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Evaluation of yield and yield attribute performance of jowar (*Sorghum bicolor*) under different plant densities and nutrient management practices

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Abstract

A field experiment was performed at College Farm, Agricultural College, Aswaraopet, Khammam, Telangana during *maghi* 2023- 2024. The experiment had been designed in split plot design with sixteen treatments, consisting of four plant densities viz., M1- 2.22 lakh plants ha⁻¹ (30 x 15 cm), M2- 2.22 lakh plants ha⁻¹ (45 x 10 cm), M3- 1.48 lakh plants ha⁻¹ (45 x 15 cm) and M4- 1.66 lakh plants ha⁻¹ (60 x 10 cm) as main plots and four nutrient management practices S1- Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha⁻¹ & 57.5 kg P₂O₅ ha⁻¹), S2- 100% RDF (80:60:40), S3- 75% RDN + urea spray @ 2 ml lit⁻¹ at 45 DAS + 100% PK and S4- 75% RDN + Azotobacter + Phosphorous solubilizing bacteria + 100% K as sub plots which replicated thrice. The experimental field soil was sandy loam soils with a pH of 6.9 and EC of 0.1 dS m⁻¹. The experimental soil was medium in organic carbon (0.5%), low in available nitrogen (204.6 kg ha⁻¹), medium in available phosphorous (22.3 kg ha⁻¹) and medium in available potassium (219 kg ha⁻¹). Yield attributes and grain yield were significantly higher in plant densities of 1.48 lakh plants ha⁻¹ (M3- 1798.1 kg ha⁻¹) than 1.66 lakh plants ha⁻¹ (M4- 1669.3 kg ha⁻¹), 2.22 lakh plants ha⁻¹ (M2- 1651.7 kg ha⁻¹) and 2.22 lakh plants ha⁻¹ (M1- 1602.7 kg ha⁻¹). Yield attributes and grain yield were significantly higher in 75% RDN + Azotobacter + Phosphorous solubilizing bacteria + 100% K (S4- 1896 kg ha⁻¹) than 100% RDF (S2- 1876 kg ha⁻¹), 75% RDN + urea spray @ 2 ml lit⁻¹ at 45 DAS + 100% PK (S3- 1776 kg ha⁻¹) and Farmers practice (S1- 1176 kg ha⁻¹).

Keywords: Plant densities, nutrient management practices, biofertilizer, yield, *maghi*

Introduction

Sorghum (*Sorghum bicolor* L.) is cultivated widely in tropical and sub-tropical regions. It is the world's fifth most important cereal crop after rice, wheat, maize and barley, as it is rich in nutrients like iron, magnesium, and copper. It is the king of millets, staple diet for more than 500 million people globally in about 30 countries. India ranks fifth in production after USA, Nigeria, Mexico and Ethiopia. In India, it is grown in an area of 4.24 m ha with a production of 4.78 million tonnes and productivity of 1128 kg ha⁻¹. Maharashtra accounts about 36.85% of the total production and it is the leading producer in India followed by Karnataka (18.43%), Rajasthan (12.35%), Tamil Nadu (9.41%) and Andhra Pradesh (7.70%). In Telangana, it is cultivated in an area of 0.10 m ha⁻¹ with a production of 0.19 million tonnes and productivity of plays an important role on growth, development and yield of crops. Improper spacing reduces the yield but optimum spacing ensures plants to grow properly making better utilization of sunlight and nutrients. Hence, maintenance of an optimum level of jowar plant population in the field is necessary to maximize the grain yields. The worthwhile production of sorghum depends on the balanced inputs application. Imbalanced fertilization to crops not only leads to low crop yields but also decreases soil quality (Jat *et al.*, 2018) [7]. There is a need to develop more efficient, economic and integrated system of nutrient management. To sustain the soil health and to attain the production potential of crops, a complementary usage of chemical fertilizers, organic manures and bio fertilizers is important (Deshmukh *et al.*, 2014) [3].

Use of biofertilizers like *Azotobacter* and PSB in sorghum crop not only fixes the atmospheric nitrogen but also solubilizes the insoluble form of nutrients in soil. Thus improves the fertilizer

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use efficiency and improves germination, vigor in seedling and yield in sorghum crop. India is a large country with a myriad of ecological environments. Scant research exists on the interaction of plant density and balanced nutrient management. However, for better understanding, the evaluation of different plant density of sorghum in relation with nutrient management would lead to selection of the most adoptable spacing under various nutrient management practices.

