



## Integrated effect of bio-organics with chemical fertilizer on growth, yield and quality of cabbage (*Brassica oleracea* var *capitata*)

RAJHANS VERMA<sup>1</sup>, B R MAURYA<sup>2</sup> and VIJAY SINGH MEENA<sup>3</sup>

*Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh*

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### ABSTRACT

This experiment focused on the effects of *Pseudomonas fluorescens* and humic acid in combination with three different levels of fertilizers on growth, yield and quality traits of *Brassica oleracea* L. Results indicated that treatments comprising 100% recommended fertilizers package coupled with seedling treated with *Pseudomonas fluorescens* and humic acid caused significantly higher plant height, dry matter in leaves (head), higher number of non-wrapper leaves and head yield (54.38 tonnes/ha) over 50% recommended dose of fertilizer with *Pseudomonas fluorescens* applied. Treatment 50% recommended dose of fertilizer applied with *Pseudomonas fluorescens* and humic acid was at par with 100% recommended dose of fertilizer alone. Total carbohydrate content in head (40.46%) was significantly higher with use of 100% recommended dose of fertilizer with *Pseudomonas fluorescens* and humic acid. Maximum protein content (18.54%) was noticed with application of 100% recommended dose of fertilizer with *Pseudomonas fluorescens* and humic acid that was 10.90% higher than recommended dose of fertilizer alone. Fibre content in head was improved remarkably with the use of *Pseudomonas fluorescens* and humic acid. Significantly higher content of ascorbic acid (34.51 mg/100 g) in head was also registered with application of 100% recommended dose of fertilizer with *Pseudomonas fluorescens* and humic acid.

**Key words:** Cabbage, Growth, Humic acid, *Pseudomonas fluorescens*, Quality, Yield

Cabbage (*Brassica oleracea* var. *capitata*) is a dicotyledonous biennial but grown as annual cole crop (Smith 1995) and belongs to Cruciferae (Brassicaceae) family. It contains essential vitamins, minerals and small amount of protein with good caloric value (Haque *et al.* 2006). It can be grown on all types of soil that having pH range in between 5.5-6.5 (Chadha 2006). Optimum temperature for growth of cabbage is 15-18 °C. Brassicaceous plants represent one of the major leafy vegetable worldwide (Ayaz *et al.* 2006).

Organic input as humic substances are significantly increases nutrients availability and consequently affects growth, yield and quality of plant. The bio-organic substances with chemical fertilizers to have favourable effect overall, plant health (Kumar 2009). Humic acid is particularly used to decrease the negative effect of chemical fertilizers and reduce dependence on chemical fertilizers (Salman *et al.* 2005). Traditional uses of costly chemical fertilizers in agricultural production cannot be over-emphasized. There is a need to adopt the integrated plant

nutrients system which includes application of organic and biofertilizers to supplement of chemical fertilizers to maintain and increase the soil fertility status for sustaining the crop production and productivity. Bio-organics have an ability to convert nutritionally important elements from unavailable to available form through biological processes (Hafeez *et al.* 2006). Researchers showed that humic substance acid can be used as growth regulator to improve plant growth and to enhance soil quality and microbial dynamics (Dilly *et al.* 2003). Application of *P. fluorescens* stimulates growth and growth contributing characters of cabbage. Vegetables, like cabbage, cauliflower and tomato respond well to plant growth enhancer by humic substances and *P. fluorescens* in minimizing the transplanting shock and being encouraged to a quick growth (Karungi *et al.* 2010). Considering the above facts, the present study was undertaken to find out the effect of humic acid and *Pseudomonas fluorescens* for better vegetative growth, maximization of yield and improvement in quality of cabbage.

