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Effect of Fertigation and Bio-Fertilizers on Growth and Yield Attributes of Sprouting Broccoli (*Brassica Oleracea* Var. Italica) Cultivar Fiesta

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ABSTRACT

The field experiment was conducted in sandy loam soil of the Horticulture farm, Rajasthan Agricultural Research Institute, Durgapura (Jaipur-Rajasthan) during rabi 2013-14 and 2014-15. The experiment, comprising of 18 treatment combinations replicated four times, was laid out in split-plot design with three fertigation levels of NPK (F_{50}, F_{75} and F_{100}) with main plot and two levels of biofertilizers (without and with Azotobacter + PSB) were added in sub plots. The results of the study have clearly shown that application of fertigation levels (F_{75}) significantly increased yield attributes and yield (volume of head, diameter of head, weight of main head and secondary head, total head yield per bed and per hectare and biological yield). While biofertilizers (Azotobacter + PSB) in combination significantly enhanced the growth parameters (plant height, number of leaves, leaf area), yield attributes and yield (volume of head, diameter of head, weight of main head and secondary head, total head yield per bed and per hectare and biological yield).

Key words: *Fertigation, Biofertilizer, Azotobacter, Growth, yield, Harvest, Broccoli.*

INTRODUCTION

Broccoli belongs to Brassicaceae family. Broccoli is a garden vegetable and closely resembles to cauliflower. Broccoli has thick clusters of flower buds that form edible "heads". These heads are green, purple and white in colour. Broccoli is an important vegetable crop with high nutritional value[22]. It is fairly high in protein (3.3%), high in Vitamin-C content (137 mg/100 g) and a good source of Vitamin-A (3500 IU), Vitamin-B_2 (0.12 mg), iron (205 mg/ g) and calcium (0.80 mg /100 g)[3].

Fertigation provides a variety of benefits to the users like high crop productivity and quality, resource use efficiency, environmental safety, flexibility in field operations, effective weed management and successful crop cultivation on fields with undulating topography. Fertigation is considered eco-friendly as it voids the leaching of nutrients.

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Fertigation through drip irrigation can yield a fertilizer savings in the range of 25 to 50 per cent[7].

Biofertilizers can serve as alternative to mineral fertilizers for improving soil structure and microbial biomass for sustainable increased production. *Azotobacter* and Phosphorus Solubilizing Bacteria (PSB) are the biofertilizers which nourish the crops and soil by liberating the growth promoting substances and vitamins. *Azotobacter* fixes atmospheric nitrogen in the root zone of the plants where as PSB solubilises unsoluble fixed phosphates already present in the soils[10].

These biofertilizers are organic and thus absolutely safe and provide mechanical support, vigor and health to the seedlings. Not only this, biofertilizers suppress the incidence of pathogens and aid as biological control agents. They also provide tolerance to the plants against drought and stresses. Therefore, the application of biofertilizers are economical, eco-friendly (pollution free) and are based on renewable energy sources and provide sustainability to the farming system.

MATERIAL AND METHODS

The experiment was laid out in Split Plot Design (SPD) with 4 replications and 8 treatments. Randomization of the treatments was done with the help of random number table as advocated by Fisher and Yates[5].

Thirty two pro-tray of 104 chambers were taken for raising seedlings. Each tray was prepared by filling coco-peat and vermicompost. Seeds were treated with 0.2 per cent Carbendazim to check the infection of damping off. Seeds were sown on 26th September, 2013 and 2014 in pro trays by placing the seeds at 1-2 cm depth. A thin layer of coco-peat was applied to cover the seed. Fertigation application in sub-plot as nitrogen (N) @ 120 kg ha^{-1}, phosphorus (P_2O_5) @ 80 kg ha^{-1} and potassium (K_2O) @ 60 kg ha^{-1} were applied. The fertigation was applied in five split doses after transplanting.

Healthy seedlings were transplanted on 25th October, 2013 and 2014 when average height of seedlings was about 10-12 cm. The distance between row to row and plant to plant was kept as 45 cm × 45 cm. Plant height was recorded at 40, 60 DAT and at harvest. The number of leaves of five tagged plants were counted from each plot at 40, 60 DAT, the days were counted from the date of transplanting and average days to head initiation for the plant was calculated, The leaf area of five tagged plants were recorded from each plot at harvest by leaf area meter (LICOR-3100, Lincoln, USA), Volume of head was recorded by measuring the displaced water which was obtained by dipping the broccoli head in a measuring cylinder, The diameter of head was measured by dividing the circumference by 3.14 for five selected plants, Weight of main head and secondary head was taken from tagged plants after removing stem and leaves and average weight of main head and secondary head per plant was calculated, The total yield of central head and secondary head per bed was recorded by weighing with the help of single pan balance, The total yield per hectare in quintals was calculated on the basis of the total head yield per plot the tagged plants were weighed at the time of harvesting and average biological yield per plant was calculated.

