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Effect of integrated nitrogen management in cabbage-summer squash-okra cropping system in the mid hills of Himachal Pradesh

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Abstract

A field experiment was conducted to study the response of integrated chemical nitrogen fertilizer with biofertilizers on cabbage-summer squash-okra cropping sequence during September 2002 to October 2004. The treatment combinations comprised of three nitrogen levels (80, 60 and 40% of the recommended dose), two biofertilizers (*Azotobacter* and *Azospirillum*) and two methods of biofertilizer application (soil and seed application) and control (recommended dose of chemical fertilizers). The treatment combinations 80% N + *Azospirillum* as soil or seed application in all crops of the cropping sequence studied and 80% N + *Azotobacter* as soil/seed application in summer squash and okra were at par with the control. The nitrogen uptake by the plants was significantly higher in treatment combinations giving marketable yield at par or better than control. In general, the application of 80% N along with *Azotobacter/Azospirillum* as soil/seed application gave benefit : cost ratios higher or almost equal to the control.

Key words: Nitrogen, cabbage, summer squash, okra, biofertilizers.

Introduction

Vegetable cultivation has turned out to be a profitable enterprise in the hills over the years primarily due to the availability of produce at such a period when these cannot be grown in the North Indian Plains on account of unfavourable weather conditions. The importance of cabbage-summer squash-okra sequence in the mid hills of Himachal Pradesh is attributed to the fact that cabbage is one of the commercial vegetables grown throughout the year, while summer squash is the earliest cucurbit which comes to the market after winters and pays handsome returns in a short time. Okra is an important vegetable cultivated during rainy season because of its tolerance to more rains and relatively lesser incidence of yellow vein mosaic disease in the mid hills.

Nitrogen is one of the chief and important constituents of proteins and nucleic acid molecules, which play a basic role in cell metabolism, growth, reproduction and transmission of heritable characters. Nitrogen can be supplied through organic and inorganic sources. Application of inorganic fertilizers alone for harnessing high production over a long period causes deleterious effects on soil physio-chemical and microbial properties and adversely affects the environment (Papavizas and Davey, 1961).

With ever-increasing cost of chemical fertilizers and widening gap between demand and supply, utilization of biofertilizers can partially substitute the chemical fertilizers. Among the biofertilizers, biological nitrogen fixers are widely exploited.

The non-symbiotic nitrogen fixers *viz.*, *Azotobacter* and *Azospirillum,* are currently being used in large number of non-leguminous crops. Both are reported to be economical in saving up to 20 to 50% of the recommended dose of nitrogen fertilizers (Kumaraswamy and Madalageri, 1990; Kalyani *et al.*, 1992; Swain *et al.*, 2003). Apart from nitrogen fixation, they are also capable of producing antibacterial and antifungal compounds, hormones and micronutrients resulting in better vegetative growth, yield and quality attributes of various vegetables. Realizing their potential, they are being experimented in selected vegetable crops at a number of centers through All India Coordinated Vegetable Improvement Project since 1997. To date, no recommendation has been finalized. Keeping in view the above facts, the present studies had been planned to integrate the biofertilizers with chemical fertilizers and encourage their application to the maximum possible level.

Materials and Methods

The field experiments were conducted at Experimental Farm of the Department of Vegetable Science and Floriculture, CSKHPKV, Palampur during September 2002 to October 2004. The soil was silty clay loam in texture with pH 5.7, and the available N, P and K were 292.93, 13.76 and 223.8 kg ha^{-1}, respectively. The field

