Int.J.Curr.Microbiol.App.Sci (2017) *6*(3): 301-309

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 3 (2017) pp. 301-309**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.603.033

Enhancing Production Potential of Cabbage and Improves Soil Fertility Status of Indo-Gangetic Plain through Application of Bio-organics and Mineral Fertilizer

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ABSTRACT

Keywords

Cabbage productivity, Humic acid, Mineral fertilizer, *P. fluorescens*, Soil properties

Article Info

Accepted:
10 February 2017
Available Online:
10 March 2017

The role of humic acid for enhancing biofertilization performance was studied on production potential of cabbage in alluvium soil. Application of *Pseudomonas fluorescens* (*P. fluorescens)* in combination with humic acid was evaluated. The results indicated that the *P. fluorescens* and humic acid both are significantly influenced the productivity of cabbage and physicochemical properties of soil. The highest values of physicochemical properties as pH, EC, organic carbon, available NPK in were observed when the plants were treated by humic acid in the presence of *P. fluorescens*. There were remarkable increases in available nutrients in rhizosphere of plants those inoculated with biofertilizers in combination with humic acid. Application of *P. fluorescens* either alone or in the presence of humic acid gave considerable improvement in productivity of cabbage as well as nutrients status. Moreover, application of humic acid gave the highest values of cabbage yield when associated with inoculation or *P. fluorescens* individually. Also, maximum values of cabbage productivity were obtained from plants those treated with dual inoculation of *P. fluorescens* and humic acid. Therefore, application of humic acid can be considered as a good approach in enhancement of biofertilizers performance in alluvium soil.

Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.) is by far the most important member of the genus *Brassica* grown in the world belonging to family *Crucifereae* is most popular vegetable around the world in respect of area, production and availability (Smith, 1995). Cabbage is an important leafy vegetable in India (Fageria, 2003). Now it is most popular vegetable around the world in respect of salad, boiled, cooked, curing, pickling and dehydration purposes (More, 2006). Golden Acre is one of the most popular variety of cabbage being grown by the farmers in the vicinity of big cities owing to its earliness, round and production of compact head (Verma *et al.*, 2014). The Food and Agriculture Organization (FAO, 1988) has identified cabbage as one of the top twenty vegetables and an important source of food globally. Many countries have incorporated cabbage as part of their national cuisine (Olaniyi *et al.,* 2008). In the present market economy of cabbage product quality has become increasingly important. Hence, under the prevailing circumstances, restoration and maintenance of soil fertility is a basic and critical problem, particularly in the newly reclaimed soil. This can be accomplished by adding bio-organic in addition to other field practices (Akhtar *et al.*, 2007).

Humic acids (HA) improved soil structure, cation exchange capacity, nutrient retention and soil microbial activity. The impact of humic acids will therefore be comprehensively discussed under physical, chemical and biological soil properties (Mikkelsen, 2005). Humus is an component of organic matter, Soil organic contents are one of the most important parts that they directly affected the soil fertility and structure as well as increasing the microbial activities in the soil (Tejada *et al.*, 2011). Bio-organics improved the soil structure, aeration, slow release nutrient which support root development leading to higher yield (Verma and Maurya, 2013). Moreover, organic matter plays an important role in the chemical behavior of several metals in soils throughout its active groups (fulvic and humic acids) which have the ability to retain the metals in complex and chelate forms. Bio-organic plays functional key role in plant growth as a source of all necessary macro and micronutrients in available forms through mineralization as well as improving the physical, chemical and biological properties of soils (Shukla *et al.*, 2013). Mineral fertilizer improves growth and yield of crop due to the role of nitrogen, phosphorus and potassium on the meristematic activity. Many investigators found that using mineral fertilizer (NPK) increased vegetative growth and improved soil properties. At the time of globalization, increasing cost of fertilizers, growing ecological concern and conservation of energy, have required the use of organics and bi-organics as a source of plant nutrients for crop production (Dotaniya *et al.,* 2013, Dotaniya *et al.,* 2014). Present investigation evolution of bio-organic on production potential of cabbage under Indo-Gangetic plans of Uttar Pradesh.

