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Effect of oleiferous brassicas, their staggered sowing and fertility levels on potato *(Solanum tuberosum)* performance in potato-based intercropping systems

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ABSTRACT

A field experiment was conducted during the winter (*rabi)* seasons of 1995–97 to assess the performance of potato (*Solanum tuberosum* L.) in potato-based intercropping systems (sole potato and 6 intercropping systems created by intercropping 3 *Brassica* spp. at the time of potato planting and 20 days after potato planting in 3:1 replacement series) under 5 fertility levels (N_0, N_{75}, N_{150}, N_{75} + S_{30} and N_{150} + S_{30} kg/ha). Irrespective of staggered sowing, intercrop caused significant reduction in leaf-area index (LAI), tubers/hill, proportion of A-grade tubers, tuber yield and green tubers (%) when compared with sole crop of potato, whereas plant height and shoots/hill remained unaffected. Among the intercropping systems, potato+staggeredly sown *Brassica carinata* A. Braun showed its superiority by recording relatively higher values of growth and yield attributes, yield of A-grade tubers and tuber yield/ha and minimum value of green tubers(%). Irrespective of time of sowing, *Brassica carinata* and its system with potato recorded the highest seed yield and tuber equivalent respectively. Nitrogen application induced significant increase in number of shoots and tubers/hill only up to 75 kg N/ha, whereas plant height, LAI, yield of A- and B-grade tubers and tuber, seed and tuber-equivalent yields/ha recorded significant increase up to 150 kg N/ha. Application N+S caused perceptible increase in the seed yield, B-grade tubers and tuber-equivalent yield over N alone.

Key words : Potato, Oleiferous brassicas, Intercropping, Staggered sowing, Nitrogen, Sulphur

Potato (*Solanum tuberosum* L.) is a high-input management crop. At the same time, its cultivation involves high degree of risk due to disease infestation, its sensitiveness to unfavourable climatic conditions and market forces. As a results of these factors, both yield and economic returns are unstable and at times uneconomical. To alleviate this problem, intercropping of Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] with potato has been recommended in the north–west part of India for stabilizing farmer's income from potato cultivation and increasing oilseed production (Saran *et al.*, 1994). In addition to *Brassica juncea, gobhi sarson* (*Brassica napus* ssp *oleifera* var. *annua*) and Karan rai (*Brassica carinata* A. Braun) also stand a better chance of intercropping with potato due to differences in yield potential and growth rhythm (Narwal and Prakash, 1989; Saran and Rana, 1996). The spatial and temporal complementarity of the intercropping systems can be manipulated further by resorting to staggered sowing of the component crops.

There is practically, no information available on the comparative performance of these *Brassica* spp. in intercropping system with potato under staggered sowing and different combinations of nitrogen and sulphur. Hence a field experiment was conduced to screen oleiferous brassica for intercropping with potato and response of the emerging cropping systems to the staggered sowing of component crops and combination of nitrogen and sulphur. Results pertaining to growth and yield attributes of potato, tuber quality and yield at harvest are presented here.

MATERIALS AND METHODS

A field experiment was conducted during winter seasons of 1995–96 and 1996–97 at Indian Agricultural Research Institute, New Delhi. The soil was sandy loam with pH 7.2 and having low available nitrogen (270 kg N/ha) and medium available phosphorus (14 kg/ha), potassium (202 kg/ha) and sulphur (13.3 ppm). The experiment was laid out in split-plot design with 3 replications. The main plot treatments comprised 7 cropping systems, whereas sub plots received 5 fertility levels. Of the 7 cropping systems, the sole crop of potato was sown in rows inter-spaced at 60 cm, while the remaining 6 cropping systems were created by replacing every fourth row of potato with 1 row of either Indian mustard 'Pusa Jaikisan' cv. or *Brassica napus* strain 'ISN 706' or Ethiopian mustard c.v. DLSC 1 in combination with staggered sowing of the brassicas (sowing at the time of potato planting (D_1) and 20 days after potato planting (D_2). Five fertility levels were 0, 75 and 150 kg N/ha and combination of 30 kg S/ha with 75 and 150 kg N/ha. Both potato and brassicas were planted on ridges. Sole potato was planted on 4 November 1996 and 22 October 1997 at 60 cm × 20 cm spacing and same date of planting as well as population were maintained in intercropped potato by adjusting intra-hill distance. In brassica, uniform intra-row spacing of 10 cm was maintained by thinning at appropriate stage. Half nitrogen and full dose of sulphur as per treatments and 80 kg P_2O_5 and 100 kg K_2O/ha were applied plot-wise on the demarcated lines before the preparation of ridges. Remaining half dose of nitrogen was top-dressed at the time of earthing up. First irrigation was given just after the planting of potato and remaining irrigations were given as per recommendation for potato.