RESULT AND DISCUSSION

FERTIGATION

GROWTH PARAMETERS: The significantly higher value of growth parameters *viz*., plant height, number of leaves per plant and leaf area were recorded with increasing level of fertigation upto F_{100} (Table 1) . However, days taken to head initation after transplanting was not significantly affected due to various fertigation levels. Application of increasing levels of fertigation may be attributed to better nutritional environment in the root zone as well as in the plant system. It is well established that nitrogen is the most indispensable of all mineral nutrients for growth and development of the plant as it is the basis of fundamental constituents of all living matter. It also plays an important role in plant metabolism by virtue of being an essential compounds like amino acids, protein,

nucleic acids, enzymes, co-enzymes and alkaloids[20].

Similar to nitrogen, phosphorus is also a nutrient that plants need in relatively large quantities for normal plant growth. Plants derive their internal energy form P-containing compounds, mainly Adenosine Di Phosphate (ADP) and Adenosine Tri Phosphote (ATP). This means that inadequate P supply will result in a decreased synthesis of RNA, the protein maker leading to depressed growth. Phosphorus deficient plants, therefore, are stunted with a limited root system and thin stem[13].

The response to potassium fertilization in terms of overall improvement in growth parameters is further supported by the fact that the leaching losses of potassium were more in light textured soils. Therefore, potassium fertilization improved overall crop growth in terms of plant height and number of leaves per plant. The findings of this investigation were in close conformity with those of Sanchita *et al*[14]., Selim *et al*[15]., Imamsaheb *et al*[8]., and El-Helaly[4].

YIELD ATTRIBUTES: Data pertaining to fertigation levels revealed that volume of head, diameter of head, average weight of main head and secondary head per plant, total head yield per bed and per hectare and biological yield per plant increased with application of NPK at increasing level upto F_{100} (Table 2). However, fertigation levels F_{100} and F_{75} remained at par with all above parameters. This might be due to overall improvement in vigour and crop growth as already been explained in preceding paragraphs. Since an adequate supply of nitrogen to the plant is considered to be important in promoting rapid vegetative growth, including average weight of main head, secondary head, total head yield and biological yield. Overall improved growth i.e. plant height, number of leaves per plant with the nitrogen fertilization coupled with increased net photosynthesis on one hand and greater mobilization of photosynthates towards depository stature, on the other hand, might have increased the yield significantly. Nitrogen application further helps in the translocation of photosynthates in the head resulting in increased diameter and weight of head. The head yield, being a resultant of the cumulative effect of these parameters increased significantly upto 256.70 q ha^{-1} (Table 2) with F_{100}. Improved weight of head with nitrogen fertilization led to significant improvement in yields and resulted in better source and sink relationship. The present trend of increase in head yield under fertigation with nitrogen is in close conformity with the findings of Sanchita *et al*[14]., and Imamsaheb *et al*[8].

The beneficial influence of phosphorus in early stage of growth may be explained by early stimulation of scanty root system through efficient translocation to the roots of certain growth stimulating compounds formed on account of protoplasmic activity in phosphorus fed plants, which enhanced absorption of nitrogen and other nutrients along with their utilization.

Since an adequate supply of potassium stimulated weight of head, total head yield and biological yield. The increase in yield attributes and yield due to potassium application may be due to its functional role in higher net photosynthetic activity. Adequate nutrient supply caused denser rooting system, which resulted into improvement in yield attributing characters and yield[18] and Yang and Guan[21].

BIOFERTILIZERS

GROWTH PARAMETERS: The significant increase in plant height, number of leaves per plant, and leaf area were observed due to inoculation of biofertilizers (Table 3). Application of *Azotobacter* improved nitrogen status of the soil because this is free nitrogen fixer. Application of efficient and healthy strain of *Azotobacter* in rhizosphere have resulted in greater fixation of atmospheric nitrogen for use by the plant resulting in vigorous growth of plant. Similar results have been reported by Badawy and Imam[1], Chattoo *et al*[2]., Jayathilake *et al*[9]., Manivannan and Singh[11] and Yadav *et al*[19]. Inoculation with PSB transforms unavailable phosphorus into plant utilizable form. Results of present

investigation showed the use of these biofertilizers has significantly improved growth parameters. However, the improvement in these characters were limited where these biofertilizers were used singly, but the additive effect was noticed when N_2 fixers and PSB were used together. Such an additive influence of biofertilizers is attributable to mutually beneficial role played by each of the two groups of biofertilizers used. These findings have been supported by Yadav *et al*[19]., and Mohapatra *et al*[12].

