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EFFECT OF BIO-ORGANICS AND FERTILIZERS ON YIELD AND NUTRIENT UPTAKE BY CABBAGE

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ABSTRACT

The present investigation was carried out during two successive rabi seasons (2009-10 and 2010-11) at Vegetable Research Farm, Institute of Agricultural Sciences, BHU, Varanasi. Studies confined to the effect of Pseudomonas fluorescens and humic acid in combination with levels of fertilizer on cabbage cv. Golden acre. The pooled data revealed that root treatment of seedling with Pseudomonas fluorescens + humic acid + 100% NPK gave significantly greater fresh and dry biomass (36.97 and 3.79 t ha^{-1}) and fresh and dry head yield (53.86 and 4.98 t ha^{-1}) in comparison to 100% NPK. Application of P. fluorescens and HA with 100 % NPK was more effective in producing higher yields of cabbage than those with 50 and 75% NPK. The maximum protein content and protein yield (18.81 % and 936.9 kg ha^{-1}) were also found with 100 NPK + Pseudomonas fluorescens + humic acid. Same treatment resulted in maximum and significantly greater N, P and K content as (1.64, 0.46 and 3.98 %) and uptake (62.8, 17.7 and 152.2 kg ha^{-1}) by shoot. Maximum N, P and K content (3.01, 0.61 and 2.89 %) and uptake (149.9, 30.3 and 144 kg ha^{-1}) by cabbage head was recorded with this treatment. Application of Pseudomonas fluorescens with NPK and humic acid also improved the uptake of nutrients by the crop. Humic acid was more effective as compared to Pseudomonas fluorescens. Minimum values of NPK content were recorded with 100 % NPK while minimum yield and uptake were noted with 50 % NPK + P. fluorescens as seedling treatment.Total uptake of N (212.8 kg ha^{-1}) P (48.0 kg ha^{-1}) and K (296.1 kg ha^{-1}) by the crop was recorded with 100% NPK + P. fluorescens + HA treatment.

Key words: Cabbage, humic acid, fertilizer, nutrient uptake, Pseudomonas fluorescens, yield

INTRODUCTION

Cabbage (*Brassica oleracea* Var. *capitata*) is a popular, nutritious and short duration cole vegetable crop being grown on a large scale. Fertilizer is a decisive nutrient for cole vegetables with regard to the quantity and quality of produced phytomass. Integrated and judicious use of organic material and microbial inoculants contributed more in maintaining the fertility and productivity of agricultural soils. Appropriate inoculation of beneficial microorganisms enhanced nutrient mineralization, decomposition rate of organic wastes and residues, nutrient cycling and production of bioactive compounds that stimulate plant growth and increased nutrient uptake and crop yield (Chatterjee *et al.*, 2012). *Pseudomonas fluorescens*, a plant growth promoting bacteria (PGPB), increased nutrient uptake and crop yield. There are ample evidences that mode of action of many PGPB increased the nutrients availability to plants under rhizosphere. Seedling treatments with liquid humic acid stimulate seed germination and increase water absorption, root elongation and dry weight of roots and shoots. Application of humic substances also enhances crop yield and nutrient uptake (Arancon *et al*., 2006). However, the possibility also exists that humic acids and *Pseudomonas fluorescens* might have a direct and indirect influence on plants through ion uptake or on the growth regulation of the plant. The focus of this study was to investigate the effect of *Pseudomonas fluorescens*, humic acid with levels of NPK fertilizer on above ground phytomass, yield, quality, NPK content and their uptake by the shoot and head of cabbage crop.

MATERIALS AND METHODS

A field experiment using cabbage as test crop was conducted at Vegetable Research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (250 18′ N latitude, 830 03′ E longitude and 128.93 m above MSL) during rabi season 2009-10 and 2010-11. The soil of experimental site had pH 7.7, wet oxidizable organic C 3.9 g kg^{-1}, available N 194 kg ha^{-1}, available P_2O_5 22 kg ha^{-1} and available K_2O 215 kg ha^{-1}. The experiment was laid out under randomized block design with three replications. The experiment consist of ten treatments *viz*., [(i) 100% NPK, (ii) 50% NPK+ *P. fluorescens*, (iii) 75% NPK+