Growth and yield attributes were recorded at different growth stages from 5 random plants, whereas the tuber quality and tuber yield were assessed on the basis of the produce recorded from the net plot.

RESULTS AND DISCUSSION

Growth and yield attributes of potato

The effect of cropping systems on the plant height and shoots/hill of potato was not merked in any of the seasons (Table 1). In the former case, the effect of intercrop might have been offset by the ability of the plant to grow taller under the impact of shade, whereas in the later case, i.e. shoots/hill, the number of shoots were decided at the initial stage of crop growth when the impact of intercrop was absent. The leaf-area index (LAI) and tubers/hill showed marked variation due to cropping systems in both the seasons. Sole crop of potato recorded significantly higher number of tubers/hill compared with intercropped stands except intercropping with *B. carinata* in the second season. Among intercropping systems, the stand with *Brassica carinata* produced maximum number of tubers/hill irrespective of time of sowing of intercrop. The stand created by simultaneous sowing of *Brassica juncea* produced minimum tubers/hill. Sole crop of potato recorded the highest LAI at 90 days after planting during both the years, however it was of the same statistical order compared with C_3, C_4, C_5 and C_7 during the first year and C_4, C_5 and C_7 systems during the second year. The variation in LAI and tubers/hill might be because of variation in plant density of potato, and levels of intercrop interference. These results support those reported by Narwal and Prakash (1989) and Saran *et al.*(1994).

The significant effect of N on plant height and LAI was up to 150 kg N/ha, while on number of shoots and tubers/hill showed significant increase only up to 75 kg N/ha. Addition of 30 kg S/ha with N improved the growth and yield attributes over N alone but margin so created was found significant on number of tubers/hill during 1995–96. The increase in plant height with N application may be ascribed to the role of nitrogen in meristemetic activity, which increased the number of nodes and or internodes length, resulting an increase in plant height. The favourable effect of nitrogen on number of shoots/hill might be explained that in the process of establishment and initial growth the root system was not well developed, so some of the sprouts/shoots might have failed to establish under insufficient supply of nitrogen. Nitrogen being the constituent of amino acids, proteins and protoplast, induced better mobilization and utilization of photosynthates (Wright *et al.*, 1988) resulting in rapid expansion of leaves and variation in LAI. The favourable influence of N on tubers/hill might be ascribed to variable availability of photosynthates for stolenization and tuberization. These findings confirm the reports of Singh and Sood (1996) and Saran *et al.* (1994) in intercropping of potato with various crops.

Grade-wise tuber yield

Grade-wise tuber yield of sole potato was significantly higher than any of the intercropping systems except small-grade tubers during 1996–97, which may be ascribed to low plant density, higher leaf area and absence of intercrop competition in sole stand (Table 2). Among the inter-cropping systems, tuber yield of large-grade and medium-grade tubers was the greatest in staggeredly sown potato +

Table 1. Height (cm) of main shoot, number of shoots/hill, leaf-area index and number of tubers/hill of potato as influenced by cropping systems and fertility levels

Treatment	Height (cm) at 80 days*		Shoots/hill at 70 days*		LAI at 90 days*		Tubers/hill at 110 days*	
	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97
Cropping system								
C_1, Sole potato (60 cm)	45.3	40.0	4.60	4.21	3.54	3.04	10.70	9.83
C_2, Potato + *B. juncea*, D_1, 3:1	43.1	37.7	4.13	3.71	3.15	2.76	9.96	8.73
C_3, Potato + *B. juncea*, D_2, 3:1	43.9	39.1	4.06	3.71	3.34	2.84	9.84	9.03
C_4, Potato + *B. carinata*, D_1, 3:1	42.8	39.8	4.46	3.89	3.37	2.90	10.19	9.35
C_5, Potato + *B. carinata*, D_2, 3:1	45.7	36.7	4.42	3.82	3.50	2.95	12.20	9.35
C_6, Potato + *B. napus*, D_1, 3:1	43.5	38.3	4.60	3.86	3.22	2.84	10.02	8.87
C_7, Potato + *B. napus*, D_2, 3:1	44.4	37.6	4.66	3.93	3.42	2.94	10.05	9.01
CD (P=0.05)	NS	NS	NS	NS	0.22	0.16	0.49	0.58
Fertility (kg/ha)								
F_1, 0 N	32.3	32.0	3.79	3.19	2.65	2.02	8.83	7.90
F_2, 75 N	43.9	38.6	4.59	3.95	3.41	2.99	10.9	9.33
F_3, 150 N	49.3	41.0	4.66	4.08	3.65	3.25	10.19	9.55
F_4, 75 N + 30 S	45.6	39.0	4.30	3.92	3.41	3.00	10.82	9.60
F_5, 150 N + 30 S	49.3	41.5	4.86	4.20	3.70	3.28	10.75	9.51
CD (P=0.05)	2.02	2.0	0.77	0.72	0.16	0.11	0.50	0.44