experiment was conducted in RBD with four replications. The treatment combinations comprised of three nitrogen levels (80, 60 and 40% of the recommended dose), two biofertilizers (*Azotobacter* and *Azospirillum*) and two methods of biofertilizer application (soil and seed application) and control (recommended dose of chemical fertilizers). The recommended doses of chemical fertilizers were 125, 100, 50 kg/ha (cabbage), 100, 50, 50 kg/ha (summer squash) and 75, 50, 50 kg/ha (okra) of N, P_2O_5 and K_2O, which were supplied through calcium ammonium nitrate, single super phosphate and muriate of potash, respectively along with 10 t ha^{-1} of FYM. The entire dose of FYM, P_2O_5 and K_2O and one third dose of nitrogen treatment wise was applied at the time of field preparation. The remaining dose of nitrogen was top dressed in two equal parts at weeding and hoeing and during earthing up operations within 6-8 weeks of sowing/transplanting. The biofertilizers were procured from the Division of Microbiology, IARI, New Delhi. Both the biofertilizers were applied at the rate of 2.5 kg/ha in the soil. The volume of biofertilizers was increased by mixing sand @ 10 kg/ha and placed at the spots/within rows where seedlings/seeds were to be transplanted/sown. The seeds of cabbage (400 g/kg seed), summer squash (200 g/kg seed) and okra (100 g/kg seed) were treated with *Azotobacter or Azospirillum* culture separately in the morning time on the date of sowing. The biofertilizer slurry was prepared by mixing respective culture in 10% *gur* + 2% gum solution. The seeds of respective crops after treatment were allowed to dry in shade for 30 minutes before sowing in nursery beds/fields. The cultivars were KGAT III (cabbage), Pusa Alankar (summer squash) and P-8 (okra). The plot size was 2.7 × 2.7 m. The spacings were 45 x 45 cm (cabbage), 90 x 90 cm (summer squash) and 45 x 22.5 cm (okra).

The plant samples were digested with concentrated H_2SO_4 and digestion mixture (K_2SO_4: $CuSO_4$: Se powder in the ratio of 10:1:0.1). The total nitrogen content in plant was then estimated by micro-kjeldahl method as suggested by Jackson (1973). The total uptake of nitrogen was calculated by using the following formula:

$$\text{Nitrogen uptake (kg/ha)} = \frac{\text{Nitrogen content} \times \text{gross yield on dry weight basis (kg/ha)}}{100}$$

Available soil nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956). Benefit : cost ratios were also worked out.

Results and Discussion

Marketable yield

In first year, the marketable yield (Table 1) of cabbage was highest (357.53 q/ha) with the application of 80% N + *Azospirillum* as soil application which was significantly superior to the control (285.28 q/ha). Higher marketable yield can be attributed to the favourable response of this treatment on yield attributes *viz.*, gross head weight, net head weight, heading percentage and non-wrapper leaves which were either at par or better than the control. However, in second year, the marketable yield of control (244.80 q/ha) was significantly higher than the yield of other treatments. The lower marketable yield of cabbage recorded in the second year (2003-04) can be ascribed to more rainfall (282.8 mm) during January to March, 2004 as compared to 168.5 mm received during the corresponding period of 2002-03. The nutrient nitrogen plays a vital role in enhancing the photosynthetic efficiency, which leads to the production of more carbohydrates that accelerate growth. *Azospirillum* in the presence of inorganic nitrogen results in increased nitrogenase activity, synthesis of plant growth promoting hormones like auxins, gibberellins and cytokinins (Pandey and Kumar, 1989), enhanced root biomass (Thomas, 1993), thus, improving mineral uptake and plant water relationship (Govindarajan and Thangaraju, 2001).

In summer squash, the treatment combination 80% N + *Azotobacter* as soil application gave the maximum fruit yield of 477.74 q/ha (Table 1) during second year (2004) which was significantly higher than the control (425.35 q/ha) and the treatment combination 80% N + *Azotobacter* as seed application was at par with the control. However, in first year, 80% N + *Azospirillum* as soil application was the only treatment combination, which was at par with control. The results are in consonance with the

finding of Karuthamani *et al.* (1995) in pumpkin and Wange and Kale (2003) in bitter gourd.

In okra, the marketable fruit yield was not influenced by any of the treatment combinations during first year (2003). The lower marketable yield of okra recorded in first year (2003) was the consequence of more rains during second fortnight of June 2003 (226.9 mm, 8 rainy days) which led to delay in sowing on 1st July 2003 followed by relatively more rainfall even after sowing. In second year, the treatment combinations 80% N + *Azotobacter* as soil application (101.05 q/ha) and 80% N + *Azospirillum* as seed application (96.58 q/ha) were significantly superior to control (74.65 q/ha) but at par with 60% N + *Azotobacter* as seed application (85.28 q/ha). The *Azotobacter* excretes plant growth promoting substances (vitamins, kinetins and gibberellins) and antibacterial and/or antifungal compounds which improve vigour of the crop plants and thereby productivity. Besides, they help in the development and branching of roots, which enhance the uptake of NO_3, NH_4, H_2PO_4, K and Fe, improve water status of plants and increase nitrate reductase activity. The results are in conformity with Bahadur and Manohar (2001), Swain *et al.* (2003) and Ray *et al.* (2005).