Materials and Methods

The studies pertaining to the effect of *Pseudomonas fluorescens* and humic acid with mineral fertilizer on cabbage was conducted at Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25^o 18′ N latitude, 83^o 03′ E longitude and 128.93 m MSL). The experiment was laid out in Randomized Block Design with three replications. The experiment consist of ten treatment combinations *viz*., [(T_1) 100% RDF (control), (T_2) 50% RDF + *Pseudomonas fluorescens*, (T_3) 75% RDF + *Pseudomonas fluorescens*, (T_4) 100% RDF + *Pseudomonas fluorescens*, (T_5) 50% RDF + Humic acid, (T_6) 75% RDF + Humic acid, (T_7) 100% RDF + Humic acid, (T_8) 50% RDF + *Pseudomonas fluorescens* + Humic acid, (T_9) 75% RDF + *Pseudomonas fluorescens* + Humic acid (T_{10}) 100% RDF + *Pseudomonas fluorescens* + Humic acid. Cabbage seedlings were raised in seedbeds of 5 × 4 m size using seeds of cabbage *var.* Golden Acre F1 hybrid produced by Sakata Seed Corporation, Japan. Recommended dose of fertilizers were 120 N: 60 P_2O_5: 60 K_2O kg/ ha. Nursery raised transplanting, fertilization and crop cultivation practices according to Verma *et al.*, (2014). Initial soil samples were collected from surface soil (0-15 cm depth) and analyzed for physicochemical properties (Table 1). The rhizospheric soil collected from surrounding of cabbage plant roots from each plot at harvesting of crop and brought to laboratory. Air dried soil samples were ground to pass through 2 mm mesh sieve. The yield potential of cabbage as fresh biomass yield, fresh head yield, biological yield and harvest index were estimated at harvest.

Statistical analysis

Statistical analysis of the data was done by using analysis of variance (ANOVA), assessed by Panse and Sukhatme (1985), with a probability, the treatment mean were compared at P < 0.05 by using the statistical computer programme MSTAT, version 5.

Results and Discussion

Productivity of cabbage

Data in table 2 showed that, the productivity of cabbage significantly increased in response to any of the tested biofertilizer compared to control. Also, humic acid had positive effect on the same parameters. Moreover, humic acid application triggered and increased the positive effects of *P. fluorescens* inoculation. The combined application of humic acid, *P. fluorescens* and fertilisers levels has significant effect on the yield parameters. The non-wrapper leaves, which are the main site for carbohydrates assimilation, also impart to head yield. Maximum fresh biomass, head and biological yields (37.9, 55.1 and 92.9 t/ha) were found with 100% RDF + *P. fluorescens* and humic acid which was significantly superior over rest of treatments. The fresh biomass yield (46.8%), total biological yield (51.8%) and marketable yield (49.8%) were increased over control. The fertilization with humic acid gave more yields as compared to *P. fluorescens* inoculation. Significantly and maximum harvest index (59.17%) was found with 100% RDF + *P. fluorescens* and humic acid which was statistically at par with 100% RDF + *P. fluorescens*, 100% RDF + humic acid and 75% RDF + *P. fluorescens* and humic acid. The harvest index (8.5) was increased over control. These results showed the higher plant growth is a symbol of higher nutrient transformations, so that higher yields were obtained. The combined application of *P. fluorescens* and humic acid weight of fresh head might be due to *P. fluorescens* worked as bio-control agent and humic acid a source of macro and micronutrients bio-transformations and producing growth substances. The results confirmed that the appropriate combination of organic and bio-fertilizers are important to increase their potentiality and efficiency. These findings are supported by Shukla *et al.*, (2005) and Akhtar *et al.*, (2007). They reported that the combined application of biofertilizers with humic substances increased plant yield.

Soil reaction and EC

Data in table 2 showed that pH varied between 7.0 and 7.2 with bio-organic with fertilization, result indicates that *P. fluorescens* decreased the soil pH might be due to production of organic and inorganic acid. The levels of fertilizer with humic acid gave non-significant effect on soil pH. The pH varied between 6.9 and 7.2 with humic acid in combination of levels of chemical fertilizer which was 0.8 and 0.9 pH-units decreased of soil pH as compared to initial pH by inoculation of *P. fluorescens* and humic acid, respectively. The combine Application of chemical fertilizer with *P. fluorescens* and humic acid had non-significant effect on soil pH. This indicated that the pH was more influenced by combined application of *P. fluorescens* and humic acid. The treatment 100% RDF + *P. fluorescens* + humic acid gave pH 6.8 at harvest of soil which was 0.4 and 1.0 pH lower than control and initial pH of soil, respectively. Decrease in soil pH due to bio-organics application has been reported by (Frequez *et al.*, 1990). Similar finding were reported by Pertusatti and Prado (2007) and Campitelli *et al.*, (2008).