### MATERIALS AND METHODS

The studies pertaining to the effect of *Pseudomonas fluorescens* and humic acid with inorganic sources of nutrients on cabbage was conducted at Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu

<sup>1</sup> Ex-Ph D Student. Present address: Assistant Professor (e mail: raj80v@gmail.com), SKRAU, Bikaner; <sup>2</sup> Professor (e mail: brmauryaias@gmail.com), <sup>3</sup> Research Scholar (e mail: vijayssac.bhu@gmail.com), Department of Soil Science and Agricultural Chemistry

University, Varanasi (25° 18'N latitude, 83° 03' E longitude and 128.93 m above MSL). The field experiment conducted for two consecutive years, during *rabi* 2009 and 2010. The soil of experimental site had pH 7.75, organic carbon content 0.39%, available N 193.49 kg/ha, available P 22.28 kg/ha, available K 214.45 kg/ha, dehydrogenase 46.84 µg TPF/g soil/day, urease 124.93 µg UH/g soil/h and alkaline-phosphatase 20.11 µg PNP/g soil/h. The experiment was laid out in randomised block design with three replications. The experiment consisted of ten treatment combinations of *Pseudomonas fluorescens* and humic acid with different levels of fertilizers, viz. [(i) 100% RDF (control), (ii) 50% RDF + *Pseudomonas fluorescens*, (iii) 75% RDF + *Pseudomonas fluorescens*, (iv) 100% RDF + *Pseudomonas fluorescens*, (v) 50% RDF + Humic acid, (vi) 75% RDF + Humic acid, (vii) 100% RDF + Humic acid, (viii) 50% RDF + *Pseudomonas fluorescens* + Humic acid, (ix) 75% RDF + *Pseudomonas fluorescens* + Humic acid (x) 100% RDF + *Pseudomonas fluorescens* + Humic acid.

Cabbage seedlings were raised in seedbeds of 5 m × 4 m size using seeds of cabbage var. golden acre F<sub>1</sub> hybrid produced by Sakata Seed Corporation, Japan. Recommended dose of fertilizers were 120: 60 kg/ha (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O). Where, 1/3<sup>rd</sup> N and full dose of P and K were applied as basal. The next 1/3<sup>rd</sup> of total N was applied 21 days after transplanting and the rest 1/3<sup>rd</sup> of total N was applied at 42 days after transplanting. Source of NPK nutrients were urea, di-ammonium phosphate and muriate of potash, respectively. 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<sup>2</sup> in first week of October 2009 and 2010. However, pooled data are presented and discussed herein. Intercultural operations were done as and when required.

Cabbage growth parameters such as plant height, number of non-wrapped leaves, root length, leaf area, fresh and dry weight of shoot and roots were recorded at 55 and 75 days after transplanting (DAT). Yield parameters such as diameter, height, fresh weight and yield of heads were estimated at harvesting (75 DAT). For biochemical analysis, 10 g sample of cabbage from each replication was taken at 75 days after transplanting. The carbohydrate, protein, Vitamin-C (ascorbic acid) and crude fiber in cabbage head were determined following the procedures as described by anthropic method of Hedge and Hofreiter (1962), Lowry *et al.* (1951), AOAC's official titrimetric method (AOAC 1990) and oxidative hydrolytic degradation method of Maynard (1970), respectively. Data were analyzed statistically as per Panse and Sukhatme (1985), using the statistical computer programme MSTAT, version 5.

## RESULTS AND DISCUSSION

### Growth parameters

The plant height varied significantly among the

treatments and maximum plant height at 55 and 75 DAT (28.08 and 30.78 cm), respectively were recorded with 100% RDF + *Pseudomonas fluorescens* + humic acid which was significantly higher than rest of the treatments except 100% RDF with *Pseudomonas fluorescens* and 100% RDF with humic acid at 55 DAT and 100% RDF with humic acid at 75 DAT. However, among the treatments plant height was significantly influenced with application of *Pseudomonas fluorescens* and humic acid. The lowest values of plant height 18.67 and 20.67 cm were observed with 50% recommended dose of fertilizers with *Pseudomonas fluorescens* at both of the growth stages, respectively. Alone application of *Pseudomonas fluorescens* and humic acid caused an average of 38.5 and 30.3% significantly higher plant height than control at 55 and 75 DAT of cabbage. However, combined use of *Pseudomonas fluorescens* and humic acid gave about 4% and 11% more height of plant compared to their individual application at 55 and 75 DAT (Fig 1). This indicates clearly that judicious use of *Pseudomonas fluorescens* and humic acid increased the efficiency of fertilizer, solubilization and transport of nutrients and increased the plant height. Burd *et al.* (2000) have also reported that PGPR plant height enhances increasing the availability of nutrients. Increments in plant growth are also expected by application of humates with biofertilizers due to increased microbial biomass and consequently increase in nutrient mineralization. Similar results were observed by Mujahid and Gupta (2010).

