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Effect of microbial inoculants and chemical fertilizers on yield and economics of hybrid cabbage (*Brassica oleracea* var. *capitata*)

■ **KAMAL KANT, DEVI SINGH[1] AND V.M. PRASAD[1]**

Members of the Research Forum

Associated Authors:
Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, ALLAHABAD (U.P.) INDIA

Author for correspondence :
KAMAL KANT
Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, ALLAHABAD (U.P.) INDIA

ABSTRACT : The present investigation was carried out at Department of Horticulture, Allahabad School of Agriculture, SHIATS, Allahabad, U.P. during winter season of 2014-15 and 2015-16 in Factorial Randomized Block Design (RBD) for yield and quality contributing characters. The microbial inoculants (*Azospirillum*) significantly reduced the number of days taken to head initiation (52.20 days). The plants developed under NPK levels of N_{200} P_{100} K_{100} along with microbial inoculant *Azospirillum* significantly produced the highest average head yield (1.753 kg) per plant. The highest head yield (787.47 q/ha) was obtained with the use of microbial inoculant *Azospirillum* and proved its superiority over *Azotobacter.* For economics components the highest gross return (607954.67Rs./ha) was associated with NPK levels of N_{200} P_{100} K_{100} + *Azospirillum.* Moreover, net return (463011.69Rs./ha) was associated with NPK level of N_{200} P_{100} K_{100} per hectare. The plants grown at NPK levels of N_{200} P_{100} K_{100} per hectare produced significantly maximum benefit: cost ratio (3.96). Therefore, it may be concluded that application of microbial inoculants basically *Azospirillum* as soil application of NPK levels of N_{200} P_{100} K_{100} per hectare was the most effective treatment combination for higher yield and economics in hybrid cabbage.

KEY WORDS : *Azotobacter, Azospirillum*, Cabbage, NPK, Yield, Economics

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Among the cole crops, cabbage is one of the most important commercial vegetable crops in India. It is widely grown all over India and abroad for its high nutritive values, high productivity and wider adaptability. It can withstand rough handlings as well as long distance transport and thus fetch better return. A rich source of minerals, vitamins and roughages. In India, cabbage is cultivated in an area of 0.39 Mha with production of 8.41 MT whereas productivity of the crop is 21.6 MT/ha (Anonymous, 2013). However, the national productivity of cabbage is far below the global average productivity (Sachdeva *et al.*, 2013).

Consistent and indiscriminate use of chemical fertilizers had caused serious damage to the soil and ecology. Soil micro-organisms play a significant role in regulating the dynamics of organic matter decomposition and the availability of plants nutrients. It is recognized that microbial inoculants constitute an important component of integrated nutrient management (INM). In addition, microbial inoculants can be used as an input to increase crop productivity, fertilizer doses can be lowered and more nutrients can be harvested from the soil. It is important to provide quality enough vegetables, for balanced diet but also to produce quality vegetables that are acceptable and competitive in international market. In addition to nutrient mining, the increasing dependence on imports of chemical fertilizers at very high international prices underlining the need to explore and exploit the potential of alternative sources of plant nutrients of late microbial inoculants have shown a good promise and has emerged as an important component of integrated plant nutrition system (IPNS). Use of microbial inoculants is needed as an alternative source to bring forth the eco-friendly methods of farming. The concept of sustainable agriculture envisages primary emphasis on manipulation and management of biological systems not only to maximize yield but also to stabilize the agro-systems and to minimize industrial input demands. In a country like India a large majority of the farmers are poor and have small holdings, the use of microbial inoculants in combination with chemical fertilizers offers a great opportunity to increase the crop production at less cost.

Microbial inoculants are the carrier based preparations containing beneficial microorganism in viable state intended for seed or soil application. These microbes help to fix atmospheric nitrogen, solubilize and mobilize phosphorous, translocate minor elements like zinc, copper etc. to the plants, produce plant growth promoting hormones, vitamins and amino acids and control plant pathogenic fungi thus, helping to improve the soil health and increase crop production. *Rhizobium*, *Azobacter*, *Acetobacter* and *Herbaspirillum* isolates can excrete and synthesize gibberellins, auxins and cytokinins (Bastian *et al.*, 1998). Earlier studies showed that plant growth-promoting rhizobacteria (PGPR) could stimulate the growth and yield of cabbage (Thran *et al.*, 2014).

