0.60	0.44	1.08	1.27
Staggered sowing						
D_1 - Sowing at time of planting potato	192.0	192.6	7.60	7.83	21.01	22.23
D_2 - Sowing 20 DAP of potato	167.0	173.4	7.03	6.73	18.80	19.50
CD (P = 0.05)	6.4	4.9	0.50	0.35	0.88	1.27
Fertility level (kg/ha)						
F_1-N_0	166.0	169.9	5.98	6.15	16.70	17.78
F_2-N_{75}	179.0	182.0	7.66	7.35	20.09	20.96
F_3-N_{150}	183.0	187.0	7.77	7.65	21.07	21.85
F_4-N_{75} + D_{30}	183.0	185.0	7.44	7.44	20.33	21.50
F_5-N_{150}+ S_{30}	186.0	190.0	7.72	7.83	21.35	22.22
CD (P = 0.05)	9.2	9.4	0.73	0.24	0.76	0.83

DAP = Days after planting

intercropped stand by doing intra-hill adjustment. In *Brassica*, a uniform intra row spacing of 10 cm was maintained by doing thinning at appropriate stage. First irrigation was given just after planting the potato to ensure good germination and later on cropping systems received irrigations as per need of potato crop. A gist of other field operations and growth stages of the crop is given in Table 1. The study was evaluated *inter-alia* for the growth and yield attributes of brassicas based on three randomly selected plants from the sampling row of each plot and seed yield based on the harvest from net plot.

RESULTS AND DISCUSSION

Growth and yield attributes

Oleiferous brassicas showed significant differences in their growth rhythm and growth and yield attributes during consecutive years of study. These species behaved differently in attaining 50% flowering and maturity. Indian mustard 'Pusa Jaikisan' flowered 19 and 13 days early than 'ISN 706' of *gobhi sarson* and 47 and 41 days early than 'DLSC 1' of Ethiopian mustard in 1995-96 and 1996-97, respectively (Table 1). In contrast to flowering, 'DLSC I' took only 19 to 22 more days to attain maturity

Table 3. Yield attributes of *Brassica* species at harvest as influenced by cropping systems staggered sowing and fertility levels

Treatment	Siliquae/plant		Seeds/siliqua		Siliqua length (cm)		1000-seed wt (g)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
Cropping system								
Potato + *B. juncea*	368.3	404.9	12.06	13.50	4.55	4.16	3.81	5.20
Potato + *B. carinata*	502.3	723.7	16.38	19.04	4.23	4.70	2.96	3.69
Potato + *B. napus*	290.4	315.6	23.42	26.01	7.32	6.94	3.38	3.82
CD (P = 0.05)	34.2	39.3	0.48	0.63	0.18	0.25	0.20	0.22
Staggered sowing								
D_1 - Sowing at time of planting potato	427.9	523.7	17.38	19.39	5.28	5.13	3.50	4.43
D_2 - Sowing 20 DAP of potato	346.0	439.2	17.20	19.65	5.45	5.41	3.27	4.10
CD (P = 0.05)	27.9	32.1	NS	NS	0.14	0.20	0.16	0.18
Fertility level (kg/ha)								
F_1 - N_0	274.8	341.8	16.80	19.43	4.98	4.87	2.99	3.86
F_2 - N_{75}	393.7	481.3	17.27	19.41	5.34	5.35	3.30	4.19
F_3 - N_{150}	423.5	533.9	17.11	19.28	5.46	5.38	3.40	4.23
F_4 - $N_{75} + S_{30}$	399.0	502.3	17.62	19.65	5.52	5.31	3.56	4.51
F_5 - $N_{150} + S_{30}$	443.8	547.8	17.63	19.82	5.54	5.42	3.65	4.54
CD (P = 0.05)	31.4	37.3	0.31	NS	0.18	0.17	0.11	0.10