LAI, Leaf-area index; NS, not significant; *days, days after planting; D_1, *Brassica* species sown at the time of planting potato; D_2, *Brassica* species sown 20 days after planting potato; N, nitrogen; S, sulphur

Brassica carinata (C_5). This margin was significantly superior to rest of systems during 1995–96 and C_2 during 1996–97. Irrespective of the *Brassica* species, staggered sowing gave higher tuber yield of large- and medium-size tubers over simultaneous sowing and the margin with respect to medium-grade tubers during 1996–97 in respective species was found significant. This behaviour of grade-wise tuber yield may be ascribed to low growth profile of *Brassica carinata* in the beginnning and shifting of sowing by 20 days which did not offer intensive competition during the bulking stage.

Positive effect of N application was recorded on the large- and medium-size tuber yield up to 150 kg N/ha in both the years. Influence of N on small-grade tubers was not visible during 1995–96, whereas a significant decline in small-size tubers was noted due to N application during 1996–97. This may be attributed to better nourishment of the tubers in terms of photosynthates and nutrients at higher level of nitrogen. Tuber yield of medium-size tubers was further improved by the inclusion of S with N over N alone, but marked impact was observed only during 1995–96.

Green tuber (%) at harvest

The influence of cropping systems on green tubers (%) at harvest was significant in both the crop seasons (Table 2). In sole crop of potato, the highest percentage of green tubers was recorded, which differed statistically to any other system, barring C_2 and C_3 during 1995–96. Among the intercropping systems, C_4 system recorded the minimum number of green tubers, followed by C_5, C_6 and C_7 systems. Significant variation among the cropping systems with respect to green tubers(%) might be explained on the basis of differential shading caused by *Brassica* species due to variation in their growth rhythm and date of sowing. Similar observations were also made by Nankar (1990) in potato intercropped with sugarcane.

Tuber yield, seed yield and tuber-equivalent yield

The tuber yield of potato was greatly influenced by the cropping systems and fertility levels (Table 3). The tuber yield of potato was the highest in sole stand due to less competition for space, light, moisture and nutrients. Among the intercropping systems, potato+*Brassicas carinata* on an average gave higher tuber yield, which might be attributed to the variation in the growth rhythm of brassicas. *Brassica juncea* and *Brassica napus* caused early shading of the potato crop, resulting reduction in the yield attributes and thereby in the tuber yield. Irrespective of the species, staggered sowing produced more tubers across the years due to shift in setting of competition between the components by 20 days. On pooled basis, intercropped potato gave higher tuber-yield recovery than the area occupied by it and the highest recovery (83.8%) was recorded in potato+staggered sown *B. carinata*. This was because of higher plant density under intercropped stand which partly compensated for the adverse effect of intercrop on the tuber yield. The results are in confirmity

Table 2. Grade-wise tuber yield (q/ha) and green tubers (%) at harvest as influenced by cropping systems and fertility levels

Treatment	Grade-wise tuber yield (q/ha)						Green tubers (%)	
	1995–96			1996–97			1995–96	1996–97
	A-grade >75 g	B-grade 25-75 g	C-grade <25 g	A-grade >75 g	B-grade 25-75 g	C-grade <25 g		
Cropping system								
C_1, Sole potato (60 cm)	125.9	122.5	55.1	68.3	166.8	27.9	7.50	6.25
C_2, Potato + *B. juncea*, D_1, 3:1	77.7	104.4	36.1	52.3	127.5	53.3	6.75	5.00
C_3, Potato + *B. juncea*, D_2, 3:1	80.8	109.0	40.7	55.3	138.1	34.6	6.50	4.50
C_4, Potato + *B. carinata*, D_1, 3:1	81.6	109.0	32.3	54.5	132.9	33.5	4.25	3.00
C_5, Potato + *B. carinata*, D_2, 3:1	87.0	112.4	34.4	58.1	145.3	33.1	4.50	3.25
C_6, Potato + *B. napus*, D_1, 3:1	79.1	106.0	38.9	54.9	118.5	32.0	5.00	3.75
C_7, Potato + *B. napus*, D_2, 3:1	80.6	107.3	43.6	55.1	134.8	30.9	4.25	3.50
CD (P=0.05)	5.6	8.2	13.0	5.9	10.1	4.4	1.28	1.00
Fertility level (kg/ha)								
F_1, 0 N	48.7	78.6	39.5	30.1	77.7	35.5		
F_2, 75 N	89.1	101.9	37.8	57.2	132.7	32.5		
F_3, 150 N	107.0	124.8	41.9	71.1	165.2	30.6		
F_4, 75 N + 30 S	86.0	113.3	40.6	57.1	140.7	31.9		
F_5, 150 N + 30 S	106.1	134.3	40.9	69.1	172.2	31.8		
CD (P=0.05)	6.3	6.3	NS	5.1	8.2	3.0		

