Growth, development, physiological growth parameters and yield of grain amaranth as influenced by integrated nitrogen management under south Gujarat condition

Rameti Jangir, JD Thanki, Kranti B Patil and Sunil Kumar

Abstract

A field experiment was conducted at College Farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari during rabi seasons of 2016-17 and 2017-18. There were six treatments applied to grain amaranth. Significantly higher dry matter accumulation and straw yield were recorded under treatment T1 (100% RDN through inorganic fertilizer) and being at par with treatment T2 (75% RDN through chemical fertilizer + 25% through BC) and T3 (75% RDN through chemical fertilizer + 25% through FYM). Whereas, significantly higher grain yield was recorded under the treatment of 75% RDN through chemical fertilizer + 25% through BC (T4) and which remained at par with application of 100% RDN through inorganic fertilizer (T1) and 75% RDN through chemical fertilizer + 25% through FYM in pooled analysis. Thus, integration of organic manure and inorganic fertilizer have higher yield potential and performed better as compared to inorganic fertilizer treatment as well as the treatment which receiving organic manure only.

Keywords: Grain amaranth, recommended dose of nitrogen (RDN), Leaf weight ratio (LWR), Crop growth rate (CGR), Net assimilation rate (NAR), Dry matter accumulation (DMA)

Introduction

Although, in the absence of organic manure the soil productivity declines, probably result of deficiencies of secondary nutrients and micronutrients. On the other hand, use of organic manures alone suffers from drawback of low content of nutrients and its slow release characteristics, high transportation costs and limited availability in agricultural regions have prevented their widespread use. Therefore, neither organic manures nor chemical fertilizers alone can help in achieving sustainable yield production under highly intensive farming when nutrient turn over in soil plant system is much larger. Keeping in mind these all issues related to crop production, increasingly greater emphasis is now being given to the integrated nutrient management (INM) system, which plays an important role in sustaining soil health and crop production. Organic manures such as farm yard manure (FYM) and biocompost play a direct role in supplying macro-nutrients. It is a well known fact that residual effects of organic manures enhance microbial activity in soil and increase soil biomass. Nitrogen availability to crop is one of the big limiting factors in the productivity of crop and increase in the use of nitrogen fertilizers for enhancing the agricultural production has been under consideration. For economic and environmental reasons, nitrogen fertilizers should be utilized more efficiently as much as possible in crop production. So, considering the nitrogen deficiency in soils, due to increase in cropping intensity and addition of high yielding crop varieties, there is a need to supplement part of nitrogen requirement of crops through organic manures.

Amaranthus or pigweed belongs to the family Amaranthaceae. It is originated from Central and South America (Grubben and Von Sloten 1981) [4]. Grain amaranth commonly called as Chaulai, Bhuabhi, Ganhar, Harave, Keere, Maursu, Marsha, Pung-keerai, Rajakeeru, Sawai, Sih or Ram Dana. However, in parts of Maharashtra and Gujarat, it is known as Rajgirah "King seed". Recently, an increased interest in amaranth appeared in the 1980s, when the United States National Academy of Science performed research on the grain and described its high nutritional value and agronomic potential. At present, India is the largest exported of amaranth seeds. India has the most favourable climate for the growth of amaranth as the crop responds well to high sunlight and warm temperature.

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In the year 2015-16 India exported amaranth seeds worth USD 1,138,974. India export near to 70% of amaranth every year of the total exports made out of India. Amananth is a quick growing multipurpose crop. Grain amaranth produces significant edible cereals grain but known as “pseudo-cereals” to distinguish it from other cereal producing crops. It is the richest source of protein (16%) and amino acids like lysine (5%), cystine (2.9%), methionine (4.4%) and tryptophan (1.4%) in comparison to the cereal crops viz., barley, maize, rice and wheat. Compared to staple food crops, the grain amaranth is early maturing (less than three months), can be grown several times a year and tolerates drought, heat stress, high soil acidity and salinity. Besides amaranth also attribute more efficient C₄ metabolic pathways and low input requirements. Grain amaranth has potential for increased production due to fewer requirements of inputs and its adaptation to a wide range of agro-ecological zones.