DAP = Days after planting

than 'ISN 706' and 31 to 32 days than 'Pusa Jaikisan'. Plant height, primary and secondary branches/plant and siliquaea/plant were greatest in *B. carinata* during both the crop seasons. It produced 134 and 318 more siliquae/plant than *B. juncea* and 212 and 408 than *B. napus* during 1995-96 and 1996-97, respectively, This could be ascribed to its long growth period and tall growing character which produced greater pod bearing surface in the form of primary and secondary branches. *B. napus* proved significantly superior with respect to seeds/siliqua and produced 7.00 and 11.9 more seeds/siliquaea (mean) than *B. napus* respectively. Longest pod length of this species, might be probable reason for higher seeds/siliquaea during both the crop seasons. However. *B. juncea* produced the boldest seed resulting in the highest 1000-seed weight which tried to compensate for the loss of seed yield due to low values of other parameters on the seed yield. Similar results have also been reported by Ganga Saran and Giri (1987) and Garnayak (1994).

Except seeds/siliqua and siliqua length, other growth and yield attributes showed significant reduction with delay in sowing. Seeds/siliqua were not affected by sowing time, whereas siliqua length recorded significant increase with delay in sowing during both the years of experimentation. Ad-

Table 4. Seed yield (q/ha) and seed yield recovery (%) of *Brassica* species as influenced by staggered sowing and fertility levels

Treatment	Seed yield (q/ha)			Seed yield recovery (%)	
	1995-96	1996-97	Pooled mean	1995-96	1996-97
Cropping system					
Potato + *B. juncea*	8.20	10.46	9.31	44.8	41.2
Potato + *B. carinata*	12.60	19.89	16.20	55.7	63.9
Potato + *B. napus*	7.75	10.82	9.33	45.0	58.2
CD (P = 0.05)	0.66	0.81	0.71	-	-
Staggered sowing					
D_1 - Sowing at time of planting potato	10.70	15.53	13.14	50.4	60.1
D_2 - Sowing 20 DAP of potato	8.32	11.92	10.10	47.5	49.6
CD (P = 0.05)	0.54	0.66	0.58	–	–
Fertility level (kg/ha)					
F_1 - N_0	6.99	8.39	7.66	49.2	57.8
F_2 - N_{75}	9.20	13.42	11.28	46.4	54.3
F_3 - N_{150}	10.07	15.24	12.69	48.6	53.4
F_4 - N_{75} + S_{30}	10.16	14.51	12.38	49.3	54.3
F_5 - N_{150} + S_{30}	11.15	17.06	14.06	51.6	55.5
CD (P = 0.05)	1.48	1.44	1.44		

verse effect of delayed sowing on the growth and yield attributes was obvious because of shorter days and lower temperature during early stages of crop growth which limited the growth and development of vegetative phase and rising temperature and day length at later stages of growth hastened their maturity. Beside this, late sown crop faced comparatively more competition from the intercrop, weeds and insect-pest infestation.

Successive increase in N application improved the growth and yield attributes but the significant effect of 150 kg N over 75 kg N/ha was observed only on primary branches (1996-97) , secondary branches and siliquae/plant (1996-97). Application of 30 kg S/ha along with 75 and 150 kg N improved the growth and yield attributes over alone treatment of N but significant changes were noted in seeds/siliquae during 1995-96 and 1000 seed weight during both years of investigation. Improvement in the growth and yield attributes due to N and S application could be ascribed to the role of these nutrients in synthesis of chlorophyll, protein and oil, energy transfer and utilization of photosynthates. Similar effect of N and S on the growth and yield attributes of *Brassica* species was also reported by Kachroo and Kumar (1997).