Maximum number of non-wrapped leaves were recorded at 55 and 75 DAT (25.8 and 24.0) were significantly superior with 100% RDF + *Pseudomonas fluorescens* with humic acid in all treatment combinations, except in 100% RDF with humic acid and 75% RDF *Pseudomonas fluorescens* with humic acid at 55 DAT and 100% RDF with humic acid at 75 DAT. The lower number of non-wrapped leaves (16.14 and 15.57) were observed with 50% RDF + *Pseudomonas fluorescens* which were at par with 50% RDF with humic acid and 100% RDF alone applications. The number of non-wrapped leaves significantly increased with the *Pseudomonas fluorescens* (44.61 and 33.34%), humic acid (46.27 and 39.32%) and both combined applications (57.83 and 53.75%) over the control at both growth stages. The humic acid was increased in the number of non-wrapped leaves (3.58 and 14.19%) at both growth stages over the *Pseudomonas fluorescens*. The non-wrapped leaves which are the main site of carbohydrate assimilation, also impart to head yield of cabbage (Upadhyay *et al.* 2012).

An appropriate distribution of biomass in different plant parts is an important aspect, which ultimately determines the yield. The fresh and dry biomass of cabbage plant was significantly varied with seedling inoculation of bio-organics. Maximum fresh shoot weight (732.37 and 999.22 g), fresh root weight (41.59 and 52.25 g), dry shoot weight (70.75 and 103.42 g), dry root weight (4.35 and 6.25g), were significantly higher recorded with 100% RDF + *Pseudomonas fluorescens* with humic acid at 55 and 75

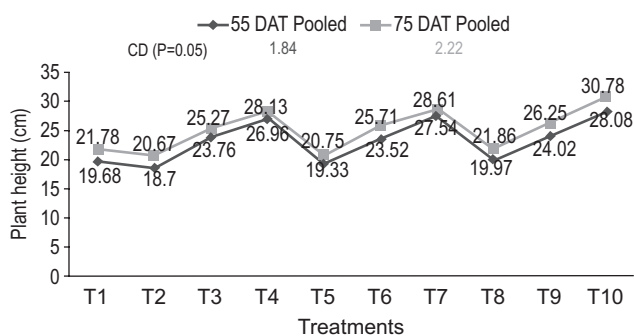


Fig. 1 Effect of *P. fluorescens*, humic acid and level of fertilizers on plant height of cabbage at different days after transplanting (DAT)

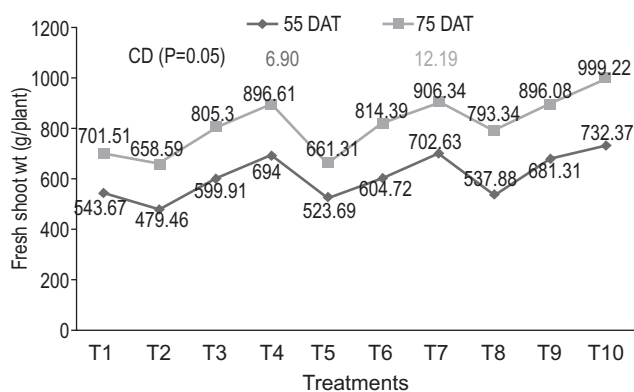


Fig. 2 Effect of *P. fluorescens*, humic acid and level of fertilizers on fresh shoot weight of cabbage at different days after transplanting (DAT)