Material and Methods
The field experiment was conducted at College Farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari during rabi seasons of 2016-17 and 2017-18. The soil of the experimental field was clayey in texture and low in organic carbon (0.39%), available nitrogen (200.70 kg/ha), moderately high in available phosphorus (37.79 kg/ha), very high in available potassium (311.70 kg/ha) and slightly alkaline in reaction (pH 8.1) with normal electrical conductivity (0.145 dS/m). The field experiment consisted of integrated nitrogen management viz., T₁ - 100% RDN through inorganic fertilizer, T₂ - 75% RDN through chemical fertilizer + 25% through FYM, T₃ - 75% RDN through chemical fertilizer + 25% through BC, T₄ - 50% RDN through chemical fertilizer + 50% through FYM, T₅ - 50% RDN through chemical fertilizer + 50% through BC and T₆ - 50% RDN through FYM + 50% through BC to grain amaranth in rabi season and replicated four times in randomized block design. Recommended dose of fertilization (RDF) for grain amaranth is 60 N + 40 P₂O₅ + 00 K₂O kg/ha. Grain amaranth cv. GA 2 was sown with spacing of 30 cm x 10 cm in November and harvested in March during both the years. The grain amaranth crop was fertilized as per treatments. The nitrogen was applied through FYM, bio compost and urea whereas phosphorus was applied through single superphosphate. The 50% dose of fertilizer nitrogen and full dose of phosphorus were applied at the time of sowing and remaining 50% dose of fertilizer nitrogen was applied at 30 days after sowing. In case of phosphorus fertilizer, the quantity of phosphorus from FYM and bio compost was counted and deducted from the quantity of recommended dose of phosphorus and remaining phosphorus was applied in the form of SSP. FYM and bio compost was applied as per treatment before sowing and mixed well in soil. The seed of grain amaranth variety GA 2 was treated with biofertilizer Azotobacter @ 200 ml, suspended in 400 ml water and used for inoculating 10 kg seed.

Dry matter accumulation per plant were recorded from three plant selected from border area, while net plot yield was converted into hectare basis. Leaf weight ratio is the ratio of mass of leaf to total dry mass of plant. It is a measure of allocation of leaf biomass. The following formula was used to get leaf weight ratio.

\[
LWR = \frac{\text{Mass of leaf (g/plant)}}{\text{Total mass of plant (g/plant)}}
\]

Crop growth rate (g m⁻² d⁻¹)
Crop growth rate (CGR) was calculated by using the formula given by Watson (1952) [8].

\[
CGR = \frac{W_2 - W_1}{(t_2 - t_1) S}
\]

Where, \(W_1\) and \(W_2\) were the dry weights of aerial plant parts/unit land area at times \(t_1\) and \(t_2\) respectively and \(S\) was land area (m²) over which dry matter was recorded.

Net assimilation rate
It is the rate of increase in the dry matter per unit leaf area per unit time and expressed as g per m² per day. It was calculated by the formula as suggested by Gregory (1926) [9].

\[
NAR= \frac{(\log L_2 - \log L_1) (W_2 - W_1)}{(t_2 - t_1) (L_2 - L_1)}
\]

Where, \(\log\) - logarithm to the base ‘e’ (Naperian constant), \(W_1\) and \(L_1\) - dry matter and leaf area of plant at time ‘\(t_1\)’ and \(W_2\) and \(L_2\) - dry matter and leaf area of plant at time ‘\(t_2\)’.

Pooled analysis of the grain amaranth analyzed for two years was worked out as per the method described by Panse and Sukhatme (1967) [10].

