Yield and quality of African marigold as influenced by biofertilizers and nitrogen levels

AR Singanjude, RP Gajbhiye, YR Khobragade and SS Moon

Abstract
An experiment to study the response of biofertilizers and nitrogen levels on yield and quality in African marigold was carried out during kharif season of the year 2017-18 at Research Farm, Horticulture Section, College of Agriculture, Nagpur. A field experiment comprised of two factors i.e. factor A and factor B. Factor A consist of 3 levels of biofertilizers (N0 - Control, N1 - Azotobacter and N2 - Azospirillum) and factor B consist of 5 levels of nitrogen (N0 - Control, N1 - 50 kg N ha\(^{-1}\), N2 - 75 kg N ha\(^{-1}\), N3 - 100 kg N ha\(^{-1}\) and N4 - 125 kg N ha\(^{-1}\)) with fifteen treatment combinations replicated thrice in a Factorial Randomized Block Design. The flower yield characters like flower yield plant\(^{-1}\), flower yield plot\(^{-1}\) and flower yield ha\(^{-1}\) were recorded maximum with an individual application of B1 (Azotobacter) and N3 (100 kg N ha\(^{-1}\)). Significantly maximum flower yield plant\(^{-1}\), flower yield plot\(^{-1}\) and flower yield ha\(^{-1}\) were observed in the treatment combination of B1N3 (Azotobacter and 100 kg N ha\(^{-1}\)). Whereas, the quality parameters like weight of flower, flower diameter, flower disc diameter and number of petals flower\(^{-1}\) were recorded maximum with an individual application of B1 (Azotobacter) and N3 (100 kg N ha\(^{-1}\)). Significantly maximum weight of flower and flower diameter were observed in the treatment combination of B1N3 (Azotobacter and 100 kg N ha\(^{-1}\)). The interaction effect of biofertilizers and nitrogen levels with respect to quality parameters i.e. flower disc diameter and number of petals per flower were found non-significant in the treatment combination of B1N3 (Azotobacter and 100 kg N ha\(^{-1}\)).

Keywords: Biofertilizers, nitrogen, yield, quality, African marigold

I. Introduction
Marigold occupies a prominent place in ornamental horticulture and it is one of the commercially exploited flower crop. Marigold is a native of Central and South America especially Mexico. It belongs to family Asteraceae and genus Tagetes. Marigold flower for special importance during festival days especially Diwali and Dashehara. There is a constant demand for flowers throughout the year for various functions, festivals, marriages and floral decoration. Recently, dried flower petals of marigold are used in poultry feed to improve the colour of egg yolk as well as broiler’s skin. Recently, dried flower petals of marigold are used in poultry feed to improve the colour of egg yolk as well as broiler’s skin. Marigold has nematicidal property. The root-knot nematode (Meloidogyne spp.) can be effectively managed in the field without pesticides. One alternative to use Nematicide as intercrop with other crops to reduce the population of most common nematodes i.e. M. incognita and M. javanica.

In Vidharbh marigold was grown in an estimated area of about 935.7 hectare with production of 5589.8 MT and productivity of 6.0 MT ha\(^{-1}\). In Nagpur division marigold was grown in an area of 651 ha and production of 4109 MT and productivity 6.3 MT ha\(^{-1}\) (Anon, 2017). Biofertilizers are microbial inoculants of selective microorganisms help in improving soil fertility by way of accelerating biological nitrogen fixation, decomposition of plant residues, stimulating plant growth and development ultimately. Nitrogen is the most commonly deficient nutrient in the soil and gives considerable response to this crop. It has the quickest and the most pronounced effect on plant growth and development and ultimately on flower yield. It is an integral part of chlorophyll, which is essential for photosynthesis. Nitrogen is essential constituent of protein and is present in many other compounds of physiological importance in plant metabolism such as nucleotide, phosphatides, alkaloids, enzymes, hormones and vitamins etc.
Materials and Methods
The present investigation was carried out during kharif season of the year 2017-18 at Research Farm, Horticulture Section, College of Agriculture, Nagpur to study the effect of biofertilizers and nitrogen levels on growth and flowering in African marigold. A field experiment comprised of two factors i.e. factor A and factor B. Factor A consist of 3 levels of biofertilizers (N0-Control, N1 - Azotobacter and N2 - Azospirillum) and factor B consist of 5 levels of nitrogen (N0 - Control, N1 - 50 kg N ha⁻¹, N2 - 75 kg N ha⁻¹, N3 - 100 kg N ha⁻¹ and N4 - 125 kg N ha⁻¹) with fifteen treatment combinations replicated thrice in a Factorial Randomized Block Design. The seeds of African marigold var. African Double Orange were obtained from Horticulture Section, College of Agriculture, Nagpur. The seeds were sown 30 days before the actual transplanting date on previously sterilized raised bed and seedlings were prepared. The beds were prepared thoroughly by mixing soil with farm yard manure and linden powder. Seeds were treated with fungicide for healthy growth of seedlings and sown in lines at 10 cm spacing and 2-3 cm deep in the soil. Seeds were then gently covered with the soil. Seeds were sown on nursery bed of 3 m x 1 m x 0.15 m size. Thirty days old uniform well developed and healthy seedlings of African marigold were selected for transplanting. Seedlings were transplanted on raised bed planting of one seedling hill⁻¹ in the experimental field on 13th July, 2017 at the distance of 45 cm x 30 cm.

