Efficiency of bio-organic nutrition on vegetative growth, yield and quality of Broccoli (*Brassica oleracea* L. var. *italica* Plenck)

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**ABSTRACT**

The present experiment was conducted during rabi season of 2015-16 with an aim to study the effect of biofertilizers and organic nutrition on broccoli production. The experimental site has annual rainfall of 750 mm, 60-90 per cent relative humidity with high pH soil (pH 8.2). The experiment was carried out in a Randomized Block Design with ten treatments (control, Recommended dose of fertilizer, Rhizobium, Azotobacter, Azospirillium, PSB, VAM, FYM, Vermicompost and Farm compost) by three replication. Observations were recorded for growth parameters like plant height, stem circumference, plant spreading, number of leaves, length and width of leaves, yield (kg plot⁻¹ and q ha⁻¹), quality parameters viz., curd weight, curd diameter, Vitamin C, T.S.S., Total sugars, Reducing sugar, Non-reducing sugar, Titratable acidity etc. The experimental result revealed that the use of biofertilizers improved the production of broccoli in general as compared to untreated control. Among the treatments, application of Azospirillum can be suggested to broccoli growers for obtaining better growth, yield and quality improvement of broccoli cv. KTS-1 under Lucknow subtropical condition.

**Keywords** : Biofertilizers, broccoli, organics, quality, yield

Broccoli (*Brassica oleracea* var. *italica* Planck) of Brassicaceae (Cruciferae) family is a rabi season cole crop. Apart from other nutritional antioxidants, broccoli is a significant source of calcium, folic acid, carotenoids, ascorbic acid and known to reduce risk of breast and prostate cancer (Beecher, 1994). Thus, importance of broccoli production is increasing day by day. Farmers are repeatedly using chemical fertilizers to obtain maximum yield in broccoli, which is creating problems of soil deterioration, affecting soil flora and fauna and ultimately affecting yield and quality of broccoli. There is a growing concern throughout the world on adverse effect of indiscriminate use of inorganic fertilizer, pesticide, herbicide etc. to the environment and human health. Therefore, a combination strategy of using judicious chemical fertilizer, organic manures and bio-fertilizers may be helpful in increasing production with less hazard. Such efforts will be effective not only in supplementing a part of chemical fertilizers requirement of the crops and yield, but also influence quality attributes in several vegetables, besides minimum use of inorganic fertilizers.

There are abundant microorganisms living in soil, especially in the rhizosphere of plants. It is well known that a considerable number of bacterial and fungal species possess a functional relationship and constitute a holistic system with plants having beneficial effects on plant growth (Vessey, 2003). Bio-fertilizers are natural fertilizer containing carrier based beneficial microorganisms which help to enhance productivity by biological nitrogen fixation or solubilization of insoluble phosphate or producing growth hormones, vitamins and other growth factors required for plant and thus, help to reduce the application of chemical fertilizers. Among these bio-fertilizers, Rhizobium is an aerobic and heterotrophic bacteria that induces nodule formation on the roots of their host plants and symbiotically fixes atmospheric nitrogen and can increase the yield by 25-30 per cent in succeeding crop (Sunda, 2011). Azotobacter fix atmospheric nitrogen under free living condition and promote plant growth activities like phosphate solubilization, production of plant growth hormones like auxins, gibberellins, cytokines, vitamins and amino acids (Kloepper and Schroth, 1978). Azospirillum a free-living, nitrogen-fixing bacteria, secretes phytohormones (auxins, gibberellins, cytokinins, and nitric oxide) as signals of plant growth promotion (Cecagno et al., 2015). Phosphate solubilizing bacteria (PSB) biofertilizer are life forms that can help in improving the phosphate uptake of plants in various ways. PSB also has the potential to enable the utilization of India’s abundant rock phosphate deposits, much of which is not enriched (Ghosh, 2004). Vesicular Arbuscular Mycorrhizae (VAM) are symbiotic soil fungi which colonize the roots of approximately 80 per cent of plant families. They impart to their hosts a variety of benefits like increased growth and yield due to enhanced nutrient acquisition, water relations, pH tolerance and

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disease and pest resistance. The most common beneficial
effect of mycorrhizae is increased uptake of immobile
nutrients, notably P, from soil. Vermicompost is another
kind of organic source of nutrients has been found to
effectively enhance the root formation, elongation of stem (Edwards, 1988). Farm Yard Manure (FYM) and
farm compost promote soil microbes that aid plant
growth. Now a day the people are more concerning the
hazards of indiscriminate use of chemical inputs
(fertilizers and pesticides etc.) and are more attracted to
the organically produced products as well as the organic
and bio-fertilizers is good for crop and soil also (Ray
et al., 2017 and Sau et al., 2017). With the available
resources different kinds of bio-fertilizers and organic
manures are taken in the present study. Thus, keeping
these views the present experiment was conducted with
an aim to produce good quality broccoli by application
of different bio-fertilizer doses and organic manuring
at high pH soil of Lucknow.