The extent of benefit from these micro-organisms depends on their number and efficiency which, however, is governed by large number of soil and environmental factors. When the number and activity of specific micro-organism is sub-optimal, artificially multiplied microbial inoculants are used to hasten the biological activity to improve availability of plant nutrient. Thus, it makes imperative to make a concerted efforts to bridge the gap between potential yield and actual yield harvested by the farmers to make cabbage cultivation more remunerative through the better management of inputs like nutrients management practices and microbial inoculants for better exploitation of yield potentialities.

Therefore, this study was carried out to investigate the effect of different levels of NPK and microbial inoculants on yield and economics of hybrid cabbage.

RESEARCH METHODS

The present investigation was conducted in the winter season at Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India. The design of experiment was RBD (Factorial), replicated thrice and a common hybrid variety Indo-American Seeds Pvt. Ltd. Hybrid Cabbage Indom-216 was used for the study. Seeds were sown and covered with thin layer of soil mixed with FYM. There after the bed was covered with paddy straws. Twenty five days old seedlings were used for transplanting in the main field.

Microbial inoculants were used as seedlings inoculation and soil application and twenty five days seedlings were transplanted in the main field at the spacing of 45 x 45 cm. the soil and the weather condition prevailing during the period of investigation was close to normal for the place and could be termed congenial for growth and development of hybrid cabbage.

The treatments comprised of four microbial inoculants (M_0-0, M_1-*Azotobacter*, M_2-*Azospirillum*, M_3-VAM and M_4-PSB) and five different levels (F_1-80:40:40 NPK kg/ha, F_2-120:60:60 NPK kg/ha, F_3-160:80:80 NPK kg/ha, F_4- 200:100:100 NPK kg/ha and F_5- 240:120:120 NPK kg/ha) in different combinations. Treatment wise different microbial inoculants in @ 10 g/ lit. of water were mixed and required quantity of solution was prepared. The roots of uprooted seedlings were dipped in this solution for 20 minutes before transplantation. Half dose of nitrogen as urea with full dose of phosphorus (P_2O_5) as single super phosphate and potash (K_2O) as murate of potash were applied before planting of seedlings as basal dressing as per the treatments were mixed thoroughly and the mixture was placed and incorporated in the top 6-8 layer of soil on the point marked for transplanting of each seedlings. After placement and incorporation of the fertilizers mixtures, seedlings were transplanted. The remaining half amount of nitrogen was top dressed in two equal split doses at 25 days and 50 days after transplanting. Five plants in each treatment combination and in each replication were randomly selected and tagged properly for recording various observations. The observation recorded for the aforesaid five plants were worked out to give mean in respect of all the characters, *viz*. diameter of head (cm), weight of head (kg), yield/plot (kg), yield (q/ha) and economics *viz.*, gross return (Rs./ha), net return (Rs./ha) and benefit: cost ratio. The statistical analysis of the data recorded in all observations was carried out by the method of analysis of the variance prescribed by Fisher and Yates (1963). Comparison of treatment was made with the help of critical differences (C.D).

RESEARCH FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Yield contributing traits :

The microbial inoculant (Table 1) M_2 (*Azospirillum*) significantly reduced the number of days taken to head formation (52.20 days) which was at par with M_1 (*Azotobacter*). The maximum number of days taken to head formation was noted in treatment without microbial inoculant (M_0). The microbial inoculants might have accelerated to complete the vegetative growth earlier due to certain growth promoting substances secreted by the microbial inoculants, which in turn, might have to be better root development, better transportation of water, uptake and deposition of nutrients. The plants getting the highest dose of NPK of F_4 (N_{240} P_{120} K_{120}) *i.e.* F_5 were reached first to head formation (51.53 days) which showed statistically equality with F_3. The lowest level of NPK *i.e.* F_1 (N_{80} P_{40} K_{40}) significantly delayed to head formation (55.47 days) which was similar with NPK level of F_2 (N_{120} P_{60} K_{60}). The interaction effect of microbial inoculants and levels of NPK was found to be non-significant. The probable reasons for earlier heading is due to higher uptake of NPK and increased nutrients transport from root to the aerial parts and increased rate of photosynthesis and transport of photosynthesis. These results are in close agreement with the findings of Chaubey *et al.* (2006) and Kumari *et al.* (2015).