Treatment wise biofertilizers were applied at the rate of 5 kg Azotobacter and 5 kg Azospirillumha⁻¹ in the soil respectively. The Azotobacter and Azospirillum slurry was prepared by mixing Azotobacter and Azospirillum culture @ 1 kg ha⁻¹ in 5 liters of water. Roots of seedlings were dipped in the slurry for 30 minutes before transplanting in the field. Treatment wise nitrogen levels 50 kg, 75 kg, 100 kg, 125 kg N were calculated according to plot size and subsequently applied in the form of urea. A constant recommended dose of P₂O₅ and K₂O were applied through single superphosphate and muriate of potash according to the plot size. Full dose of P₂O₅ and K₂O along with half dose of N was applied at the time of transplanting. Remaining dose of N was given 30 days after transplanting as per the treatments.

Observations on yield parameters viz., flower yield plant⁻¹, flower yield plot⁻¹ and flower yield ha⁻¹, on quality parameters viz., weight of flower, flower diameter, flower disc diameter and number of petals flower⁻¹. Collected data was statisticially analyzed as per the method given by Panse and Sukhatme (1967) [6]. The appropriate standard error of mean SE (m±) and the critical difference (CD) were calculated at 5% level of probability.

Results and Discussion
Effect of biofertilizers
The data presented in table 1 revealed that, biofertilizers and nitrogen levels had significant effect on yield and quality parameters in African marigold studied in this experiment. However, interaction effect of biofertilizers and nitrogen levels was found to be significant in respect of all the yield and quality parameters except flower disc diameter and number of petals flower⁻¹ (Table 2).

Yield Parameters
Significantly, maximum flower yield plant⁻¹ (288.22 g), flower yield plot⁻¹ (10.37 kg) and flower yield ha⁻¹ (134.45 q) was recorded with an application of B₁ (Azotobacter). However, minimum flower yield plant⁻¹ (221.95 g), flower yield plot⁻¹ (7.99 kg) and flower yield ha⁻¹ (103.52 q) was recorded in the treatment B₃(Control). This might be due to the secretion of growth promoting substances espically cytokinis by the application of Azotobacter which increased plant growth as well as flowering as cytokinin helps in branching and development of side buds which resulted increased in flower yield plant⁻¹, flower yield plot⁻¹ and flower yield ha⁻¹. These results are in close conformity with the findings of Singh A. K. (2006) [9], who reported that, the application of Azotobacter resulted in production of maximum yield of flowers/m² in Rose.

Quality Parameters
An application of B₁ (Azotobacter) received significantly maximum weight of flower (15.23 g), flower diameter (7.07 cm), flower disc diameter (0.61 cm) which was at par with B₂ (0.60 cm) i.e. application of Azospirillum and maximum number of petals flower⁻¹ (271.67) which was at par with B₃ (249.99) i.e. application of Azospirillum. However, minimum weight flower (9.90 g), flower diameter (4.86 cm), flower disc diameter (0.54 cm) and number of petals per flower (199.97) was recorded in treatment B₄(Control). This might be due to better plant growth which indirectly influenced on weight of flower, flower diameter, flower disc diameter and number of petals flower⁻¹ apart from nitrogen fixation, Azotobacter significantly enhanced uptake of Fe, Zn, Cu and Mo. These findings are in close conformity with the results of Singh A. K. (2006) [9], who reported that the maximum weight of flower, flower diameter, flower disc diameter and number of petals flower⁻¹ were obtained with the application of Azotobacter in Rose.