MATERIALS AND METHODS

The field experiment was conducted at Department
of Horticulture, Babasaheb Bhimrao Ambedkar
University (A Central University), Vidya-Vihar, Rai-
Bareli Road, Lucknow - 226025 (U.P.), India during Rabi
season of 2015-16. Experimental site is under subtropical
agro-climatic zone, having 25.7°C to 44.3°C temperature
during summer and 1.5°C to 18.9°C during winter and
has annual rainfall of 896.2mm and 60-90 per cent
relative humidity. The soil of experimental field had high
pH of 8.2. Seeds of broccoli cv. Pusa KTS-1 were sown
on nursery beds after treated with thiram and bavistin
mixed in 2:1 ratio @ 3.0 g kg⁻¹ of seeds. Seeds were
sown on 29th October 2015 and the soil of seed bed was
mixed in 2:1 ratio @ 3.0 g kg⁻¹ of seeds. Seeds were
sown on 29th October 2015 and the soil of seed bed was
covered with organic mulching (grass) to protect the
young seedlings from adverse climatic condition and
keep soil moist. Covering materials were removed from
the bed after seed germination (5 days after sowing) for
optimum growth of seedlings. 30 days old healthy
seedlings were transplanted on 25th November 2015 at a spacing of 45 x 35 cm accommodating 9 plants plot⁻¹ (1.35 × 1.05 m² plot size).

The observations on plant height, stem circumference,
plant spreading, number of leaves, length of leaves, width
of leaves were taken as vegetative growth parameter.
Yield parameters viz., weight of curd with and without
guard leaf, yield (kg plot⁻¹) and (q ha⁻¹), quality
parameters viz., curd diameter, vitamin – C, T.S.S. (Total soluble solids) (0Brix), Total sugars (%), Reducing sugars (%), Non-reducing sugars (%), Titratable Acidity (%). Plant canopy spreading was measured at both directions i.e. East-West and North –South directions at 30 and 60 DAT. It was seen that plant treated with Azospirillum (T₄) recorded maximum canopy spreading (32.68 cm in East-West, 37.34 cm North-South direction at 30 DAT and 45.23 cm in East-West, 48.28 cm North-
Efficiency of bio-organic nutrition on broccoli

Table 1: Effects of bio-organic nutrition on vegetative growth of broccoli

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Stem diam. (cm)</th>
<th>No. of leaves plant(^1)</th>
<th>Plant spreading (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAT</td>
<td>60 DAT</td>
<td>30 DAT</td>
<td>60 DAT</td>
</tr>
<tr>
<td>T0</td>
<td>20.38</td>
<td>37.26</td>
<td>1.23</td>
<td>2.17</td>
</tr>
<tr>
<td>T1</td>
<td>27.53</td>
<td>45.14</td>
<td>2.16</td>
<td>4.04</td>
</tr>
<tr>
<td>T2</td>
<td>21.72</td>
<td>38.48</td>
<td>1.55</td>
<td>2.37</td>
</tr>
<tr>
<td>T3</td>
<td>25.22</td>
<td>44.31</td>
<td>1.19</td>
<td>2.51</td>
</tr>
<tr>
<td>T4</td>
<td>27.76</td>
<td>45.50</td>
<td>1.89</td>
<td>4.16</td>
</tr>
<tr>
<td>T5</td>
<td>22.12</td>
<td>39.31</td>
<td>1.86</td>
<td>3.68</td>
</tr>
<tr>
<td>T6</td>
<td>26.53</td>
<td>42.62</td>
<td>1.29</td>
<td>3.58</td>
</tr>
<tr>
<td>T7</td>
<td>24.42</td>
<td>39.87</td>
<td>1.18</td>
<td>2.96</td>
</tr>
<tr>
<td>T8</td>
<td>22.69</td>
<td>39.51</td>
<td>1.50</td>
<td>2.46</td>
</tr>
<tr>
<td>T9</td>
<td>24.78</td>
<td>39.49</td>
<td>1.36</td>
<td>2.45</td>
</tr>
</tbody>
</table>