Seed yield

Seed yield of *B. carinata* invariably was higher because of its tall growing and profused branching habit and the greatest siliquae/plant as well as high degree of resistance to insect-pest and diseases (Table 4). In spite of higher number of siliquae/plant and 1000 seed weight *B. juncea* cv. Pusa Jaikisan did not show much variation over *B. napus* strain ISN 706 with respect to seed yield because the effect was neutralised by the greater siliqua length and seeds/siliqua. Owing to the unfavourable effects of delayed sowing on growth and yield attributes a significant reduction in the seed

Table 5. Interactive effects between *Brassica* species and staggered sowing on secondary branches and seed yield

Brassica species	Staggered sowing			
	1995-96		1996-97	
	D_1	D_2	D_1	D_2
	Secondary branches/plant			
B. juncea	15.35	13.93	15.91	15.00
B. carinata	36.48	32.91	39.35	33.67
B. napus	11.20	9.58	11.42	9.82
CD (P = 0.05)		1.20		1.20
	Seed yield (q/ha)			
B. juncea	10.12	6.31	12.98	7.93
B. carinata	13.24	11.91	22.93	16.84
B. napus	8.76	6.73	10.67	10.98
CD (P = 0.05)		0.94		1.15

yield also became inevitable. Seed yield response to N application was limited to 75 kg N/ha during 1995-96 whereas during second season significant response was noted up to 150 kg N/ha which might be attributed to early sowing of *Brassica* species during second season in comparison to first season. *Brassica* species gave spectacular performance in intercropp-ing systems when compared to their sole stand. On an average, seed yield produced from the 25% area occupied by *B. juncea, B. carinata* and *B. napus* in their respective intercropped stand was 42.6, 60.6 and 52.1%, respectively of the seed yield recorded in their sole stand (Table 4). Similar behaviour of brassicas in the intercropped and sole stand was also reported by Narwal and Prakash (1991) and Ganga Saran *et al.* (1994) and could be attributed to indeterminate plasticity of *brassica* in response to low degree of competition for the inputs.

Table 6. Interactive effects between *Brassica* species and fertility levels with respect to siliquae/plant. seeds/siliqua and seed yield (q/ha)

Brassica species	Fertility level (kg/ha)				
	N_0	N_{75}	N_{150}	$N_{75} + S_{30}$	$N_{150} + S_{30}$
			Siliquae/plant - 1996-97		
Brassica juncea	283.3	415.3	450.2	426.8	449.0
Brassica carinata	536.5	697.7	808.8	739.2	836.7
Brassica napus	205.8	330.8	342.8	341.0	357.8
CD (P = 0.05)			32.3		
			Seeds/siliquae - 1995-96		
Brassica juncea	11.67	12.15	12.12	12.23	12.37
Brassica carinata	14.45	16.35	16.77	17.00	17.35
Brassica napus	24.50	23.33	22.47	23.65	23.18
CD (P = 0.05)			0.82		
			Seeds/siliquae - 1996-97		
Brassica juncea	12.76	13.20	13.50	13.85	14.13
Brassica carinata	17.75	18.68	19.23	19.57	19.93
Brassica napus	27.80	26.28	25.05	25.58	25.40
CD (P = 0.05)			0.80		
			Seed yield (q/ha) - 1996-97		
Brassica juncea	6.65	11.12	11.22	11.40	12.91
Brassica carinata	11.66	18.88	22.23	21.10	24.95
Brassica napus	6.82	10.66	12.29	11.05	13.32
CD (P = 0.05)			3.32		

Interaction

Interactive effects between the *Brassica* species and sowing time were noted. Irrespective of sowing time, *B. carinata* recorded the highest secondary branches/plant, siliquae/plant and seed yield (Table 5). With the delay in sowing secondary branches and seed yield declined but the magnitude of decrease in each character was different for different species. This might be ascribed to different degree of stability among the species across the sowing time. The magnitude of nitrogen induced changes in the growth and yield attributes and seed yield varied with the species (Table 6). In *B. carinata* siliquae/plant (1996-97) and seed yield (1996-97) responded to the successive increase in N level up to 150 kg N/ha, while in *B. juncea* response to the highest level of N tested was recorded only with respect to siliquae/plant. Contrary to *B. juncea* and *B. carinata, B. napus* recorded significant decrease in seeds/siliquae with successive increase in N levels (Table 6). *Brassica* species also showed variable response to S application when it was superimposed over N levels. In *B. carinata,* N + S application induced significant change over alone application of N with respect to siliquae/plant and seed yield (q/ha) during second year of investigation.

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