Materials and Methods

The field experiment was conducted during *maghi*, 2023-24 at College Farm, Agricultural College, Aswaraopet, Bhadradi Kothagudem District, Professor Jayashankar Telangana Agricultural University situated at an altitude of 162 m above mean sea level at 17°24'54" N latitude and 81°10'34" E longitude (Fig. 3.1) which is located in the Central Telangana Agro climatic Zone in Telangana State. The primary objective of the study was to identify suitable plant densities and nutrient management practices, assess nutrient uptake, and evaluate the cost-effectiveness of various treatment combinations. The crop growing period was from 2nd October 2023 to 12th January 2024. The experimental field soil was sandy loam in texture, non-saline condition, neutral in reaction, medium in organic carbon, low in available nitrogen, medium in available phosphorus and medium in available potassium. The experiment had been designed in split plot design with sixteen treatments, consisting of four plant densities viz., M1- 2.22 lakh plants ha⁻¹ (30 x 15 cm), M2- 2.22 lakh plants ha⁻¹ (45 x 10 cm), M3- 1.48 lakh plants ha⁻¹ (45 x 15 cm) and M4- 1.66 lakh plants ha⁻¹ (60 x 10 cm) as main plots and four nutrient management practices S1- Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha⁻¹ & 57.5 kg P ha⁻¹), S2- 100% RDF, S3- 75% RDN + urea spray @ 2 ml lit-1 at 45 DAS + 100% PK and S4- 75% RDNP + Azotobacter + Phosphorous solubilizing bacteria + 100% K as sub plots which replicated thrice. The recommended dose of fertilizer was 80, 60 and 40 kg N, P₂O₅ and K₂O ha⁻¹, which were given to the field in the form of urea, DAP and MOP. A dose of urea @ 2 ml lit-1 P₂O₅ ha⁻¹ was applied for the treatment S3.

Results and Discussion: Yield attributes

Number of grains per ear head

Number of grains per ear head of sorghum (PYPS-2) was significantly influenced by plant densities and different integrated nutrient management practices, whereas, their interaction was statistically non-significant.

The plant density of 1,48,148 plants ha⁻¹ (M3- 45 x 15 cm) recorded the highest number of grains per ear head (935) which is significantly on par with the plant densities of 1,66,666 plants ha⁻¹ (M4- 60 x 10 cm) and followed by 2,22,222 plants ha⁻¹ (M2- 45 x 10 cm). The least number of grains per ear head (735) was recorded with the plant density of 2,22,222 plants ha⁻¹ (M1- 30 x 15 cm). This could be due to more competition between plants for nutrients and space at closer spacing. Number of grains per ear head decreased as plant density increased due to intra and inter plant competition for nutrients. Similar result was obtained with Abuzar *et al.* (2011)^[1].

Among the different nutrient management practices, maximum number of grains per ear head (981) was recorded in the treatment 75% RDNP + Azotobacter + Phosphorous solubilizing bacteria + 100% K (S4) was significantly on par with the treatments 100% RDF (S2) and 75% RDN + urea spray @ 2 ml lit-1 at 45 DAS + 100% PK (S3). The least number of grains per ear head (549) recorded with the treatment S1- Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha⁻¹ & 57.5 kg P ha⁻¹). This might be

due to azotobacter and PSB inoculation resulted in better availability of macro nutrients to the plants and better translocation from source to sink and finally lead to more number of grains per ear head. The least number of grains per ear head observed in Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha⁻¹ & 57.5 kg P ha⁻¹) was likely due to the application of fertilizers only at the basal stage, leading to nutrient unavailability during the critical grain filling stage, which adversely affected the plants. This results closely align with the findings of Reddy *et al.* (2018)^[10].

Girth of the ear head

Girth of the ear head of sorghum (PYPS-2) was significantly influenced by plant densities and different integrated nutrient management practices. The effects of interaction on girth of the ear head were found to be statistically non-significant.

The treatment with the plant density of 1,48,148 plants ha⁻¹ (M3- 45 x 15 cm) recorded the thicker ear head (17.1), which is significantly on par with the plant density of 1,66,666 plants ha⁻¹ (M4- 60 x 10 cm) and followed by 2,22,222 plants ha⁻¹ (M2- 45 x 10 cm). The thinner ear head (14.7) was recorded with the plant density of 2,22,222 plants ha⁻¹ (M1- 30 x 15 cm). This results closely align with the findings of Ijoyah *et al.* (2015)^[5].