Result and Discussion
Effect on growth and physiological growth parameters
Data presented in Table 1 indicated that the dry matter production increased with the advancement in the age of the crop till harvest. The rate of increase was more pronounced during 40 to 60 DAS and then after slightly increased till at harvest. Dry matter accumulation was significantly influenced by different treatments tried in the experiment at all the stages of crop growth except at 20 DAS. Significantly higher dry matter accumulation at 40, 60 DAS and at harvest was recorded under treatment T₁ (100% RDN through inorganic fertilizer) and being at par with treatment T₃ (75% RDN through chemical fertilizer + 25% through BC) and T₂ (75% RDN through chemical fertilizer + 25% through FYM) except during pooled analysis at 40 DAS, where it was found at par with treatment T₁ only. This might be due to well known fact that application of nitrogen has accelerated the synthesis of chlorophyll and amino acids which associated with major photosynthetic process of plants. Availability of more photosynthates resulted in higher plant height, stem girth, leaf area and ultimately higher dry matter accumulation. Such improvement in dry matter accumulation was also reported by Olofinyoye et al. (2015) [11]. In case of combination of organic and inorganic fertilizers provide slow, consistent and better availability of nutrients resulted in higher dry matter accumulation was also reported by Akanbi and Togun (2002) [12] as well as Gunjal (2011) [13].

Leaf weight ratio (LWR) of grain amaranth was found non significant due to effect of various INM treatments at course of investigation during both the years as well as in pooled analysis. Significantly higher crop growth rate between 20 to 40 DAS was recorded with application of 100% RDN through inorganic fertilizer (T₁) and remained at par with T₃ (75% RDN through chemical fertilizer + 25% through BC). Crop growth rate between 40 to 60 DAS and 60 DAS to harvest was observed significantly higher with application of 75%
RDN through chemical fertilizer + 25% through BC (T₃) and it remained at par with treatment 75% RDN through chemical fertilizer + 25% through FYM (T₂) and 100% RDN through inorganic fertilizer (T₁). The probably reason for high crop growth rate is due to increased leaf area and leaf area index (LAI) in these treatments, where in availability of more photosynthates for longer periods resulted in higher dry matter accumulation (DMA) per plant per unit time and ultimately more crop growth rate. Therefore CGR has similar trend with LAI and DMA. Similarly, this findings tally with that of Ainika et al. (2011) [1] as well as Gunjal (2011) [3] and reported that high crop growth rate obtained with judicious and balanced nitrogen combined with organic matter amendment.

The analyzed pooled data revealed that different treatments did not exert any significant effect on net assimilation rate between 20 to 40 DAS and 60 DAS to harvest in pooled analysis. However, significantly higher net assimilation rate between 40 to 60 DAS was registered with application of 50% RDN through chemical fertilizer + 50% through FYM (T₄) and remained at par with treatment 50% RDN through FYM + 50% through BC (T₅). The mean values of NAR were 25.65, 25.38 and 25.52 g m⁻² d⁻¹ between 20 to 40 DAS, 7.48, 7.10 and 7.29 g m⁻² d⁻¹ between 40 to 60 DAS and 1.11, 1.10 and 1.10 g m⁻² d⁻¹ between 60 DAS to harvest, indicating decreasing trend of net assimilation rate. It was obviously due to that NAR values decrease with advancement of crop growth due to mutual shading of leaves and reduced photosynthetic efficiency of older leaves. These findings are in conformity with results of Gunjal (2011) [5].

Effect on developmental parameters
Application of 100% RDN through inorganic fertilizer (T₁) took significantly more number of days to attain 50% flowering as compared to other treatments and which was found at par with treatment T₃ (75% RDN through chemical fertilizer + 25% through BC), T₂ (75% RDN through chemical fertilizer + 25% through FYM) and T₃ (50% RDN through chemical fertilizer + 50% through BC) in pooled analysis, while in case of days to maturity it remained at par with treatments T₁ (75% RDN through chemical fertilizer + 25% through BC) and T₂ (75% RDN through chemical fertilizer + 25% through FYM). Due to excessive vegetative growth might have resulted in delayed flowering and maturity of crop. Whereas, application of 50% RDN through FYM + 50% through BC (T₅) registered significantly lesser number of days to 50% flowering as well as days to maturity on the basis of mean pooled data. Use of purely organic manures can speed up flowering and maturity of crop. This favourable influence saves the energy required to dry grain to appropriate moisture levels and permits an earlier harvest. These results are also in agreement with earlier studies of Gunjal (2011) [5].