Nitrogen uptake

The treatment combination 80% N + *Azotobacter* (seed application) during both the years and 80% N + *Azotobacter* (soil application) during second year showed significantly higher nitrogen uptake by the plants but these were at par with the treatment combination 80% N + *Azospirillum* (soil application) which had given marketable yield significantly higher during first year but lower during second year as compared to control. Increased nitrogen uptake in the presence of biofertilizers can be ascribed to an increase in the formation of root hairs and lateral roots in the seedlings (Singh *et al.*, 1997).

In summer squash, the treatment combinations 80% N + *Azotobacter* (soil/seed application) exhibited nitrogen uptake at par (2003) or significantly higher (2004) than the control (Table 2) but these were at par with *Azospirillum* as seed application (2003). The treatment combinations 80% N + *Azospirillum* (soil application) in first year and 80% N + *Azotobacter* as soil application in second year also happened to be associated with higher marketable yield, which were at par or more than control.

In okra, the treatment combination 80% N + *Azotobacter* irrespective of the method of application recorded significantly higher nitrogen uptake by the plants (Table 2) during both the years. Swain *et al.* (2003) have also reported significantly higher nitrogen uptake by okra plants when biofertilizers (*Azotobacter* + *Azospirillum*) were applied as soil application along with 100% N.

Available N-status in the soil after harvest of each crop in sequence

The nitrogen status in soil after the harvesting of cabbage crop in first year was lower than the control in most of the treatment combinations. The data revealed that except one of the treatment combinations (80% N + *Azospirillum* as seed application), all others were at par with control. The variations might be attributed to more rains during January-March 2004, which might have resulted in more leaching of nitrogen from the control plots. The nitrogen status in soil after the harvesting of summer squash in first year (2003) was at par with the treatment combination 60 and 80% N irrespective of biofertilizers and methods of biofertilizers application, and in general, these were at par with control.

In second year also, the differences due to treatment combinations of nitrogen, biofertilizers and methods of application were non-significant and at par with control. The nitrogen status in soil after the harvesting of okra crop was not affected by the treatment combinations. It is quite predictable that the excess of nitrogen in free form in soil will get leached due to more rains during rainy season leading to no differences among the treatment combinations receiving differential doses of nitrogen fertilizer in combination with biofertilizers.

Benefit : Cost Ratio

The use of biofertilizers will be acceptable to the growers only if it is economical. Hence, the benefit : cost ratio's of each treatment was worked out and compared with control.

In cabbage, the benefit : cost ratio was highest when 80% N was applied in combination with *Azotobacter/ Azospirillum* as soil/seed application as compared to control in first year. In second year, due to excess rainfall during

Table 1. Effect of integrated nitrogen management on marketable yield and benefit : cost ratio in cabbage-summer squash-okra cropping system in mid hills of H.P.

Treatments	Marketable Yield (q/ha)						Benefit : Cost Ratio					
	Cabbage		Summer Squash		Okra		Cabbage		Summer Squash		Okra	
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year
80% N + AZT (soil application)	305.14	200.34	418.84	477.74	30.81	101.05	3.70	2.43	5.43	6.19	0.55	1.80
80% N + AZT (seed application)	320.89	200.00	465.75	450.34	24.65	80.50	3.91	2.43	6.05	5.85	0.44	1.44
80% N + AZS (soil application)	357.53	182.18	527.05	335.27	24.30	66.80	4.34	2.21	6.83	4.34	0.43	1.19
80% N + AZS (seed application)	254.11	197.26	440.75	354.11	19.53	96.58	3.09	2.40	5.73	4.60	0.35	1.73
60% N + AZT (soil application)	233.22	135.25	389.38	423.29	21.60	62.68	2.88	1.67	5.12	5.57	0.39	1.14
60% N + AZT (seed application)	235.96	139.38	360.96	389.04	25.35	85.28	2.92	1.73	4.76	5.13	0.46	1.55
60% N + AZS (soil application)	214.38	142.78	413.36	287.33	21.22	69.50	2.65	1.76	5.44	3.78	0.38	1.26
60% N + AZS (seed application)	172.60	152.05	347.26	337.33	19.17	71.55	3.15	1.88	4.58	4.45	0.35	1.30
40% N + AZT (soil application)	140.75	124.65	340.07	330.82	17.83	75.35	1.77	1.57	4.54	4.42	0.33	1.39
40% N + AZT (seed application)	189.73	115.40	358.22	336.30	21.93	67.48	2.39	1.46	4.80	4.50	0.40	1.25
40% N + AZS (soil application)	167.13	129.78	376.37	289.38	22.60	71.23	2.10	1.63	5.03	3.86	0.42	1.31
40% N + AZS (seed application)	168.85	134.59	338.70	366.44	20.58	76.65	2.13	1.70	4.54	4.91	0.38	1.40
Recommended Dose	285.28	244.20	533.90	425.35	21.55	74.65	3.41	2.92	6.84	5.45	0.38	1.32
CD (P=0.05)	25.11	25.96	45.27	44.33	NS	18.37						
CV (%)	7.30	11.22	7.73	8.37	26.59	16.67						