SEm (±) 0.92 1.35 0.13 0.20 0.56 0.82 1.17 1.12 1.27 0.77
LSD (0.05) 2.78 4.06 0.39 0.62 1.65 2.45 3.51 3.35 3.83 2.31

Note: T0 - (Control), T1 – RDF, T2 – Rhizobium, T3 - Azotobacter, T4 - Azospirillum, T5 – PSB, T6 – VAM, T7: FYM, T8 – Vermicompost, T9 – Farm compost

Table 2: Effects of bio-organic nutrition on vegetative growth and curd yield of broccoli

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Average length of leaf (cm)</th>
<th>Average width of leaf (cm)</th>
<th>Curd weight</th>
<th>Curd yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAT</td>
<td>60 DAT</td>
<td>30 DAT</td>
<td>60 DAT</td>
</tr>
<tr>
<td>T0</td>
<td>22.97</td>
<td>31.11</td>
<td>11.36</td>
<td>21.66</td>
</tr>
<tr>
<td>T1</td>
<td>24.63</td>
<td>35.47</td>
<td>12.09</td>
<td>23.56</td>
</tr>
<tr>
<td>T2</td>
<td>21.82</td>
<td>31.44</td>
<td>12.56</td>
<td>23.82</td>
</tr>
<tr>
<td>T3</td>
<td>24.45</td>
<td>32.95</td>
<td>11.78</td>
<td>22.73</td>
</tr>
<tr>
<td>T5</td>
<td>23.24</td>
<td>31.23</td>
<td>12.15</td>
<td>24.66</td>
</tr>
<tr>
<td>T6</td>
<td>24.07</td>
<td>33.11</td>
<td>11.58</td>
<td>23.27</td>
</tr>
<tr>
<td>T7</td>
<td>23.91</td>
<td>32.58</td>
<td>12.20</td>
<td>23.52</td>
</tr>
<tr>
<td>T8</td>
<td>24.58</td>
<td>33.52</td>
<td>11.62</td>
<td>23.36</td>
</tr>
<tr>
<td>T9</td>
<td>25.58</td>
<td>34.60</td>
<td>11.82</td>
<td>22.87</td>
</tr>
</tbody>
</table>

SEm (±) 0.68 0.70 0.44 0.69 18.59 | 16.11 | 0.14 | 10.33 |
LSD (0.05) 2.06 2.11 1.30 2.08 55.67 | 48.25 | 0.43 | 30.95 |

South direction at 60 DAT) at both directions followed by T1, i.e. (RDF). However, the treatment effects due to all the biofertilizer and organic supplement applications are statistically very close to each other as compared to the minimum spreading observed under control plant (Table 1).

Similar trend was also observed in case of increase in number of leaves. It was clearly found that treatment T4 showed maximum leaf production per plant at 30 and 60 DAT. Chattoo et al. (1997) observed that bacterial inoculants responded better for increase in leaf number of leaves and plant spreading and Azospirillum proved better than Azotobacter while experiment in Knol-khol cv. Early White Vienna. The length and width of leaves was also recorded maximum under T4 (Azospirillum) whereas, the minimum value was observed in the treatment T0 (control). Similar study was also reported by Bambal et al. (1998) who found that Azotobacter + Azospirillum + 100% nitrogen resulted maximum leaf area (643.58 cm\(^2\) plant\(^{-1}\)) in on cauliflower cv. Snowball-16.

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Weight of curd with guard leaves and without guard leaves were recorded maximum under T4 (*Azospirillum*) and minimum recorded under control (T0). It was clearly seen that there was no statistical differences among T1 (RDF) and T4 (*Azospirillum*). Similarly, the curd yield (kg plot\(^{-1}\) and q ha\(^{-1}\)) was also maximum (2.59 kg plot\(^{-1}\) and 183.92 q ha\(^{-1}\)) under treatment T4 followed by T1 (RDF). The effect of *Azospirillum*, *Azotobacter*, phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) inoculation on the yield of cauliflower was studied and it obtained the maximum yield of cauliflower with the application of *Azospirillum* (213.25 and 219.95 q ha\(^{-1}\)), followed by *Azospirillum* + 75% dose of N which was also in accordance the finding of Singh *et al.* (2014) in improvement of yield and quality of broccoli.

In respect of quality of curd, it was observed that application of inoculants *Azospirillum* (T4) significantly increased the curd size (15.48 cm diameter). Vitamin-C and Total Soluble Solids (TSS) were found maximum under T4 (*Azospirillum*) (93.31 mg 100g\(^{-1}\) and 9.23°Brix, respectively) and minimum observed in T0 (control) and T4 (VAM) followed by T1.