Effect of nitrogen
Yield Parameters
Significantly, maximum flower yield plant⁻¹ (278.75 g) was recorded with an application of N₁ (100 kg N ha⁻¹) which was at par with N₂ (271.60 g and 262.46 g), maximum flower yield plot⁻¹ (10.03 kg) which was at par with N₂ (9.77 kg) and maximum flower yield ha⁻¹ (130.06 q) which was at par with N₂ and N₄ (126.69 q and 122.45 q). However, minimum flower yield plant⁻¹ (220.87 g), flower yield plot⁻¹ (7.95 kg) and flower yield ha⁻¹ (103.01 q) was recorded in treatment N₄ (0 kg N ha⁻¹). This might be due to that, nitrogen is an important constituent of nucleotides, phosphatidizes, enzymes, hormones etc. which have great importance in plant metabolism, augmented crucial role in enhancement of plant growth and resulted in higher flower yield. However, Dhaked et al. (2013) [3] noticed that, maximum flower yield/plot and flower yield/ha were obtained under higher dose of nitrogen (100 kg N/ha) in Calendula.

Quality Parameters
An application of N₁ (100 kg N ha⁻¹) was recorded significantly maximum weight of flower (14.02 g) which was at par with the treatment N₂ and N₃ (13.96 g and 13.42 g), maximum flower diameter (6.78 cm) which was at par with N₂ and N₄ (6.44 cm and 6.07 cm), maximum number of petals flower⁻¹ (260.87) which was at par with N₁ and N₄ (251.03 and 244.21) and maximum flower disc diameter (0.64 cm) which was at par with N₁ (0.61 cm). However, minimum weight of flower (11.19 g), flower diameter (5.47 cm), number of petals flower⁻¹ (220.17) and flower disc diameter (0.50 cm) was recorded in the treatment N₀(Control).
This might be due to the nitrogen which helped in improving the protein synthesis, more metabolic transport, increased photosynthesis and cell multiplication and results in production of flowers having maximum weight, flower diameter, flower disc diameter and number of petals flower\(^{-1}\). These findings are in close conformity with the results of Dhaked et al. (2013)\(^{[3]}\), who reported that the maximum flower diameter, weight of single flower were obtained under higher dose of nitrogen (100 kg N/ha). However, Singh A. K. (2006)\(^{[9]}\) revealed that, 60 kg N/ha produced maximum number of petals flower\(^{-1}\) in Rose.

**Interaction effect**

**Yield Parameters**

Data presented in the Table 2 revealed that, the interaction effect due to biofertilizers and nitrogen levels on flower yield was found significant. The maximum flower yield plant\(^{-1}\) (320.34 g) was recorded in the treatment combination of B\(_1\)N\(_3\) (Azotobacter and 100 kg N ha\(^{-1}\)) which was at par with treatments B\(_2\)N\(_3\), B\(_3\)N\(_3\) and B\(_4\)N\(_3\) (305.02 g, 299.46 g and 288.88 g) i.e. Azospirillum and 100 kg N ha\(^{-1}\), Azotobacter and 75 kg N ha\(^{-1}\) and Azotobacter and 50 kg N ha\(^{-1}\) respectively. The maximum flower yield plot\(^{1}\) (11.53 kg) was recorded in the treatment combination of B\(_3\)N\(_1\) (Azotobacter and 100 kg N ha\(^{-1}\)) which was at par with treatments B\(_2\)N\(_1\) and B\(_1\)N\(_2\) (10.98 kg and 10.78 kg) i.e. Azospirillum and 100kg N ha\(^{-1}\) and Azotobacter and 75 kg N ha\(^{-1}\) respectively. The maximum flower yield ha\(^{-1}\) (149.46 g) was recorded in the treatment combination of B\(_1\)N\(_3\) (Azotobacter and 100 kg N ha\(^{-1}\)) which was at par with the treatments B\(_2\)N\(_1\), B\(_3\)N\(_2\) and B\(_4\)N\(_1\) (142.33 q, 139.74 q and 134.68 q) i.e. Azospirillum and 100kg N ha\(^{-1}\), Azotobacter and 75 kg N ha\(^{-1}\) and Azotobacter and 50 kg N ha\(^{-1}\) respectively. However, minimum flower yield plant\(^{-1}\) (191.62 g), flower yield plot\(^{1}\) (6.89 kg) and flower yield ha\(^{-1}\) (89.31 q) was recorded in B\(_0\)N\(_0\) (No biofertilizer and 0 kg N ha\(^{-1}\)). This might be due to the role of nitrogen and Azotobacter through atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water, higher photosynthetic activity and enhanced food accumulation which might have resulted in better plant growth and subsequently higher flower yield. However, Singh and Kumar (2016)\(^{[10]}\) noticed that, the plant received treatment of Azotobacter + PSB + 50% N + 50% P + 100% K + FYM recorded, highest flower yield plant\(^{-1}\), maximum flower yield plot\(^{1}\) and maximum flower yield ha\(^{-1}\) in Marigold.