P. fluorescens, (iv) 100% NPK+ *P. fluorescens*, (v) 50% NPK + Humic acid, (vi) 75% NPK + Humic acid, (vii) 100% NPK + Humic acid, (viii) 50% NPK + *P. fluorescens* + Humic acid, (ix) 75% NPK + *P. fluorescens* + Humic acid (x) 100% NPK + *P. fluorescens* + Humic acid. Cabbage nursery was raised in seedbeds of 5 m × 4 m size using seeds of cabbage *var*. Golden acre F1 hybrid produced by Sakata Seed Corporation, Japan. Recommended doses of fertilizers i.e. 120: 60: 60 kg ha^{-1} (N: P_2O_5: K_2O) were applied through urea, DAP and muriate of potash, respectively. The 1/3 N and full P and K were applied as basal and the rest 1/3 of total N at 21 days after transplanting and the rest 1/3 of N at 42 days after transplanting. Twenty five days old healthy and uniform seedlings were uprooted carefully from the seedbed to avoid damage of root system. Seedling roots were treated with *Pseudomonas fluorescens* and humic acid and transplanted in the experimental plots (5×4 m^2) in first week of October, 2009 and 2010. Intercultural operations were done as and when required. Shoot and head samples collected at harvest were dried (65±2 °C for 48 hr) ground to a fine powder for estimation of N, P and K content. Nitrogen content in the head and shoot was estimated as described by Snell and Snell (1949) with slight modification of Nesselar's reagent. Phosphorus was estimated by molybdovanadate yellow colour method in diacid digest. Potassium content in acid digest was estimated by flamephotometer (Jackson, 1973). The protein content in cabbage head was calculated by multiplying per cent nitrogen in the cabbage head by the factor 6.25.

RESULTS AND DISCUSSION

Yield and yield attributes

Fresh and dry shoot biomass and fresh and dry head yield of cabbage were significantly influenced by bio-organo-chemical fertilization (Table 1). Highest fresh and dry shoot biomass (36.97 and 3.79 t ha^{-1}) and fresh and dry head yield (53.86 and 4.98 t ha^{-1}) were recorded with treatment 100% NPK + *P. fluorescens*+ humic acid which showed its superiority over rest of treatments except T_4, T_7 and T_9. Application of 100% NPK with *P. fluorescens* gave fresh and dry biomass (33.17 and 3.28 t ha^{-1}) and fresh and dry head yield (45.27 and 4.02 t ha^{-1}). Humic acid application with 100% NPK gave fresh and dry biomass yield (25.54 and 3.37 t ha^{-1}) and fresh and dry head yield was 45.37 and 4.05 t ha^{-1}. Humic acid produced 9.1, 3.3, 2.9 and 0.9% more fresh and dry yield of biomass and fresh and dry yield of head over *Pseudomonas fluorescens* inoculation, respectively. The minimum fresh and dry biomass yield (24.37 and 2.40 t ha^{-1}) and fresh and dry head yield of cabbage (31.67 and 2.75 t ha^{-1}) were recorded with 50 % NPK + *Pseudomonas fluorescens* which was statistically at par with 100 % NPK, 50% NPK + humic acid application. Increase in fresh and dry biomass and fresh and dry head yield due to inoculation of *P. fluorescens* and humic acid could be attributed to the expected increase in the available nitrogen, phosphorus and potassium which were continuously available to the cabbage plants. It indicated that inoculation of cabbage seedling with *P. fluorescens* and humic acid application significantly contributed to the growth and yield of cabbage. The higher yield response due to inorganic sources with bio-organics may be ascribed to improvement in physic-chemical and biological properties of soil resulting in better supply of plant nutrients led to good crop growth and yields. These

Table 1: Effect of *P. fluorescens*, humic acid and level of fertilizers on biomass and head yield of cabbage (pooled)