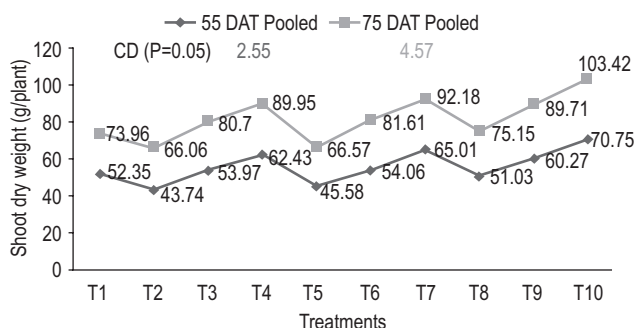


Fig. 3 Effect of *P. fluorescens*, humic acid and level of fertilizers on shoot dry weight of cabbage at different days after transplanting (DAT)

DAT, respectively. The lesser biomass values of as fresh shoot weight (523.69 and 658.59 g), fresh root weight (26.88 and 33.73 g), dry shoot weight (43.74 and 66.06 g), dry root weight (2.15 and 2.84 g), respectively were observed with 50% recommended dose of fertilizers with *Pseudomonas fluorescens* which were at par with 100% RDF alone and 50% RDF + humic acid at 55 and 75 DAT (Fig 2,3). However, in growth parameter at both growth stages such as fresh shoot weight (5.43 and 4.76%), fresh root weight (8.26 and 8.30%), dry shoot weight (20.35 and 12.22%) and dry root weight (17.99 and 26.60%) increased, respectively with combined application of humic acid and *Pseudomonas fluorescens* application with 100% RDF. The

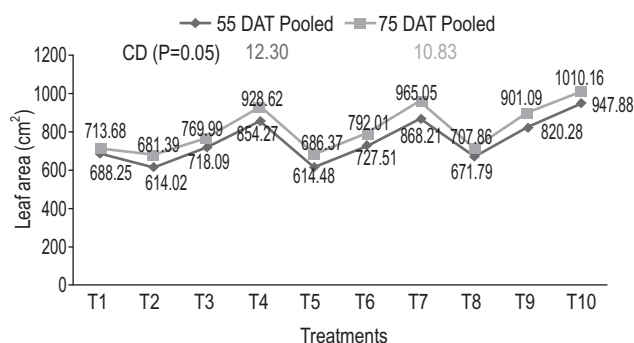


Fig. 4 Effect of *P. fluorescens*, humic acid and level of fertilizers on leaf area of cabbage at different days after transplanting (DAT)

maximum biomass allocation in leaves was obviously due to more initial biomass synthesis in leaves, less biomass accumulation in stem and balanced biomass distribution in roots. Earlier, Bahadur *et al.* (2006) also noticed that the use of vegetable cowpea has significantly contributed in translocation of assimilates from leaves and stems to the pods. The findings were augmented by Magdi *et al.* (2011), Chatterjee *et al.* 2012. The similar trend was found in leaf area at head formation (55 DAT) and head maturity stage (75 DAT). The leaf area varied from 614.02 to 947.88 cm<sup>2</sup>/plant at 55 DAT and 681.39 to 1010.16 cm<sup>2</sup>/plant at 75 DAT from 50% RDF + *Pseudomonas fluorescens* to 100% RDF + *Pseudomonas fluorescens* with humic acid, respectively. These treatments showed significant effect on leaf area of cabbage (Fig 4). The leaf area increased up to 14.52% with 100% RDF + *Pseudomonas fluorescens* and humic acid. Similarly result was found by Magdi *et al.* (2011).