Among the different nutrient management practices, thicker ear head (18.3) was observed with the treatment S4- 75% RDNP + Azotobacter + Phosphorous solubilizing bacteria + 100% K, which was significantly superior over the treatments S2- 100% RDF and S3- 75% RDN + urea spray @ 2 ml lit-1 at 45 DAS + 100% PK. The thinner ear head (11.1) was recorded with the treatment S1- Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha⁻¹ & 57.5 kg P ha⁻¹).

Ear head length

The ear head length of sorghum was significantly influenced by plant densities and different integrated nutrient management practices. The effects of interaction on ear head length were found to be statistically non-significant.

In respect of the main plot treatments, significantly higher ear head length (29.2) was recorded with the plant density of 1,48,148 plants ha⁻¹ (M3- 45 x 15 cm) and followed by 1,66,666 plants ha⁻¹ (M4- 60 x 10 cm) and 2,22,222 plants ha⁻¹ (M2- 45 x 10 cm). The plant density of 2,22,222 plants ha⁻¹ (M1- 30 x 15 cm) resulted in the shortest panicle length (23.6), likely because the plants had sufficient space, nutrients, and moisture, leading to reduced competition and enhanced growth, a finding that aligns with the results of Isah *et al.* (2017)^[6].

Among the different nutrient management practices, the treatment S4- 75% RDNP + Azotobacter + Phosphorous solubilizing bacteria + 100% K recorded the longest ear head length (28.9), which was significantly on par with the treatments S2- 100% RDF and S3- 75% RDN + urea spray @ 2 ml lit-1 at 45 DAS + 100% PK. The lowest ear head length (19.8) was recorded with the treatment S1- Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha⁻¹ & 57.5 kg P ha⁻¹). The present results closely align with the findings of Thumar *et al.* (2016)^[14].

Ear head grains weight

The ear head grains weight of sorghum was varied significantly based on the plant densities and different integrated nutrient management practices, although the interaction effect between these factors was not statistically significant.

Sorghum planted with density of 1,48,148 plants ha⁻¹ (M3- 45 x 15 cm) recorded higher ear head grains weight (20.8), which is significantly superior over the plant densities of 1,66,666 plants

ha⁻¹ (M4- 60 x 10 cm) and 2,22,222 plants ha⁻¹ (M2- 45 x 10 cm). The lowest ear head grains weight (15.2) was recorded with the plant density of 2,22,222 plants ha⁻¹ (M1- 30 x 15 cm). This might be due to adequate spacing provides favourable microclimate to crop for effective utilization of available moisture, nutrients and its early adoption leads to better partitioning of photosynthates to reproductive parts, there by recording better growth and yield attributes. Tambe and Bhoi (1999)^[13] also reported similar findings.

Among the sub plot treatments, the treatment S4- 75% RDNP + Azotobacter + Phosphorous solubilizing bacteria + 100% K recorded higher ear head grains weight (20.1), which was significantly on par with the treatment S2- 100% RDF (19.1) and followed by S3- 75% RDN + urea spray @ 2 ml lit-1 at 45 DAS + 100% PK (17.8). The lowest ear head grains weight (14.2) was recorded with the treatment S1- Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha⁻¹ & 57.5 kg P ha⁻¹). This was ascribed to increased microbial activity in the rhizosphere with application of azotobacter and PSB resulted in solubilization of bound form of soil minerals and enhanced availability of nutrients in the soil for plant growth and development by the liquid biofertilizers leading to improved yield attributing characters, further better partitioning of photosynthates might resulted in higher grains weight in ear head. The present results closely align with the findings of Khair *et al.* (2019)^[9].

Grain yield

The grain yield (kg ha⁻¹) of sorghum was significantly influenced by plant densities and different nutrient management practices. The effects of interaction on grain yield were found to be statistically non-significant.