Plot with 100% RDF + *P. fluorescens* was recorded 0.28 dS/m EC at harvest of cabbage which was 0.02 and 0.06 EC-units greater than control and initial soil EC, respectively. Result indicates that *P. fluorescens* increased the ionic activity in soil solution. Humic acid with level of fertilizer also was found non-significant effect on electrical conductivity of soil. 100% RDF with humic acid caused 0.29 dS m^{-1} EC of soil which was 0.3 and 0.7 EC-units greater than control and initial soil EC, respectively. The combined application *P. fluorescens* and humic acid with levels of fertilizer non-significantly affected on electrical conductivity of soil at harvest of cabbage crop. Treatment 100% RDF + *P. fluorescens* + humic acid gave 0.36 dS m^{-1} EC of soil which was higher than rest of all treatments (Table 2). Bio-organics applications increased electrical conductivity (EC) of acid soils (Beye *et al.,* 1978) and alkaline soils (Yodkeaw and De Datta, 1989). Mallik and Sanoria (1980) observed increase in EC is due to rhizobial inoculations. Mineralization of nutrients results in the formation of ionic compounds which in the fixation process replaces other soil cations such as Ca^{++}, Mg^{++}, Na^{+} and H^{+} in the expanded lattice of clay minerals (Subba Rao, 1977). Thus, an increment in total soluble salts in the solution is expected. Similar result was have been by Campitelli *et al.,* (2008).

Table.1 Initial physicochemical soil properties of experimental field

Parameters	Value	Method
Physicochemical		
pH (1:2.5 soil water ratio)	7.80	Jackson (1973)
EC (dSm^{-1} at 25^0C)	0.22	
Organic carbon (%)	0.38	Walkley and Black (1934)
Available Nitrogen (kg ha^{-1})	194	Subbaiah and Asija (1973)
Available Phosphors (kg ha^{-1})	22.3	Olsen's (1954)
Available Potassium (kg ha^{-1})	215	Jackson (1973)
Biological		
Bacteria (CFU $\times 10^5$ g^{-1} soil)	22.05	
Actinomycetes (CFU $\times$ 10^4 g^{-1} soil)	7.75	Rolf and Bakken (1987)
Fungi (CFU $\times 10^4$ g^{-1} soil)	14.40	
Dehydrogenase activity (µg TPF g^{-1} soil day^{-1})	46.85	Tabatabai (1994)
Alkaline Phosphates activity (µg PNP g^{-1} soil h^{-1})	20.12	Tabatabai and Bremner (1986)
Urease activity (µg UH g^{-1} soil h^{-1})	124.94	Douglas Bremner (1971)

Table.2 Effect of *P. fluorescens*, HA and chemical fertilizers on available nutrient status of post harvested soil and production potential of cabbage

Treatment	pH	EC (dS/m)	Organic carbon (g/kg)	Available nutrient			Yield (t/ha)			Harvest Index (%)
				N	P	K	Fresh	Head	Biological	
T_1-100% RDF	7.2	0.26	4.3	241	31.6	279	25.81	36.26	62.07	58.38
T_2-50% RDF+*P. fluorescens*	7.0	0.27	4.2	223	27.3	276	24.63	31.84	56.47	56.35
T_3-75% RDF+*P. fluorescens*	7.1	0.27	4.6	247	32.3	290	30.04	39.13	69.17	56.51
T_4-100% RDF+*P. fluorescens*	7.2	0.28	4.8	273	37.9	316	32.04	44.23	76.27	57.99
T_5-50% RDF+HA	7.1	0.27	4.3	231	27.3	276	24.81	32.99	57.80	57.01
T_6-75% RDF+HA	7.2	0.28	4.6	256	31.1	303	31.38	41.68	73.06	57.05
T_7-100% RDF+HA	6.8	0.29	5.0	278	36.7	327	33.47	45.76	79.23	57.74
T_8-50% RDF+*P. fluorescens*+HA	7.1	0.26	4.2	238	29.8	286	27.61	34.85	62.46	55.83
T_9-75% RDF+*P. fluorescens*+HA	7.0	0.28	4.7	283	34.6	306	33.38	46.50	79.87	58.18
T_{10}-100% RDF+*P. fluorescens*+HA	6.9	0.33	5.2	319	41.4	332	37.91	55.05	92.96	59.17
LSD (5%) (P=0.05)	NS	NS	0.06	5.58	2.66	8.39	0.29	3.01	2.91	1.81