Treatments	Fresh biomass yield (t ha^{-1})	Dry biomass yield (t ha^{-1})	Fresh head yield (t ha^{-1})	Dry head yield (t ha^{-1})	Protein content (%)	Protein Yield (Kg ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
T_1-100% NPK	25.96	2.74	36.51	3.36	14.75	495.6	102883	2.38
T_2-50% NPK +*P. fluorescens*	24.37	2.40	31.67	2.75	16.75	460.6	76907	1.55
T_3-75% NPK +*P. fluorescens*	29.80	2.94	38.08	3.64	16.88	614.3	102104	2.03
T_4-100% NPK +*P. fluorescens*	33.17	3.28	44.27	4.02	18.06	726.1	126423	2.50
T_5-50% NPK +HA	24.47	2.41	32.55	3.03	14.88	450.7	85047	1.88
T_6-75% NPK +HA	30.13	2.98	38.48	3.40	17.25	586.5	108324	2.38
T_7-100% NPK +HA	35.54	3.37	45.35	4.05	18.81	761.9	135363	2.94
T_8-50% NPK +*P. fluorescens*+HA	29.35	2.76	34.41	3.08	16.13	496.7	92052	2.02
T_9-75% NPK +*P. fluorescens*+HA	33.16	3.28	46.12	4.14	17.38	719.3	138449	3.01
T_{10}-100% NPK +*P. fluorescens*+HA	36.97	3.79	53.86	4.98	18.81	936.9	168968	3.64
CD (P=0.05)	0.45	0.07	4.09	0.56	0.62	11.8	-	-

HA: Humic acid

results are in conformity with findings of Chatterjee (2012); El-Nemr *et al* (2012) and Upadhyay *et al.* (2012).

Protein yield and economics

Protein content and protein yield increased significantly by the application of *P. fluorescens* and humic acid with increasing level of fertilizers (Table 1). The highest content and protein yield (18.81 % and 936.9 kg ha^{-1}) were recorded with 100% NPK + *P. fluorescens* + humic acid. The enhancement in protein content with seedling inoculation in *P. fluorescens* and humic acid might be because of increased P and NH_4-N uptake, enhancement of mineral uptake and production of phytohormones such as IAA and gibberelines. The results are in conformity with those of Gadagi *et al.*, (2004) and Upadhyay *et al.* (2012). The highest net return and B:C ratio (168968 Rs ha^{-1} and 3.64) were produced by 100% NPK + *P. fluorescens* + humic acid due to higher yield and less cost of cultivation by the applied treatment. The lowest net return and B:C ratio (Rs 126680 ha^{-1} and 1.55) were found with 50% NPK + *P. fluorescens*, due to higher cost of cultivation of the same treatment. The humic acid caused lower cost of cultivation and gave higher yield as compared to *P. fluorescens* inoculation with different levels of fertilizers.

Table 2: Effect of *P. fluorescens,* humic acid and levels of fertilizers on nutrients content (%) of cabbage shoot and head (pooled)

Treatments	Shoot			Head		
	N	P	K	N	P	K
T_1-100% NPK	1.30	0.26	3.53	2.36	0.43	2.26
T_2-50% NPK +*P. fluorescens*	1.35	0.30	3.57	2.68	0.47	2.39
T_3-75% NPK +*P. fluorescens*	1.41	0.34	3.76	2.70	0.51	2.48
T_4-100% NPK +*P. fluorescens*	1.56	0.44	3.92	2.89	0.57	2.75
T_5-50% NPK +HA	1.36	0.28	3.61	2.38	0.45	2.39
T_6-75% NPK +HA	1.43	0.33	3.81	2.76	0.50	2.49
T_7-100% NPK +HA	1.58	0.40	3.94	3.01	0.55	2.79
T_8-50% NPK +*P. fluorescens*+HA	1.39	0.32	3.66	2.58	0.50	2.44
T_9-75% NPK +*P. fluorescens*+HA	1.46	0.39	3.88	2.78	0.55	2.52
T_{10}-100% NPK +*P. fluorescens*+HA	1.64	0.46	3.98	3.01	0.61	2.89
CD (P=0.05)	0.09	0.06	0.17	0.15	0.05	0.16

