Agronomic and Economic Analysis of Browntop Millet under Varying Sowing Dates and Nitrogen Fertility Levels

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

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ABSTRACT

Aim: The experiment is aimed to identify ideal sowing date and nitrogen level in browntop millet during rainy season on alfisols of Telangana.
Study Design: Randomized Block Design with factorial concept and replicated thrice.
Place and Duration of Study: College Farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana State, India during rainy season, 2019.
Methodology: Browntop millet variety VZM-1 was tested under four dates of sowing *viz.,* D_1- June 15th, D_2- June 30th, D_3-July 15th and D_4 - 30th July and four N levels v*iz*; N_1- 0 kg ha^{-1} N_2 - 20 kg ha^{-1}, N_1- 40 kg ha^{-1} and N_4-60 kg ha^{-1}. The growth parameters, yield attributes, yield, nitrogen uptake at different crop growth stages and monetary returns were studied.
Results: The results indicated that plant height, tillers hill^{-1}, leaf area, dry matter accumulation at all crop intervals and yield attributes viz; effective tillers, panicle length, panicle weight, number of grains, grain, straw yield, N uptake at different crop stages and monetary returns were highest with

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sowing on D_1- June 15th.Among the N levels tested, crop fertilized with 40 kg N ha^{-1} registered higher plant height, tillers $hill^{-1,}$ leaf area, dry matter accumulation at all crop intervals, yield attributes *viz;* effective tillers, panicle length, panicle weight, number of grains, grain, straw yield N uptake at different crop stages and monetary returns.

Conclusion: On alfisols of Telangana during rainy season, sowing of browntop millet on June 15th fertilized with 40 kg N ha^{-1} helps to realize higher yield and monetary returns.

Keywords: Browntop millet; sowing dates; nitrogen levels; growth; yield; nitrogen uptake; monetary returns.

1. INTRODUCTION

With the escalating demographic pressure coupled with the dwindling natural resources one of the biggest challenges faced in agriculture during the 21st century is to meet the growing food demand of the burgeoning population. Cultivated lands under assured irrigation facilities have been exploited and the only alternative to enhance food grain production is to focus on dry lands. These areas are typically characterized by recurring droughts, shallow and degraded soils with low inherent soil fertility and water holding capacity content resulting in poor crop productivity.

Millets are staple food crops traditionally grown in rainfed conditions by the marginal farmers and tribals. They are nutritionally superior to other cereals in terms of high dietary fibers, amino acids, polyphenols and other bioactive compounds [1] and hence, known as nutri-cereals [2]. Millets play important role in lowering the rate of fat absorption, slow release of sugars (low glycemic index) and thus reducing risk of heart disease, diabetes and high blood pressure. They are nutritious, delicious, gluten free and rich in essential nutrients [1]. Millets consist of 11.9 g of moisture, 8.89g of protein, 1.89g of fat, and 71.32 g of carbohydrate and provides 338 kcal of energy. The mineral composition constitutes 28 mg of calcium, 7.72 mg of iron, 276 mg of phosphorus, 60 mg of potassium, 94.5 mg of magnesium, 1.99 mg of manganese, 7.60 mg of sodium, 2.5 mg of zinc, and 1.23 mg of copper [3]. It is a rich source of natural fibre (8.5%) due to which it serves as an excellent medicine for dealing life style diseases. Millets are climate resilient crops and rank high over cereals in terms of high nutritional value and adaptation to varied climatic and soil conditions and play vital role towards nutritional security.

Among the minor millets, browntop millet is a versatile crop remarkable for early maturity and nutritious properties and has huge demand in the recent past. To tackle the threats of malnutrition and hidden hunger, inclusion of these nutrient rich crops in staple diet could be a better nutritional security option [4]. They are well suited to warm and elevated Co_2 conditions and hence, called climate smart crops [5]. Among the small millets, browntop millet (*Brachiaria / Panicum / Urochola ramosa*), is one of the rarest crops commonly known as Dixie signal grass and locally termed as Korale in Kannada and Andukorralu in telugu (Ref IIMR). It grows well in the drylands of Tumkur, Chitradurga and Chikkaballapura districts of Karnataka and Anantapur district of Andhra Pradesh.