Effect on yield of grain amaranth
The treatment which receiving 75% RDN through chemical fertilizer + 25% through BC (T₃) recorded significantly higher grain yield and which remained at par with application of 100% RDN through inorganic fertilizer (T₁) and 75% RDN through chemical fertilizer + 25% through FYM (T₂) in pooled analysis. Grain yield, the ultimate result of various interacting growth factors interdependence of growth, development (days to 50% flowering and maturity) and yield contributing characters increased consistently and significantly with combined application nitrogen through organic and inorganic fertilizer. It may also be due to adequate availability of major nutrients which are required in larger quantity thus directly help the plants to register higher yield. The results were in agreement with the findings of Parmar and Patel (2009) [8], Gunjal (2011) [3] as well as Olofintoye et al. (2015) [6].

Unlike grain yield, significantly higher straw yield was recorded with the application of 100% RDN through inorganic fertilizer (T₁) and remained at par with application of 75% RDN through chemical fertilizer + 25% through BC (T₃) and 75% RDN through chemical fertilizer + 25% through FYM (T₂) in pooled analysis. These results are in close conformity with Parmar and Patel (2009) [8] as well as Olofintoye et al. (2015) [6]. Application of N through chemical fertilizer enhanced the straw yield significantly as organic N sources which might be attributed due to quicker conversion of N available to grain amaranth plants easily as compared to organic sources which release most of N after mineralization. Owing to their addition NPK through organics i.e. FYM and bio-compost and inorganic fertilizers increased the release of nutrients from the native sources in soil due to high biological activity in soil and also improve soil physical condition which ultimately increased straw yield of grain amaranth.

Table 1: Mean dry matter accumulation/plant (g), leaf weight ratio and crop growth rate of grain amaranth as affected periodically by different treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dry matter accumulation/plant (g) 20 DAS 40 DAS 60 DAS</th>
<th>Leaf weight ratio (LWR) 20 DAS 40 DAS 60 DAS</th>
<th>Crop growth rate (CGR g m⁻² d⁻¹) 20-40 DAS 40-60 DAS 60-at harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ 100% RDN through inorganic fertilizer</td>
<td>3.01 27.76 42.30 50.90</td>
<td>0.121 0.169 0.157 0.079</td>
<td>41.26 24.23 6.22</td>
</tr>
<tr>
<td>T₂ 75% RDN through chemical fertilizer + 25% through BC</td>
<td>2.97 24.30 39.55 47.67</td>
<td>0.122 0.168 0.155 0.075</td>
<td>35.54 25.43 5.83</td>
</tr>
<tr>
<td>T₃ 50% RDN through chemical fertilizer + 50% through BC</td>
<td>3.46 25.72 41.20 48.97</td>
<td>0.109 0.169 0.155 0.081</td>
<td>37.10 25.81 5.63</td>
</tr>
<tr>
<td>T₄ 25% RDN through chemical fertilizer + 75% through BC</td>
<td>2.83 22.82 36.34 42.29</td>
<td>0.119 0.159 0.141 0.076</td>
<td>33.31 22.54 4.31</td>
</tr>
<tr>
<td>T₅ 50% RDN through chemical fertilizer + 50% through FYM</td>
<td>2.89 23.84 36.98 42.85</td>
<td>0.119 0.157 0.152 0.081</td>
<td>34.91 21.90 4.25</td>
</tr>
<tr>
<td>T₆ 75% RDN through chemical fertilizer + 25% through FYM</td>
<td>2.87 21.64 33.25 37.99</td>
<td>0.112 0.155 0.140 0.077</td>
<td>31.29 19.36 3.44</td>
</tr>
<tr>
<td>S.Em+</td>
<td>0.13 0.89 0.99 1.14</td>
<td>0.006 0.010 0.007 0.003</td>
<td>1.49 0.63 0.24</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>NS 2.56 2.86 3.28</td>
<td>NS NS NS NS</td>
<td>4.30 1.83 0.69</td>
</tr>
<tr>
<td>CV (%)</td>
<td>12.46 10.31 7.32 7.12</td>
<td>14.66 16.92 12.77 11.15</td>
<td>11.83 7.71 13.64</td>
</tr>
<tr>
<td>General mean</td>
<td>3.00 24.35 38.27 45.11</td>
<td>0.117 0.163 0.150 0.078</td>
<td>35.57 23.21 4.94</td>
</tr>
</tbody>
</table>