Chlorophyll is the major light absorbing pigment of plant and plays an important role in the metabolic activities subsequently economic yield of crop (Chatterjee 2010). A comparison of pooled data revolved that chlorophyll content of leaves varied significantly with the various treatment combinations and advancement of crop growth stages. The chlorophyll content declined at maturity of the crop in all treatments. Maximum chlorophyll content (49.35 and 49.82 SPAD value) were observed significantly higher with 100% RDF + *Pseudomonas fluorescens* with humic acid except in 100% RDF + *Pseudomonas fluorescens* and 100% RDF with humic acid at 55 DAT and 75% RDF + *Pseudomonas fluorescens* with humic acid at 75 DAT. The lower chlorophyll content (36.42 and 35.07 SPAD value) was observed with 100% RDF (control). The chlorophyll content percentage significant increased 35.50 and 42.06% in 100% RDF + *Pseudomonas fluorescens* with humic acid at 55 DAT and 75 DAT, respectively over the control. Bio-organics are boosting in mineralization of nutrients, plant growth and circumstance of plant increased boosting of mineral nutrients for crop plant. The observation was similarly found by Jaipaul *et al.* (2011).

#### Yield parameters

Significantly higher number of fruits/plant and fruit yield was observed under integration of nutrients compared

with organic nutrient supply (Gopinath *et al.* 2008). Organics are effective alternatives as a source of macro and micronutrients and have required potential to improve yield to save costly chemical fertilizers. The bio-organic technology is based on an eco-friendly approach, utilizes the bio-transformation of energy-rich and complex organic substances into bio-stabilized composted product. Application of *Pseudomonas fluorescens* and humic acid with fertilizer levels significantly affected yield parameters of cabbage (Table 1). Head height (15.56 cm) was significantly higher as compared to all other treatments was observed with 100% RDF + *Pseudomonas fluorescens* with humic acid, except in 100% RDF + *Pseudomonas fluorescens* and 100% RDF + humic acid. Minimum head height was recorded in 50% RDF with *Pseudomonas fluorescens*, which were at par with 50% RDF applied with humic acid and alone 100% recommended dose of fertilizer. The head height was higher in humic acid application as compared to *Pseudomonas fluorescens* application in different fertilizer combinations. The percent increment in height by humic acid was 6.93% over the *Pseudomonas fluorescens* with 100% RDF application. Chatterjee *et al.* (2012) reported cabbage growth increasing trend with the increased level of organic manure and reduced level of inorganic fertilizer in presence of biofertilizers. Integrated use of chemical fertilizers along with bio-organics, like biofertilizers, vermicompost and cow urine may be an effective alternative to increase crop production by saving costly chemical fertilizers input (Bahadur *et al.* 2006).

Application of organic amendments and biofertilizers significantly influenced the head diameter, head weight and

head yield. Significantly maximum head diameter (14.41 cm), fresh head weight (1.49 kg/plant) and head yield (54.38 tonnes/ha) were observed with 100% RDF + *Pseudomonas fluorescens* with humic acid. Minimum value of head diameter (8.77 cm) and fresh head weight (0.86 kg/plant) was observed with 50% RDF + *Pseudomonas fluorescens* but the yield of cabbage was minimum recorded with 100% RDF. The application of humic acid higher percent of yield parameter as head diameter (4.60%), fresh head weight (7.14%) and head yield (3.56%) reported over *Pseudomonas fluorescens* application with 100% RDF. Similar result reported by Bahadur *et al.* (2006) on yield of cabbage due to judicious uses of inorganic and bio-organics. *Pseudomonas* spp. secrete organic acids and enzymes that act as mineralization of immobile form of phosphates, it also produce amino acids, vitamins and growth-promoting substances (Wani *et al.* 2007) which promote plants growth. Increased growth and yield of cabbage and tomato to the extent of 10-20% have been reported by using of PSB (Ponmurugan and Gopi 2006).

#### Quality parameters

A judicious use of organic manures and bio-organics may be effective not only in sustaining crop productivity and soil health but also in supplementing chemical fertilizers of the crops. There are several reports which show that the combined and sole application of organic manures and biofertilizers increase yield and influence quality attributes in vegetables (Bahadur *et al.* 2006). Organic formulation and biofertilizers had significant effect on quality parameters of cabbage (Table 2). The total carbohydrates content was maximum under 100% RDF + *Pseudomonas fluorescens* with humic acid (40.46%) followed by 100% RDF with