This millet is a hardy crop well suited for dry lands (Bhatt et al., 2018). Agronomists have generated wealth of information on efficient use of inputs such as selection of varieties and nutrient management for different millet crops but very meagre information is available with regard to the agronomic practices of brown top millet. Variation in sowing time contributes to variation in plant environment interaction, which determines the efficiency of inherent physiological processes and ultimately the crop yield. Determination of optimum nitrogen level plays an exceptional role in realizing the genetic yield potential of crops under particular geographical conditions. Keeping all this in view the experiment was planned to identify ideal sowing date and nitrogen level for browntop millet in alfisols of Southern Telangana Zone of Telangana. Keeping these points in view the present investigation was carried out at College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad during rainy season, 2019 to find the agronomic response and economics of browntop millet under varying sowing dates and nitrogen levels.

2. MATERIALS AND METHODS

2.1 Characterization of Experimental Site

The field experiment was conducted during rainy season 2019 at the experimental site of College

of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana state, India. The physical properties of the soil comprised of sandy loam texture [Sand (64.2%), Silt (27.3%) and Clay (8.2%)], pH-7.1 (neutral), electrical conductivity (0.31 dSm^{-1}), and low in organic carbon (0.31%). The chemical propertied comprised of low available nitrogen (143.0 kg ha^{-1}), medium available phosphorus (75.0 kg ha^{-1}) and high available potassium (313.0 kg ha^{-1}).

2.2 Treatment, Experimental Design and Trial Management

The experiment consisted of 16 treatment combinations *viz*; four sowing dates (June 15th, June 30th, June 15th and July 30th) and four nitrogen levels (40 kg ha^{-1}, 20 kg ha^{-1}, 40 kg ha^{-1} and 60 kg ha^{-1}). The experiment was laid out in a 4 × 4 factorial arrangement in a randomized block design with three replications. Crop was sown on different sowing windows as per treatments by adopting inter row spacing 30 cm and intra row spacing of 10 cm. The gross plot size and net plot size of the plots were 4.5 m × 3.0 m (15 rows and 30 plants per row) and 3.9 m × 2.8 m (13 rows and 28 plants). Uniform dose of P$_2$O$_5$ (30 kg ha^{-1}) and K$_2$O (20 kg ha^{-1}) along with 50% of nitrogen (as per treatments) was applied as basal and the remaining 50% nitrogen was applied at tillering in all experiment plots except in N$_1$-0 kg N ha^{-1}. Thinning was done 10 days after sowing (DAS) to ensure uniform population. Two hand weeding were done at 20 and 40 DAS to maintain weed free situation for better crop growth and development.

2.3 Data Collection

Weekly mean meteorological data were recorded during the crop growth period (15-06-2019 to 20-10-2019). The weekly mean maximum temperature during the crop growth period ranged from 27.0$^{°}$C to 37.6^{0}C with an average of 32.3^{0}C, while, the weekly mean minimum temperature ranged from 14.8^{0}C to 21.1^{0}C with an average of 17.95^{0}C. The weekly RH ranged from 76 to 98.1%. The weekly mean sunshine hours varied from 1.2 to 10.7 h day^{-1} with an average of 5.95 h day^{-1} and mean evaporation ranged from 2.6 to 9.8 mm day^{-1} with an average of 6.2 mm day^{-1}. The mean wind speed ranged from 0.1 to 6.8 km h^{-1} with an average of 3.45 km h^{-1}. Crop was grown under rainfed condition. A total rainfall of 682.2 mm was distributed in 43 rainy days during the crop growth period.

The data on growth parameters and yield attributes were recorded from the five tagged representative hills selected randomly from each treatment plot. The yield from the net plot (grain and straw) was weighed separately and converted to kg ha^{-1}. The destructive plant samples collected at harvest were shade dried followed by oven drying at 60^{0} C to attain a constant weight. The dry matter samples at tillering, heading stages and at harvest (grain and straw) were finely ground and used for nutrient analysis (N content) based on the standard procedures by [7].

2.4 Data Analysis

The data on crop parameters and nutrient uptake was statistically analyzed duly following the analysis of variance technique for factorial randomized block design as outlined by [6]. The significance among the various treatments was determined using the f-test and the least significant differences (p=0.05). The available nitrogen was determined by Alkaline permanganate method given [7] and nutrient uptake was calculated by the following formula.

Nutrient uptake (kg ha^{-1}) =

$$\frac{\text{Nutrient content (\%) x DMP/ Grain / straw (kg ha}-1)}{100}$$

Gross returns were computed by multiplying the seed yield with prevailing market price during the season of experimentation. The net returns were calculated by deducting the cost of cultivation from gross returns and the B:C ratio was computed by dividing the gross returns with cost of cultivation.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant height, number of tillers, leaf area and dry matter production revealed significant differences among treatments (dates of sowing and nitrogen levels) and sampling regimes (Table.1). However, the interaction effect of sowing dates and nitrogen levels was non- significant for all the growth parameters.