**Quality Parameters**

The interaction effect due to the biofertilizers and nitrogen levels on flower disc diameter and number of petals flower\(^{-1}\) was found non-significant; however, it was significant in respect of weight of flower and diameter of flower (Table 2). The maximum weight of flower (16.87 g) and flower diameter (8.47 cm) which was at par with B\(_2\)N\(_3\), B\(_1\)N\(_2\) and B\(_3\)N\(_1\) (7.43 cm, 7.22 cm and 7.10 cm) i.e. Azospirillum and 100 kg N ha\(^{-1}\), Azotobacter and 75 kg N ha\(^{-1}\) and Azotobacter and 50 kg N ha\(^{-1}\) respectively recorded in the treatment combination of B\(_1\)N\(_3\) (Azotobacter and 100 kg N ha\(^{-1}\)). However, minimum weight of flower (7.22 g) and flower diameter (3.98 cm) was recorded in B\(_0\)N\(_0\) (No biofertilizer and 0 kg N ha\(^{-1}\)). This might be due to combined application of Azotobacter and nitrogen as Azotobacter is a free living bacteria and has specific role in fixing atmospheric N in soil which enhance the soil fertility and nitrogen encourages the formation of new cell, cell division and cell elongation. Kumar et al. (2009) noticed that, diameter of flower and fresh weight of flower were recorded highest under the treatment PSB + Azotobacter + full K + FYM + half N and P in African marigold.

### Table 1: Effect of biofertilizers and nitrogen levels on yield and quality in African marigold

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Flower yield plant(^{-1})(g)</th>
<th>Flower yield plot(^{1})(kg)</th>
<th>Flower yield ha(^{-1})(q)</th>
<th>Weight of flower (g)</th>
<th>Flower diameter (cm)</th>
<th>Flower disc diameter (cm)</th>
<th>Number of petals flower(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor A –Biofertilizers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B(_0) - No biofertilizer</td>
<td>221.95</td>
<td>7.99</td>
<td>103.52</td>
<td>9.90</td>
<td>4.86</td>
<td>0.54</td>
<td>199.97</td>
</tr>
<tr>
<td>B(_1) - Azotobacter</td>
<td>288.22</td>
<td>10.37</td>
<td>134.45</td>
<td>15.23</td>
<td>7.07</td>
<td>0.61</td>
<td>271.67</td>
</tr>
<tr>
<td>B(_2) - Azospirillum</td>
<td>263.07</td>
<td>9.47</td>
<td>122.73</td>
<td>13.19</td>
<td>6.22</td>
<td>0.60</td>
<td>249.99</td>
</tr>
<tr>
<td>S.E (m) ±</td>
<td>4.54</td>
<td>0.13</td>
<td>6.27</td>
<td>0.47</td>
<td>0.20</td>
<td>0.01</td>
<td>7.86</td>
</tr>
<tr>
<td>CD at 5 %</td>
<td>13.17</td>
<td>0.38</td>
<td>18.17</td>
<td>1.37</td>
<td>0.57</td>
<td>0.04</td>
<td>22.79</td>
</tr>
<tr>
<td><strong>Factor B – Nitrogen</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No - 0 nitrogen</td>
<td>220.87</td>
<td>7.95</td>
<td>103.01</td>
<td>11.19</td>
<td>5.47</td>
<td>0.50</td>
<td>220.17</td>
</tr>
<tr>
<td>N(_1) - 50 kg ha(^{-1})</td>
<td>255.06</td>
<td>9.18</td>
<td>118.95</td>
<td>11.27</td>
<td>5.48</td>
<td>0.61</td>
<td>226.43</td>
</tr>
<tr>
<td>N(_2) - 75 kg ha(^{-1})</td>
<td>271.60</td>
<td>9.77</td>
<td>126.69</td>
<td>13.96</td>
<td>6.44</td>
<td>0.58</td>
<td>251.03</td>
</tr>
<tr>
<td>N(_3) - 100 kg ha(^{-1})</td>
<td>278.75</td>
<td>10.03</td>
<td>130.06</td>
<td>14.02</td>
<td>6.78</td>
<td>0.64</td>
<td>260.87</td>
</tr>
<tr>
<td>N(_4) - 125 kg ha(^{-1})</td>
<td>262.46</td>
<td>9.45</td>
<td>122.45</td>
<td>13.42</td>
<td>6.07</td>
<td>0.57</td>
<td>244.21</td>
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<tr>
<td>S.E (m) ±</td>
<td>5.87</td>
<td>0.17</td>
<td>2.95</td>
<td>0.61</td>
<td>0.25</td>
<td>0.01</td>
<td>10.15</td>
</tr>
<tr>
<td>CD at 5 %</td>
<td>17.00</td>
<td>0.49</td>
<td>8.56</td>
<td>1.78</td>
<td>0.74</td>
<td>0.05</td>
<td>29.42</td>
</tr>
</tbody>
</table>