Table 1 Effect of *P. fluorescens* and humic acid on yield parameters of cabbage

Treatment	Head height (cm)	Head diameter (cm)	Fresh head weight (kg)	Head yield (t/ha)
T <sub>1</sub> -100% RDF	11.16	9.29	0.98	30.07
T <sub>2</sub> -50% RDF+ <i>P. fluorescens</i>	10.37	8.77	0.86	31.84
T <sub>3</sub> -75% RDF+ <i>P. fluorescens</i>	11.91	10.11	1.06	38.68
T <sub>4</sub> -100% RDF+ <i>P. fluorescens</i>	14.43	12.20	1.24	45.20
T <sub>5</sub> -50% RDF+HA	10.48	8.76	0.89	32.99
T <sub>6</sub> -75% RDF+HA	11.99	10.37	1.10	39.13
T <sub>7</sub> -100% RDF+HA	14.68	12.34	1.26	45.76
T <sub>8</sub> -50% RDF+ <i>P. fluorescens</i> + HA	11.10	9.30	0.94	34.85
T <sub>9</sub> -75% RDF+ <i>P. fluorescens</i> +HA	13.36	11.81	1.26	46.50
T <sub>10</sub> -100% RDF+ <i>P. fluorescens</i> +HA	15.56	14.41	1.49	54.38
SEM±	0.46	0.32	0.03	0.95
CD (P=0.05)	1.36	0.95	0.09	2.81

Table 2 Effect of *P. fluorescens* and humic acid on quality traits of cabbage

Treatment	Protein (%)	Carbohydrate (%)	Vitamin C (mg/100g)	Crude fiber (%)
T <sub>1</sub> -100% RDF	16.51	30.36	24.75	12.91
T <sub>2</sub> -50% RDF+ <i>P. fluorescens</i>	16.74	31.74	24.57	12.31
T <sub>3</sub> -75% RDF+ <i>P. fluorescens</i>	17.04	35.88	25.99	13.56
T <sub>4</sub> -100% RDF+ <i>P. fluorescens</i>	17.51	38.10	26.55	14.80
T <sub>5</sub> -50% RDF+HA	16.61	32.55	25.27	12.33
T <sub>6</sub> -75% RDF+HA	17.56	37.67	26.65	13.72
T <sub>7</sub> -100% RDF+HA	17.70	39.57	27.48	14.94
T <sub>8</sub> -50% RDF+ <i>P. fluorescens</i> +HA	16.90	36.78	27.64	12.90
T <sub>9</sub> -75% RDF+ <i>P. fluorescens</i> + HA	17.74	37.40	31.20	14.59
T <sub>10</sub> -100% RDF+ <i>P. fluorescens</i> + HA	18.54	40.46	34.51	15.73
SEM±	0.21	0.53	0.35	0.33
CD (P=0.05)	0.62	1.57	1.03	0.99

*Pseudomonas fluorescens* (38.10%) and 100% RDF with humic acid (39.57%). The carbohydrate content was 15.99% increased with application of humic acid as compared to *Pseudomonas fluorescens* applied with 100% RDF and 39.43% over the control with application of 100% RDF+ *Pseudomonas fluorescens* with humic acid over the control. Increase in total carbohydrates content with the use of *Pseudomonas fluorescens* and humic acid might be due to the fact that these microbes enhance the nutrients availability to plant nutrients are associated in sugar synthesis and transport. Higher protein content in head (18.54%) was recorded by seedling treated with *Pseudomonas fluorescens* with humic acid along with recommended NPK. The protein content 4.72% improved when application of humic acid over the *Pseudomonas fluorescens* applied with 100% RDF and 12.30% increased over the control in 100% RDF+ *Pseudomonas fluorescens* with humic acid. This was significantly higher over rest of the treatments. The enhancement in protein content with seedling treated in *Pseudomonas fluorescens* and humic acid might be because of increased P and NH<sup>4+</sup>-N uptake, enhancement of mineral uptake and production of phytohormones such as IAA and gibberellins. Fibre content in cabbage head was improved remarkably with use of organic formulation and bio-organics. The significantly higher fibre content (15.73) was observed in 100% RDF of NPK with *Pseudomonas fluorescens* and humic acid combination which was statistically at par with 100% with *Pseudomonas fluorescens*, 100% with humic acid and 75% with *Pseudomonas fluorescens* + humic acid treatment. The similar finding was observed by Bahadur *et al.* (2006).