D_1, *Brassica* species sown at the time of planting potato; D_2, *Brassica* species sown 20 days after planting potato; N, nitrogen; S, sulphur

Table 3. Tuber yield, seed yield, and tuber-equivalent yield as influenced by cropping systems and fertility levels

Treatment	Tuber yield (q/ha)			Seed yield (q/ha)			Tuber-equivalent yield (q/ha)		
	1995–96	1996–97	Pooled	1995–96	1996–97	Pooled	1995–96	1996–97	Pooled
Cropping system									
C_1, Sole potato (60 cm)	294.0	266.0	280.0 (100.0)				294.0	266.0	280.0
C_2, Potato + *B. juncea*, D_1, 3:1	218.9	215.5	216.8 (77.4)	10.12	12.98	11.55	300.0	320.6	310.4
C_3, Potato + *B. juncea*, D_2, 3:1	230.2	228.0	229.3 (81.9)	6.31	7.93	7.12	282.1	292.2	287.1
C_4, Potato + *B. carinata*, D_1, 3:1	223.2	220.8	221.5 (79.1)	13.24	22.93	18.08	330.0	406.5	368.3
C_5, Potato + *B. carinata*, D_2, 3:1	234.0	236.0	234.6 (83.8)	11.96	16.84	14.40	331.0	372.6	351.5
C_6, Potato + *B. napus*, D_1, 3:1	224.1	205.4	214.5 (76.6)	8.76	10.67	9.70	295.0	291.8	293.5
C_7, Potato + *B. napus*, D_2, 3:1	232.6	220.7	224.9 (80.3)	6.73	10.98	8.85	286.0	309.3	297.5
CD (P = 0.05)	14.4	11.2	12.3	0.94	1.15	1.04	20.0	18.2	17.0
Fertility level (kg/ha)									
F_1, 0 N	167.4	143.7	155.1 (81.0)	6.99	8.39	7.66	216.1	201.4	208.1
F_2, 75 N	228.2	222.9	225.4 (81.0)	9.20	13.42	11.28	292.8	316.0	304.4
F_3, 150 N	273.6	267.4	269.9 (81.5)	10.07	15.24	12.69	343.8	373.3	358.6
F_4, 75 N + 30 S	238.0	230.2	234.3 (81.0)	10.16	14.51	12.38	309.3	330.8	320.0
F_5, 150 N + 30 S	281.4	273.4	277.1 (82.0)	11.15	17.06	14.06	358.1	391.8	375.2
CD (P = 0.05)	12.3	9.4	9.1	1.48	1.44	1.44	8.5	13.3	7.9

D_1, *Brassica* species sown at the time of planting potato; D_2, *Brassica* species sown 20 days after planting potato; N, nitrogen; S, sulphur with the findings reported by Narwal and Prakash (1989) and Rana and Saran (1998). Seed yield of *B. carinata* was significantly higher because of its profused branching habit and the greatest siliquae/ plant. Due to unfavourable effect of delayed sowing, there was a significant reduction in seed yield of brassicas. Intercropping of potato with *B. carinata* was found to be the best combination in term of tuber-equivalent yield.

The tuber yield increased significantly with N up to 150 kg/ha, being the result of overall improvement in growth and yield attributes. On the pooled basis, the application of 75 and 150 kg N/ha increased tuber yield by 46.2 and 17.8% over their preceeding level respectively. The increase in tuber yield owing to application of 30 kg S/ha along with N was 5.12 and 4.6% over 75 and 150 kg N respectively. Singh and Sood (1996) also reported increase in tuber yield with nitrogen. Influence of fertility levels on the tuber-yield recovery was not consistent over 2 years. Nitrogen response to seed yield was up to 75 kg N/ha during 1995–96 and 150 kg N/ha during 1996–97, which might be attributed to the corresponding increase in the growth and yield attributes. Sulphur application along with N improved the seed yield. Nitrogen alone and in combination with S significantly improved tuber-equivalent yield over their preceding level.

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