The plants developed under NPK levels of F_4 along with microbial inoculants M_2, *i.e.* M_2F_4 (Table 1)

Table 1 : Effects of microbial inoculants and chemical fertilizers on yield contributing traits in hybrid cabbage

Microbial inoculants	Levels of chemical fertilizers					Mean
	F_1-80:40:40	F_2-120:60:60	F_3-160:80:80	F_4-200:100:100	F_5-240:120:120	
Number days taken to head formation after transplanting						
M_0-0	57.00	55.67	53.67	53.67	52.00	54.40
M_1-*Azotob*	55.00	53.33	52.33	52.33	52.33	53.07
M_2-*Azosp*	54.00	51.67	52.33	52.67	50.33	52.20
M_3-VAM	56.00	52.67	53.00	53.33	51.00	53.20
M_4-PSB	55.33	53.67	52.00	53.33	52.00	53.27
Mean	55.47	53.40	52.67	53.07	51.53	
Average head weight (kg)						
M_0-0	0.91	1.51	1.56	1.60	1.64	1.45
M_1-*Azotob*	1.48	1.61	1.70	1.86	1.75	1.68
M_2-*Azosp*	1.54	1.74	1.81	1.88	1.76	1.75
M_3-VAM	1.43	1.58	1.67	1.80	1.71	1.64
M_4-PSB	1.45	1.59	1.77	1.83	1.72	1.66
Mean	1.36	1.61	1.69	1.79	1.72	
Head yield (q/ha)						
M_0-0	435.57	682.88	711.56	753.49	802.54	691.89
M_1-*Azotob*	662.71	732.05	780.94	851.26	809.45	767.29
M_2-*Azosp*	698.11	795.55	765.01	868.51	810.19	787.47
M_3-VAM	653.33	720.45	777.44	842.17	795.22	757.72
M_4-PSB	660.25	726.33	730.98	826.90	784.77	731.17
Mean	621.99	731.45	753.19	828.47	800.44	
C.D. (P=0.05)		Microbial inoculants (M)		Chemical fertilizers (F)		M x F
Number days taken to head formation after transplanting		NS		0.63		NS
Average head weight (kg)		0.02		0.02		0.14
Head yield (q/ha)		7.76		7.76		67.14

NS=Non-significant

significantly produced the highest average head weight (1.880 kg) which was statistically comparable to treatment combinations of M_1F_4 and M_2F_3. The NPK levels of F_1 without microbial inoculant (M_0), *i.e.* M_1F_1 gave the lowest head weight (0.910 kg). The head weight of cabbage was markedly influenced by application of microbial inoculants. The maximum head was recorded with the use of microbial inoculants M_2 which was significantly superior to *Azotobacter.* It is a well known fact that *Azospirillum* has definite role in cell division, cell enlargement, cell elongation and physiological activities. These physiological activities give beneficial response on uptake of water and nutrients development of cambial growth, respiration, co-enzyme activity, utilization of ATP, formation of RNA and cell permeability, due to these activities application of *Azospirillum* had induced effect on weight of head. The result in respect of head weight of cabbage is in complete agreement with the findings of Manivannam and Singh (2004) and Kumari *et al.* (2015). Morever, higher dose of NPK probably has resulted in the production of larger number of leaves and increased leaf area, which ultimately contributed towards the manufacture of more carbohydrates, consequently more weight of head. The findings pertaining to head weight are in close agreement with those reported by Bhardwaj *et al.* (2007).

The highest head yield (787.47 q/ha) was obtained with the use of microbial inoculant (Table 1) M_2 proved its superiority over M_1. The lowest head yield (435.57 q/ha) was recorded in plants developed under without microbial inoculant (M_0). The improvement in yield might be due to higher amount of nitrogen fixed in soil by *Azospirillum* and made available to plants, and growth promoting substances like IAA, GA, cytokinins and vitamins secreted by *Azospirillum* which have beneficial effects on crop growth. Better crop due to all these factors, which might have helped in increasing photosynthesis rate and more physiological and

Table 2 : Effect of microbial inoculants and chemical fertilizers on gross return (Rs./ha), net return (Rs./ha) and benefit: cost ratio of hybrid cabbage (Pooled results of two years)