Maximum ascorbic acid content (34.51 mg/100 g) was recorded with 100% RDF along with seedling treated with *Pseudomonas fluorescens* and humic acid. Among the treatment combination, when the application of humic acid increased significantly 14.64%, *Pseudomonas fluorescens* 15.72% and both are combined application 21.84% increased in vitamin-C content with 100% RDF fertilized treatment over the control. The humic acid was 6.87% vitamin-C content increased over the *Pseudomonas fluorescens* application with 100% RDF. Significantly higher ascorbic acid content in vegetables was also recorded in integrated nutrient management treatment in comparison to organic combination (Jaipaul *et al.* 2011). *Pseudomonas* is a P-solubilizing microbe, which play an important role in improving P bioavailability. Phosphorous is helpful in assimilation of carbohydrates and in turn, the synthesis of ascorbic acid. Furthermore, microorganisms consume a considerable amount of organic matters, e.g. carbohydrates to generate energy for its maintenance and growth. Thus, the microbe had better response under present study when they were combined with inorganic fertilizers. Presence of more organic manure increases more carbohydrate production and subsequently synthesis of more vitamin C as the ascorbic acid is made from carbohydrate. Inoculation with P-solubilizing biofertilizer helpful in assimilation of carbohydrates and in turn synthesis of ascorbic acid in

cabbage. Similarly, the growth and yield of cabbage also reported by Upadhyay *et al.* (2012).

## CONCLUSIONS

It may be concluded that substitution of inorganic sources with higher levels of organic manure in presence of biofertilizer like *Pseudomonas fluorescens* and humic acid have pronounced influenced on plant height, head yield, total carbohydrate, protein, crude fibre and vitamin-C contents and other physical quality attributes of cabbage head. Thus application of *Pseudomonas fluorescens* with humic acid more beneficial over the 100% RDF. The results confirmed the positive role of humic substances in promoting plant biomass, stimulation of growth and even direct effect on crop productivity and increases in crop yields as compare to *Pseudomonas fluorescens* application.

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## REFERENCES

- AOAC. 1990. *Official Methods of Analysis of the Association of Official Analytical Chemists*, pp 1058–9, 15<sup>th</sup> edn. Association of Official Analytical Chemists, Arlington VA.
- Ayaz Faik A, Glew Robert H, Millson M, Huang H S, Chuang L T, Sanz Carlos and Hayırlıyoglu-Ayaz S. 2006. Nutrient contents of kale (*Brassica oleracea*). *Food Chemistry* (96): 572–9.
- Bahadur R, Singh J, Singh K P, Upadhyay A K and Rai M. 2006. Effect of organic amendments and biofertilizers on growth, yield and quality attributes of Chinese cabbage (*Brassica pekinensis*). *Indian Journal of Agricultural Sciences* 76 (10): 596–8.
- Burd G I, Dixon D G and Glick B R. 2000. PGPR that decrease heavy metal toxicity in plants. *Canadian Journal of Microbiology*, 3: 237–45.
- Chadha K L 2006. Handbook of Horticulture, pp 365–8. Indian Council of Agricultural Research (ICAR), New Delhi.
- Chatterjee R, Jana J C and Paul P K. 2012. Enhancement of head yield and quality of cabbage (*Brassica oleracea*) by combining different sources of nutrients. *Indian journal of Agricultural Sciences* 82 (4): 323–7.
- Chatterjee R. 2010. Physiological attributes of cabbage (*Brassica oleracea*) as influenced by different sources of nutrients under eastern Himalayan region Research. *Journal of Agricultural Sciences* 1(4): 318–21.
- Dilly O, Blume H P and Munch J C. 2003. Soil microbial activities in luvisols and anthrosols during 9 years of region-typical tillage and fertilizer practices in northern Germany. *Biogeochemistry* 65: 319–39.
- Gopinath K A, Saha S, Mina B L, Kundu S, Selvakumar G and Gupta H S. 2008. Effect of organic manures and integrated nutrient management on yield potential of bell pepper varieties and on soil properties. *Archives of Agronomy and Soil Science* 54: 127–37.