Organic carbon

Data on organic carbon significantly increased with increasing dose of mineral fertilizers with the combination of *P. fluorescens* and humic acid. Significantly higher organic carbon 5.2 g/kg was recorded with 100% RDF + *P. fluorescens* and humic acid which was 20.9 % higher than control. Plot with 100% RDF with humic acid recorded 5.0 g/kg organic carbon which was 16.3% higher than control (Table 2). Thus, might be due to the humic acid have more resistant power toward the decomposition of organic carbon and slow release of nutrients maintain the long term fertility (Konomova, 1966; Kumar and Mishra, 1991). The inoculation of the *Pseudomonas* strains may change the quality of the total organic carbon (Pinheiro *et al.,* 2007).

Available NPK

Data table 2 showed that significantly higher available N 319 kg/ha was recorded with 100% RDF + *P. fluorescence* + humic acid which showed its significant superiority over rest of the treatments. However, significantly lower available N 223 kg/ha was recorded with 50% RDF + *P. fluorescens*. Plot 100% RDF + Humic acid gave 1.8% greater available N compared to plot with 100% RDF + *P. fluorescens.* Increased the availability of N might be due to the humic acid added organic matter to soil and mineralization and solubilization of available nutrients through direct and indirect mechanism of humic substances in soil and transport of nutrients to plant (Bhatti *et al.,* 2011; Burd *et al.,* 2000; Singh *et al.,* 2010). Plot with 100% RDF+ *P. fluorescens* recorded significantly higher available P 37.9 kg/ha which was 19.9% higher compared to control. 100% RDF + humic acid caused 36.7 kg/ha available P which was 16.1% greater than control the *P. fluorescens* gave 3.3 % greater available soil P compared to humic acid, this may be due to direct effect of bio-organic on solubilization and transport of nutrients to plant (Bhatti *et al.,* 2011) Significantly higher available P 41.4 kg/ha was recorded with 100% RDF + *P. fluorescens* and humic acid. Available P was increased might be due to biological and bio-organics as a source mineral transformation and enhanced the efficacy of fertilization (Usman *et al.,* 2003; Chatterjee, 2010; Sharma *et al.,* 2001; Verma *et al.,* 2014).

Significantly higher available K was recorded with 100% RDF + *P. fluorescens* + Humic acid 332 kg/ha which was 19% higher compared control and showed its superiority over rest of treatments, significantly lower available K 276 kg/ha was noticed with 50% RDF + *P. fluorescens* which was at par with 50% RDF + humic acid and control, plot with 100 % RDF + Humic acid caused 3.3 % greater available soil K as compared to plot with 100% RDF + *P. fluorescens.* This might be due to addition of potassium through organic substances. Organic matter might have interacted with potassium clay to release potassium from the non-exchangeable fraction to available pool (Lee, 1985; Meena *et al.,* 2014). Higher availability of potassium may be due to bio-transformation of unavailable and lattice fixed K and release in soil and increased this availability to plant (Maurya *et al.,* 2014; Meena *et al.,* 2014).

In conclusion, this study clearly indicated that application of humic acid positively affected the plant growth and yield of cabbage by acting as soil enhancer and as well as by improving its physicochemical properties. Also, the combined applications of humic acid with *P. fluorescens* are a good tool for improving crop yield potential and soil quality. Among the treatments, 100% RDF + *Pseudomonas fluorescens* + Humic acid improved the cabbage yield, and soil fertility of Indo-Gangetic Plain.

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How to cite this article:

Verma, R., B.R. Maurya, V.S. Meena, M.L. Dotaniya, P. Deewan and Jajoria, M. 2017. Enhancing Production Potential of Cabbage and Improves Soil Fertility Status of Indo-Gangetic Plain through Application of Bio-organics and Mineral Fertilizer. *Int.J.Curr.Microbiol.App.Sci.* 6(3): 301-309. doi: https://doi.org/10.20546/ijcmas.2017.603.033