The highest grain yield (1798.1) was recorded with the plant

density of 1,48,148 plants ha⁻¹ (M3- 45 x 15 cm), which was significantly superior over the plant densities 1,66,666 plants ha⁻¹ (M4- 60 x 10 cm) and 2,22,222 plants ha⁻¹ (M2- 45 x 10 cm). It showed 7.71%, 8.86% and 12.19% yield advantage over M4- 60 x 10 cm, M2- 45 x 10 cm and M1- 30 x 15 cm treatments respectively. The lowest grain yield (1602.7) was recorded with the plant density of 2,22,222 plants ha⁻¹ (M1- 30 x 15 cm). Narrow plant spacing likely increased competition and stressed the plants, leading to lower grain yields. In contrast, wider crop geometry improved nutrient availability, promoting more robust plant growth, faster leaf initiation and expansion, and a higher rate of photosynthesis. This, in turn, resulted in vigorous plant development. These observations align with the findings of Shashidharaiah *et al.* (2005)^[11].

Significant increase in the grain yield was observed in the treatment S4- 75% RDNP + Azotobacter + Phosphorous solubilizing bacteria + 100% K (1896), which was significantly on par with the treatment S2- 100% RDF (1876) and followed by the treatment S3- 75% RDN + urea spray @ 2 ml lit-1 at 45 DAS + 100% PK (1776). It showed 37.91%, 1.16% and 6.76% yield advantage over the treatments S1- Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha⁻¹ & 57.5 kg P ha⁻¹), S2- 100% RDF and S3- 75% RDN + urea spray @ 2 ml lit-1 at 45 DAS + 100% PK. The lowest grain yield (1176) was observed in the treatment S1- Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha⁻¹ & 57.5 kg P ha⁻¹). Higher plant height, leaf area, dry matter accumulation, grain weight per head was resulted highest grain yield in S4- 75% RDNP + Azotobacter + Phosphorous solubilizing bacteria + 100% K treatment. This results closely align with the findings of Shinde *et al.* (2010)^[12], Jat *et al.* (2013)^[8] and Dwivedi *et al.* (2016)^[4].

Table 1: Yield attributes and grain yield of sorghum as influenced by different plant densities and nutrient management practices

Treatments	No. of grains per ear head	Girth of the ear head (cm)	Length of the ear head (cm)	Ear head grains weight (g)	Grain yield (kg ha ⁻¹)
Main plots: Plant densities					
M1- 30 x 15 cm (2,22,222 plants ha ⁻¹)	735	14.7	23.59	15.2	1602.7
M2- 45 x 10 cm (2,22,222 plants ha ⁻¹)	752	15.1	24.4	15.9	1651.7
M3- 45 x 15 cm (1,48,148 plants ha ⁻¹)	935	17.1	29.19	20.8	1798.1
M4- 60 x 10 cm (1,66,666 plants ha ⁻¹)	901	16.7	26.17	19.1	1669.3
S.Em ±	23	0.3	0.71	0.3	34.4
CD (P=0.05)	79.6	1.0	2.45	1.1	119.2
CV (%)	9.6	8.3	9.4	8.1	8.1
Sub plots: Nutrient management practices					
S1- Farmers practice (2.5 bag DAP i.e., 22.5 kg N ha ⁻¹ & 57.5 kg P ha ⁻¹)	549	11.1	19.75	14.2	1176
S2- 100% RDF	963	17.7	27.1	19.1	1876
S3- 75% RDN + urea spray @ 2 ml lit-1 at 45 DAS + 100% PK	830	16.4	27.5	17.8	1776
S4- 75% RDNP + AZT + PSB + 100% K	981	18.4	28.9	20.1	1896
S.Em ±	19.6	0.4	0.66	0.4	40.3
CD (P=0.05)	57.4	1.2	1.94	1.3	117.7
CV (%)	8.2	8.7	8.9	8.6	8.3
Sub (S) at same main (M)					
S.Em±	0.9	39.4	0.8	1.3	80.6
C.D. (P=0.05)	NS	NS	NS	NS	NS
Main (M) at same or different sub (S)					
S.Em±	0.8	41.1	0.7	1.4	77.8
C.D. (P=0.05)	NS	NS	NS	NS	NS

*RDF: - Recommended dose of fertilizer, RDN: - Recommended dose of nitrogen, RDNP: - Recommended dose of nitrogen and phosphorus, AZT: - Azotobacter, PSB: - Phosphorous solubilizing bacteria

Conclusion

It is concluded that for sorghum crop grown during *maghi* season, the plant density 1.48 lakhs ha⁻¹ (M3- 45 x 15 cm) and among the nutrient management practices, application of 75% RDNP + Azotobacter + Phosphorus Solubilizing Bacteria (PSB) + 100% K (S4) proved to be beneficial in terms of yield attributes and yield of the crop.

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