AZT: *Azotobacter* AZS: *Azospirillum*

January-March 2004, the marketable head yield was higher in control leading to higher benefit: cost ratio as compared to all other treatment combinations (Table 1). In summer squash, the benefit : cost ratio with 80% N + *Azospirillum* as soil application was at par with control in first year, but in second year, 80 or 60% N in association with *Azotobacter* as soil or seed application resulted in higher benefit : cost ratio compared to control (Table 1). In okra, 80% N or 60% N or 40% N with *Azotobacter* or *Azospirillum* as soil/seed application gave higher or equivalent benefit : cost ratio when compared with control in both the years.

Conclusion

The 80% N + *Azospirillum* as soil/seed application was the best treatment combination giving marketable yield in vegetable crops sequence cabbage-summer squash-okra at least at par with control (recommended dose of chemical

Table 2. Effect of integrated nitrogen management on nitrogen uptake and post-harvest N-status in soil in cabbage-summer squash-okra cropping system in mid hills of H.P.

Treatments	Nitrogen Uptake						Post-harvest N status in soil					
	Cabbage		Summer Squash		Okra		Cabbage		Summer Squash		Okra	
	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year	I Year	II Year
80% N + AZT (soil application)	158.82	139.89	108.56	162.98	31.48	121.88	239.18	272.90	233.70	313.60	309.68	305.75
80% N + AZT (seed application)	188.39	137.07	111.13	143.69	33.89	117.80	231.18	261.00	215.58	282.25	325.35	305.78
80% N + AZS (soil application)	182.64	124.71	86.06	98.30	19.07	56.73	231.28	270.48	243.05	290.08	297.90	305.60
80% N + AZS (seed application)	153.66	122.14	111.23	127.73	19.37	90.15	254.75	254.80	239.10	321.43	301.85	282.25
60% N + AZT (soil application)	129.13	97.73	92.04	129.70	29.41	75.73	231.28	278.18	239.10	282.25	290.10	266.55
60% N + AZT (seed application)	101.36	76.06	89.66	105.41	27.72	99.40	235.18	297.93	235.18	305.78	309.68	266.55
60% N + AZS (soil application)	90.77	63.55	66.25	95.30	24.55	88.45	246.75	300.35	243.05	305.75	266.55	274.38
60% N + AZS (seed application)	157.93	112.71	91.34	112.61	19.58	58.65	231.28	305.78	215.58	297.93	293.98	305.78
40% N + AZT (soil application)	89.31	58.93	82.61	92.49	18.88	78.18	235.18	265.15	203.80	290.08	238.25	313.60
40% N + AZT (seed application)	153.36	83.37	71.85	81.63	22.22	60.60	215.58	280.75	207.73	290.08	282.25	297.93
40% N + AZS (soil application)	96.54	78.68	71.43	69.78	22.40	87.45	235.18	251.85	215.58	282.23	313.60	290.08
40% N + AZS (seed application)	141.38	97.85	72.47	89.49	22.33	82.33	227.33	321.23	207.73	297.93	344.95	274.40
Recommended Dose	158.92	119.14	102.75	132.92	22.04	90.38	258.65	286.15	243.05	266.55	282.25	305.75
CD (P=0.05)	26.12	15.63	14.94	26.35	7.02	24.24	16.45	41.71	25.09	NS	NS	NS
CV (%)	13.13	10.80	11.74	16.54	20.34	19.83	4.85	10.44	7.73	12.12	14.40	11.42

AZT: *Azotobacter* AZS: *Azospirillum*

fertilizers). In summer squash and okra, 80% N + *Azotobacter* (seed/soil application) was equally effective. In the light of marketable yield obtained and benefit : cost ratios, the use of the biofertilizers *Azotobacter* or *Azospirillum* can affect crop economics up to 20% of the recommended dose of nitrogen under the agro-climatic conditions prevailing at Palampur.

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