Nutrient content

Nutrient contents in cabbage shoot and head were significantly increased with increasing levels of fertilizer with *Pseudomonas fluorescens* and humic acid (Table 2). Maximum value of (1.64, 0.46 and 3.98%) N, P and K contents, respectively in cabbage shoot and 3.01, 0.61 and 2.89 % in cabbage head were recorded with 100% NPK + *P. fluorescens* + humic acid. The minimum value of N, P and K content in shoot and head were recorded with 100 % NPK which was statistically at par with 50% NPK + *P. fluorescens* and 50% NPK + humic acid application. The humic acid increased N content 1.3 and 2.4% in nitrogen and 0.6 and 0.5 % in potassium content over the *P. fluorescens* inoculation in shoot and head content, respectively. But phosphorus content was 15.4 and 3.6 % greater with *P. fluorescens* than humic acid application in shoot and head, respectively. Increase in nitrogen and potassium content might be due to addition of organic matter with humic acid and phosphorus due to mineralization of phosphate in soil with P. *fluorescens.* These results agree with those obtained by Kandil and Gad (2009) and El-Nemr *et al.* (2012).

Nutrient uptake

Nutrient uptake by cabbage was significantly influenced by application of *P. fluorescens* and humic acid (Table 3). Application of 100 % NPK + *P. fluorescens* + humic acid caused maximum N, P, and K uptake by shoot, head and total uptake by the crop. This treatment combination gave significantly higher uptake by shoot, head and total of N (62.8, 149.9 and 212.7 kg ha^{-1}), phosphorus (17.7, 30.3 and 48.0 kg ha^{-1}) and potassium (152.2, 144.0 and 296.1 kg ha^{-1}), respectively which showed its superiority over other rest of the treatments (table-2). This treatment caused 68.3, 122 and 71.3 % increase in total uptake of N, P and K, respectively over T_1. The uptake of N by shoot, head and total (33.1, 72.3 and 105.4 kg ha^{-1}), phosphorus (7.3, 12.9 and 20.2 kg ha^{-1}) and potassium (87.3, 65.8 and 153.1 kg ha^{-1}), respectively noted with

Table 3: Effect of *P. fluorescens,* humic acid and levels of fertilizers on nutrients uptake (kg ha^{-1}) by cabbage (pooled)

Treatments	Uptake by shoot			Uptake by head			Total uptake by cabbage		
	N	P	K	N	P	K	N	P	K
T_1-100% NPK	35.6	7.0	96.6	79.3	14.6	76.3	114.9	21.6	172.9
T_2-50% NPK +*P. fluorescens*	33.1	7.3	87.3	72.3	12.9	65.8	105.4	20.2	153.1
T_3-75% NPK +*P. fluorescens*	42.0	10.3	112.4	98.4	18.4	90.5	140.4	28.7	202.9
T_4-100% NPK +*P. fluorescens*	51.9	14.8	130.4	115.6	22.9	109.9	167.5	37.6	240.4
T_5-50% NPK +HA	33.6	6.8	89.1	71.7	13.8	72.3	105.3	20.6	161.3
T_6-75% NPK +HA	43.2	10.1	115.2	93.6	16.9	84.5	136.8	27.0	199.7
T_7-100% NPK +HA	53.8	13.7	134.5	121.6	22.2	112.9	175.4	35.9	247.4
T_8-50% NPK +*P. fluorescens*+HA	38.6	8.8	101.8	79.5	15.3	75.2	118.1	24.1	177.0
T_9-75% NPK +*P. fluorescens*+HA	48.5	13.0	128.7	115.3	22.8	104.2	163.7	35.8	232.9
T_{10}-100% NPK +*P. fluorescens*+HA	62.8	17.7	152.2	149.9	30.3	144.0	212.8	48.0	296.1
CD (P=0.05)	2.99	1.73	5.91	15.32	3.66	16.87	14.95	4.79	18.45

50 % NPK + *P. fluorescens* was ststistically at par with 50 % NPK + humic acid. The significant increase in uptake of nutrients might be due to enhanced availability of NPK as evident from the higher accumulation of these nutrients in shoot and head of cabbage plants. Moreover, the application of bio-fertilizers alongwith the chemical fertilizers favour the nutrients availability in the soil and thereby better uptake by the crop. Similar findings were recorded by the Islam *et al.* (2011) and Selim *et al.* (2012). Thus, it may be concluded that application of *P. fluorescens* + humic acid along with 100% NPK gave a significant promotive effect on heads yield, quality, absorption and uptake of nutrients shoot and head of cabbage.

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