**Interaction effect (A x B)**

| S.E (m) ± | 12.45 | 0.36 | 6.27 | 1.30 | 0.54 | 0.03 | 21.54 |
| CD at 5 % | 36.07 | 1.04 | 18.17 | 3.77 | 1.58 | - | - |
Table 2: Interaction effect of biofertilizers and nitrogen levels on yield and quality in African marigold

<table>
<thead>
<tr>
<th>Treatment combinations</th>
<th>Flower yield plant⁻¹ (g)</th>
<th>Flower yield plot⁻¹ (g)</th>
<th>Flower yield ha⁻¹ (g)</th>
<th>Weight of flower (g)</th>
<th>Flower diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B₀N₀</td>
<td>191.62</td>
<td>6.89</td>
<td>89.31</td>
<td>7.22</td>
<td>3.98</td>
</tr>
<tr>
<td>B₀N₁</td>
<td>220.66</td>
<td>7.94</td>
<td>102.92</td>
<td>10.09</td>
<td>5.07</td>
</tr>
<tr>
<td>B₀N₂</td>
<td>235.73</td>
<td>8.48</td>
<td>109.92</td>
<td>11.23</td>
<td>5.33</td>
</tr>
<tr>
<td>B₀N₃</td>
<td>210.89</td>
<td>7.59</td>
<td>98.38</td>
<td>9.35</td>
<td>4.45</td>
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<tr>
<td>B₁N₀</td>
<td>250.85</td>
<td>9.03</td>
<td>117.05</td>
<td>11.61</td>
<td>5.47</td>
</tr>
<tr>
<td>B₁N₁</td>
<td>270.89</td>
<td>9.75</td>
<td>126.38</td>
<td>14.33</td>
<td>6.33</td>
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<tr>
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<td>288.88</td>
<td>10.39</td>
<td>134.68</td>
<td>15.30</td>
<td>7.10</td>
</tr>
<tr>
<td>B₁N₃</td>
<td>299.46</td>
<td>10.78</td>
<td>139.74</td>
<td>15.52</td>
<td>7.22</td>
</tr>
<tr>
<td>B₂N₀</td>
<td>320.34</td>
<td>11.53</td>
<td>149.46</td>
<td>16.87</td>
<td>8.47</td>
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<tr>
<td>B₂N₁</td>
<td>261.52</td>
<td>9.41</td>
<td>121.98</td>
<td>14.10</td>
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<tr>
<td>B₂N₂</td>
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<td>10.06</td>
<td>130.40</td>
<td>15.12</td>
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<td>B₂N₃</td>
<td>305.02</td>
<td>10.98</td>
<td>142.33</td>
<td>15.85</td>
<td>7.43</td>
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<tr>
<td>B₃N₀</td>
<td>275.02</td>
<td>9.90</td>
<td>128.33</td>
<td>14.56</td>
<td>6.54</td>
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<tr>
<td>S.E (m) ±</td>
<td>36.07</td>
<td>1.04</td>
<td>18.17</td>
<td>3.77</td>
<td>1.58</td>
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</table>

References