YIELD ATTRIBUTES: Results of present investigation also revealed that the application of biofertilizers with *Azotobacter* + PSB in combination significantly increased volume of head, diameter of head, average weight of main head and secondary head per plant, total head yield per bed, total head yield per hectare and biological yield per plant (Table 4). This might be due to the fact that *Azotobacter* is known to produce antifungal, antibiotic substances that inhibit varieties of soil borne fungal diseases. It can also synthesise the thiamin, riboflavin, pyridoxin, cyanocobalamine, nicotinic acid, pentathenic acid, indole acetic acid and gibberellins or gibberellins like substances resulting in vigorous plant growth and dry mater production which in turn resulted in better head development and ultimately the higher yield. Similar results have also been reported by Wange *et al*[17]., Chattoo *et al*[2]., and Mohapatra *et al*[12]. *Azotobacter* inoculation helped in increasing nitrogen availability because it is a micro acrophillic nitrogen fixer. It colonizes the root mass, fixes nitrogen in loose association with plants and these bacteria induce the plant root to secrete mucilage which create low oxygen involvement and help to fix atmospheric nitrogen which reflected in the better yield attributes. Gunasekaran and Visassak[6] also noticed increased activity of plant growth substances like gibberellic acid, indole acetic acid, and dihydrozeatin in *Azospirillum* inoculated plant, which in turn improved the yield. The solubilization effect of PSB is generally due to the production of organic acids by these organisms. They are also known to produce amino acids, vitamins, growth promoting substance like indole acetic acid and gibberellic acid which help better growth of crop and ultimately yield attributes and yields. Biological nitrogen fixation depends appreciably on the available form of phosphorus. So the combined inoculation with nitrogen fixer and PSB may benefit the plant better (by providing both nitrogen as well as phosphorus), than either group of organism alone. Such mutually beneficial synergistic effect has also been reported by Verma and Yadav[16].

Table 1: Effect of Fertigation on Growth Attributes of Sprouting Broccoli (*Brassica Oleracea* Var. Italica) Cultivar Fiesta

Plant Height				**Number of Leaves per Plant**			**Days taken to head initiation**	**Leaf area (cm^2)**
Treatment	At 40 DAT	At 60 DAT	At Harvest	At 40 DAT	At 60 DAT	At Harvest		
Fertigation	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
F_{50}	16.88	23.85	30.11	7.57	11.56	15.62	51.88	1248.36
F_{75}	21.43	32.60	41.25	10.32	15.34	20.72	52.35	1542.08
F_{100}	24.81	38.94	47.52	12.78	17.96	24.82	52.54	1612.96
SEm±	0.20	0.31	0.53	0.17	0.17	0.21	0.50	14.34
CD (p = 0.05)	0.56	0.87	1.49	0.48	0.48	0.60	NS	40.28

Table 2: Effect of Fertigation on Yield Attributes of Sprouting Broccoli (*Brassica Oleracea* Var. Italica) Cultivar Fiesta

Treatment	Volume of head (cc)	Diameter of head (cm)	Average weight of main head per plant (kg)	Average weight of secondary head per plant (kg)	Total head yield per bed (kg)	Total head yield q ha^{-1}	Biological yield per plant (kg)
Fertigation	Mean	Mean	Mean	Mean	Mean	Mean	Mean
F_{50}	60.48	8.26	0.229	0.132	6.24	178.24	2.08
F_{75}	80.59	10.67	0.319	0.191	8.80	251.57	3.28
F_{100}	81.92	11.05	0.325	0.195	8.98	256.70	3.38
SEm±	0.59	0.16	0.002	0.002	0.07	2.07	0.04
CD (p = 0.05)	1.64	0.44	0.007	0.005	0.20	5.82	0.11

Table 3: Effect of Bio-fertilizer on Growth Attributes of Sprouting Broccoli (*Brassica Oleracea* Var. Italica) Cultivar Fiesta

Plant Height				Number of Leaves per Plant			Days taken to head initiation	Leaf area (cm^2)
Treatment	At 40 DAT	At 60 DAT	At Harvest	At 40 DAT	At 60 DAT	At Harvest		
Bio-fertilizer	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
B_0	20.15	30.21	37.42	9.76	13.60	19.40	52.12	1401.50
B_1	21.94	33.39	41.84	10.70	16.31	21.38	52.41	1534.10
SEm±	0.16	0.25	0.43	0.14	0.14	0.18	0.41	11.71
CD (p = 0.05)	0.45	0.71	1.22	0.39	0.39	0.49	NS	32.89
CV (%)	6.51	6.71	9.82	11.62	7.88	7.30	6.59	6.77

Table 4: Effect of Bio-fertilizer on Yield Attributes of Sprouting Broccoli (*Brassica Oleracea* Var. Italica) Cultivar Fiesta

Treatment	Volume of head (cc)	Diameter of head (cm)	Average weight of main head per plant (kg)	Average weight of secondary head per plant (kg)	Total head yield per bed (kg)	Total head yield q ha^{-1}	Biological yield per plant (kg)
Fertigation	Mean	Mean	Mean	Mean	Mean	Mean	Mean
F_{50}	70.84	9.57	0.276	0.159	7.52	214.77	2.69
F_{75}	77.83	10.42	0.306	0.187	8.50	242.91	3.14
F_{100}	0.48	0.13	0.002	0.002	0.06	1.69	0.03
SEm±	1.34	0.36	0.005	0.004	0.16	4.76	0.09
CD (p = 0.05)	5.46	10.85	5.69	7.44	6.14	6.28	9.33

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