T₁: 100% RDN through inorganic fertilizer, T₂: 75% RDN through chemical fertilizer + 25% through FYM, T₃: 75% RDN through chemical fertilizer + 25% through BC, T₄: 50% RDN through chemical fertilizer + 50% through BC, T₅: 50% RDN through chemical fertilizer + 50% through BC and T₆: 50% RDN through FYM + 50% through BC.
Table 2: Net assimilation rate, days to 50% flowering, days to maturity, seed and straw yields of grain amaranth as affected periodically by different treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Net assimilation rate (NAR g m (^{-2}) d (^{-1}))</th>
<th>Days to 50% flowering</th>
<th>Days to maturity</th>
<th>Grain yield (kg/ha)</th>
<th>Straw yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20-40 DAS</td>
<td>40-60 DAS</td>
<td>60-at harvest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (_1)</td>
<td>23.75</td>
<td>5.63</td>
<td>1.11</td>
<td>57.38</td>
<td>102.60</td>
</tr>
<tr>
<td>T (_2)</td>
<td>25.12</td>
<td>7.41</td>
<td>1.25</td>
<td>54.88</td>
<td>97.40</td>
</tr>
<tr>
<td>T (_3)</td>
<td>24.83</td>
<td>6.92</td>
<td>1.11</td>
<td>55.75</td>
<td>93.18</td>
</tr>
<tr>
<td>T (_4)</td>
<td>26.17</td>
<td>8.39</td>
<td>1.14</td>
<td>51.88</td>
<td>94.58</td>
</tr>
<tr>
<td>T (_5)</td>
<td>26.94</td>
<td>7.67</td>
<td>1.05</td>
<td>53.63</td>
<td>94.58</td>
</tr>
<tr>
<td>S. Em+</td>
<td>1.31</td>
<td>0.25</td>
<td>0.06</td>
<td>1.37</td>
<td>2.24</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>NS</td>
<td>0.71</td>
<td>NS</td>
<td>3.96</td>
<td>6.48</td>
</tr>
<tr>
<td>CV (%)</td>
<td>14.50</td>
<td>9.59</td>
<td>15.31</td>
<td>7.27</td>
<td>6.66</td>
</tr>
<tr>
<td>General mean</td>
<td>25.52</td>
<td>7.29</td>
<td>1.10</td>
<td>53.42</td>
<td>95.27</td>
</tr>
</tbody>
</table>

T \(_1\): 100% RDN through inorganic fertilizer, T \(_2\): 75% RDN through chemical fertilizer + 25% through FYM, T \(_3\): 75% RDN through chemical fertilizer + 25% through BC, T \(_4\): 50% RDN through chemical fertilizer + 50% through FYM, T \(_5\): 50% RDN through chemical fertilizer + 50% through BC and T \(_6\): 50% RDN through FYM + 50% through BC.

Fig 1: Mean crop growth rate (g m \(^{-2}\) d \(^{-1}\)) of grain amaranth as influenced periodically by different treatments.

Conclusion
It is, therefore, concluded from the present investigation that the application of 75% RDN through chemical fertilizer + 25% through BC should be applied to achieve higher growth, development and yield of grain amaranth cv. GC 4 under south Gujarat condition.

References