Microbial inoculants	Levels of chemical fertilizers					Mean
	F_1-80:40:40	F_2-120:60:60	F_3-160:80:80	F_4-200:100:100	F_5-240:120:120	
Gross return (Rs./ha)						
M_0-0	304899.00	478016.00	498094.33	527445.33	561780.33	484324.40
M_1-*Azotob*	463899.33	512437.33	546658.00	595884.33	566619.67	537099.73
M_2-*Azosp*	488674.67	556882.67	535511.67	607954.67	567137.67	551232.27
M_3-VAM	457333.33	504315.00	544210.33	589452.33	556654.00	530393.00
M_4-PSB	462175.00	508433.33	511688.33	578832.33	549339.00	511816.20
Mean	435396.27	512016.87	527232.53	579913.80	560306.13	
Net return (Rs./ha)						
M_0-0	196409.34	367411.16	385374.19	410009.89	444839.99	371606.32
M_1-*Azotob*	352809.67	399232.49	431337.86	478448.89	447079.32	421781.65
M_2-*Azosp*	377585.01	443677.83	420191.52	490519.23	447597.32	435914.18
M_3-VAM	346243.67	391110.16	428890.19	472083.56	437113.66	415088.25
M_4-PSB	351085.34	395228.49	396368.19	463996.89	429798.66	396498.12
Mean	324826.61	399332.03	412432.39	463011.69	441285.79	
Benefit: cost ratio						
M_0-0	1.81	3.32	3.47	3.49	3.8	3.28
M_1-*Azotob*	3.17	3.52	3.77	4.07	3.73	3.65
M_2-*Azosp*	4.00	3.92	3.64	4.17	3.74	3.89
M_3-VAM	3.11	3.45	3.71	4.02	3.65	3.59
M_4-PSB	3.16	3.49	3.43	4.04	3.59	3.43
Mean	3.05	3.54	3.59	3.96	3.70	

C.D. (P=0.05)	Microbial inoculants (M)	Chemical fertilizers (F)	M x F
Gross return (Rs./ha)	5429.31	5429.31	47019.23
Net return (Rs./ha)	5429.40	5429.40	47019.99
Benefit: cost ratio	0.06	0.06	0.48

biochemical activities which in turn, perheps increased the movement of photosynthesis from source to sink. Thus, finally resulted in increasing the yield and yield components. Significant increase in head yield was also reported by Bhardwaj *et al.* (2007) and Kumari *et al.* (2015).

Economics contributing traits :

The microbial inoculants exhibited significant variation on gross return (Rs./ha). Different microbial inoculants had significant variation in gross return (Table 2). Though, gross retrun was maximum (551232.27Rs./ha) in M_2- *Azospirillum* (Jana and Mukhopadhyay, 2001; Sharma, 2004; Sharma *et al*., 2004; Choudhary and Choudhary, 2005 and Sharma and Sharma, 2010).

The highest net return (463011.69Rs./ha) was associated with NPK levels of F_4 which was statistically similar to F_3 (Table 2). The lowest net return (196409.34 Rs./ha) was registered at NPK levels of F_1. The application of microbial inoculant M_2 helped to bear maximum net return which was at par with *Azotobacter.* This may be due to the fact that microbial inoculants have ability to produce some growth promoting substances which might have led to better accumulation of food materials in head. These findings get support from the results obtained by Choudhary and Choudhary (2005); Jana and Mukhopadhyay (2001); Sharma (2004); Sharma *et al*. (2004); Sharma and Sharma (2010) and Singh *et al*. (2015).

Application of microbial inoculants caused significant effect on benefit: cost ratio (Table 2). The plants grown at NPK levels of F_4 produced significantly maximum benefit: cost ratio (3.96) which was similar to F_5. The lowest benefit: cost ratio (1.81) was recorded at the lowest levels of F_1. The interaction effect of microbial inoculants and different dosages of NPK was found significant. These results are in accordance with the findings of Jana and Mukhopadhyay (2001); Sharma *et al*. (2004); Chaudhary and Chaudhary (2005) and Sharma and Sharma (2010) Singh *et al*. (2015).

On the basis of results and discussion made so far, it may be concluded that application of microbial inoculants basically *Azospirillum* as soil application of NPK (N_{200} P_{100} K_{100}) kg/ha was the most effective treatment combination for higher yield and economics improvement in cabbage cultivation. Hence, the use and management of natural resources in sustainable agriculture, the microbial fertilizers hold vast potential for future.

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