Similar observation in reducing sugars, non-reducing sugars and titratable acidity was recorded maximum in T4 (*Azospirillum*) and minimum was recorded T0 (control) but total sugars was recorded maximum in T1 (RDF) and minimum was observed in T0 (control). The increase of acidity due to *Azospirillum* (T4) is not clear. However, it may be due to the fact that *Azospirillum* or other biofertilizers might increase the mineral (Nitrogen) availability which may increase acidity (Maji *et al.*, 2015). However, overall TSS: Acid ratio is higher in T4 and T1.

It also observed that increase of ascorbic acid, carbohydrate and crude protein contents when treated with 100% NPK + FYM + *Azospirillum* + Phosphobacteria, whereas, Kumarswamy and Madalageri (1990) concluded from their study on tomato that *Azotobacter* in combination with 30Kg N ha\(^{-1}\) recorded a high marketable yield of tomato fruits and also found to improve quality in ber (Kundu *et al.*, 2015).

On the basis of present investigation it may be concluded that the use of biofertilizers improved the performance of broccoli in general, in terms of yield and quality of curd as compared to untreated control. Among the all treatment under study application of *Azospirillum* can be recommended to broccoli growers for obtaining better growth, marketable curd yield and quality improvement of broccoli cv. KTS-1 under Lucknow condition to reduce the use of chemical fertilizers.

### REFERENCES


<table>
<thead>
<tr>
<th>Treatments</th>
<th>Curd diameter (cm)</th>
<th>Vitamin C (mg 100g(^{-1}))</th>
<th>T.S.S. (°Brix)</th>
<th>Total sugars (%)</th>
<th>Reducing sugar (%)</th>
<th>Non-reducing sugar (%)</th>
<th>Acidity (%)</th>
<th>Acidity: TSS ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>12.88</td>
<td>85.91</td>
<td>7.77</td>
<td>2.61</td>
<td>2.00</td>
<td>0.45</td>
<td>0.32</td>
<td>24.28</td>
</tr>
<tr>
<td>T1</td>
<td>14.61</td>
<td>86.89</td>
<td>8.70</td>
<td>3.96</td>
<td>2.99</td>
<td>0.73</td>
<td>0.36</td>
<td>24.16</td>
</tr>
<tr>
<td>T2</td>
<td>14.37</td>
<td>87.23</td>
<td>8.40</td>
<td>2.98</td>
<td>2.23</td>
<td>0.57</td>
<td>0.40</td>
<td>21.00</td>
</tr>
<tr>
<td>T3</td>
<td>14.67</td>
<td>86.34</td>
<td>8.23</td>
<td>3.10</td>
<td>2.56</td>
<td>0.47</td>
<td>0.42</td>
<td>19.59</td>
</tr>
<tr>
<td>T4</td>
<td>15.48</td>
<td>93.31</td>
<td>9.23</td>
<td>4.20</td>
<td>3.26</td>
<td>0.90</td>
<td>0.44</td>
<td>20.97</td>
</tr>
<tr>
<td>T5</td>
<td>14.46</td>
<td>92.77</td>
<td>8.60</td>
<td>2.98</td>
<td>2.29</td>
<td>0.66</td>
<td>0.39</td>
<td>22.05</td>
</tr>
<tr>
<td>T6</td>
<td>13.70</td>
<td>88.18</td>
<td>7.70</td>
<td>3.50</td>
<td>2.74</td>
<td>0.68</td>
<td>0.41</td>
<td>18.78</td>
</tr>
<tr>
<td>T7</td>
<td>14.73</td>
<td>88.15</td>
<td>8.33</td>
<td>3.45</td>
<td>2.79</td>
<td>0.61</td>
<td>0.34</td>
<td>24.50</td>
</tr>
<tr>
<td>T8</td>
<td>14.49</td>
<td>89.15</td>
<td>8.57</td>
<td>3.32</td>
<td>2.53</td>
<td>0.70</td>
<td>0.37</td>
<td>23.16</td>
</tr>
<tr>
<td>T9</td>
<td>15.29</td>
<td>87.82</td>
<td>7.90</td>
<td>3.07</td>
<td>2.48</td>
<td>0.49</td>
<td>0.40</td>
<td>19.75</td>
</tr>
</tbody>
</table>

SEm (±) 0.32 1.25 0.29 0.29 0.27 0.26 0.038 0.982

LSD (0.05) 0.96 3.74 0.88 0.88 0.09 0.77 0.11 0.982
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