- Hafeez F Y, Yasmin S, Ariani D, Mehboob-ur-Rahman Zafar Y and Malik K A. 2006. Plant growth-promoting bacteria as biofertilizer. *Agronomy for Sustainable Development* **26**: 143–150.
- Haque K M F, Hahangir A A, Haque M E, Mondal R K, Jahan M A A and Sarker M A M. 2006. Yield and nutritional quality of cabbage as affected by nitrogen and phosphorus fertilization. *Bangladesh Journal of Scientific and Industrial Research* **41**(1-2): 41–6.
- Hedge J E And Hofreiter B T. 1962. *Carbohydrate Chemistry*, p 17. Whistler R L and Be Miller J N (Eds). Akademic Press, New York.
- Jaipaul Sharma S, Dixit A K and Sharma A K. 2011. Growth and yield of capsicum (*Capsicum annum*) and garden pea (*Pisum sativum*) as influenced by organic manures and biofertilizers. *Indian Journal of Agricultural Sciences* **81** (7): 637–42.
- Karungi J, Kyamanywa S and Ekobom B. 2010. Organic soil fertility amendments and tritrophic relationships on cabbage in Uganda: Experiences from on-station and on-farm trials. *African Journal of Agricultural Research* **5**(21): 2 862–7.
- Kumar N. 2009. Recent Advances in the production technologies of tropical fruit crops. (In) *National Workshop cum Seminar on Status and Future Strategies of Horticulture Development in A & N Islands*, 23-25 January 2009, p 82.
- Lowry O H, Rosebrough N J, Lewis Farr A and Randall R J. 1951. Protein measurement with Folin Phenol reagent. *Journal of Biology and Biochemistry* **193**: 265–75.
- Magdi T A, Selim E M and El-Ghamry A M. 2011. Integrated effect of bio and mineral fertilizers and himic substances on growth, yield and nutrients contents of fertigated cowpea (*Vigna unguiculata* L.) grown on sandy soils. *Journal of Agronomy* **10** (1): 34–9.
- Maynard A J. 1970. *Methods in Food Analysis*, p 176. Akademic Press, New York.
- Mujahid A M and Gupta A J. 2010 Effect of plant spacing, organic manure and inorganic fertilizers and their combinations on growth, yield and quality of lettuce (*Lactuca sativa*). *Indian Journal of Agricultural Sciences* **80** (2): 177–81.
- Panse V G and Sukhatme P V. 1985. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.
- Ponmurugan P and Gopi C. 2006. Distribution pattern and screening of phosphate solubilising bacteria isolated from different food and forage crops. *Journal of Agronomy* **5** (4): 600–4.
- Salman S R, Abou-hussein S D, Abdel-Mawgoud A M R and El-Nemr M A. 2005. Fruit yield and quality of watermelon as affected by hybrids and humic acid application. *Journal of Applied Sciences Research* **1**(1): 51–8.
- Smith K. 1995. Keith's Smitj's classic vegetable catalogue. Thomas C. Lothian (Pty) Ltd, Port Melbourne, Australia.
- Upadhyay A K, Bahadur A and Singh J. 2012. Effect of organic manures and biofertilizers on yield, dry matter partitioning and quality traits of cabbage (*Brassica oleracea* var. *capitata*). *Indian Journal of Agricultural Sciences* **82** (1): 31–4.
- Wani P A, Khan M S and Zaidi A. 2007. Synergistic effects of the inoculation with nitrogen-fixing and phosphate-solubilising rhizobacteria on the performance of field-grown chickpea, *Journal of Plant Nutrition and Soil Science* **170** (2)