Among the sowing dates, D$_1$- June 15th recorded tallest plants (52.46 - 126.35 cm), highest number of tillers m^{-2} (99.0 - 258.75), largest leaf area (682.50- 530.0 cm^2 plant-^{1}) and highest dry matter accumulation (2842.5 – 5402.5 kg ha^{-1}) at

all sampling regimes compared with D_2 - June 30th, D_3 -July 15th and D_4 -July 30th (Table 1). Improved plant height in pearl millet with early sowing on account of prolonged photoperiod and high photosynthesis and assimilate translocation Contrary to this, lower growth under delayed sowing D_4- July 30th could be attributed to the unfavorable weather variables and dry spells at critical stages that led to reduction in vegetative phase of the browntop millet and reflected in lower photosynthetic area, low tillers and dry matter production. Similar findings in pearl millet were earlier documented by [8].

With regard to nitrogen levels, there was a linear and significant increase in plant height, number of tillers, leaf area and dry matter production with an increase in nitrogen application from N_1-0 kg ha^{-1} to N_4- 60 kg ha^{-1} but, N_4-60 kg ha^{-1} was equally superior to N_3- 40 kg ha^{-1} and recorded statistically comparable plant height, number of tillers, leaf area and dry matter production at all the intervals as evident from the data (Table 1). Improved growth parameters recorded with the application of 40 kg N ha^{-1} was due to adequate supply of nutrients coupled with higher crop nutrient uptake that enhanced cell division, elongation, assimilatory surface and reflected in improved tiller number and dry matter production over corresponding lower levels of nitrogen application [9].

3.2 Yield attributes

From the data on yield attributes (Table1) it could be inferred that there were significant differences across sowing dates and N levels. However, the interaction effect of sowing dates and nitrogen levels was non- significant on yield attributes.

With respect to dates of sowing, D_1- June 15th registered significantly higher yield attributes *viz*; number of effective tillers m^{-2} (217.1), panicle length (17.82 cm), panicle weight (2.13 g) and number of grains per panicle (147.92) as compared to D_2 - June 30th, D_3 -July 15th and D_4 - July 30th. Early sown crop had opportunity for longer growth period and it exposed to ambient weather parameters (sufficient light and temperature) that favored towards higher assimilate synthesis and translocation to sink. While delayed sowing significantly reduced the yield attributes due to inadequate vegetative growth and curtailed growing season, coupled with critical dry spells and forced maturity [10].

Among the nitrogen levels tested, Crop fertilized with N_3- 40 kg ha^{-1} registered higher yield attributes *viz*; number of effective tillers m^{-2} (205.1), panicle length (17.58 cm), panicle weight (1.86 g) and number of grains per panicle (147.0) over N_2- 0 kg ha^{-1}, N_1- 0 kg ha-^{1}. However, N_3 and N_4 -40 kg ha^{-1} were statistically comparable with each other in terms of the yield attributes. Improved yield attributes associated with crop fertilized with 40 kg ha^{-1} could be ascribed to the adequate nitrogen availability that facilitated the crop to grow luxuriantly and put forth higher assimilatory surface and dry matter partitioning and better translocation to sink, thus leading to higher number of grains per panicle and large sized grains [11].

3.3 Yield

Seed and straw yield varied significantly among sowing dates and nitrogen levels but the interaction was found to be non- significant (Table 2).

Early sown crop on D_1- June 15th registered significantly higher grain and straw yield (2003 and 3930 kg ha^{-1}) over rest of the dates of sowing viz; D_2- June 30th (1837 kg ha^{-1}), D_3-July 15th (1737 and 3764 kg ha^{-1}) and the lowest grain yield (1539 and 3466 kg ha^{-1}) was observed with D_4-July 30th. The deviation in yield was to the tune of 8.28, 13.23 and 23.11 % respectively over earliest sowing window D_1- June 15th

Among the N levels, crop applied with N_3-40 kg ha^{-1}(1855 kg ha^{-1}) registered significantly higher seed yield over N_2-20 kg ha^{-1} (1773 kg ha^{-1}) and control- 0 kg N ha^{-1} (1569 kg ha^{-1}). The treatments N_3 was at par with N_4-60 kg ha^{-1} (1921 kg ha^{-1}). The improvement in yield with 20 and 40 kg N ha^{-1} was to an extent of 13.00 and 18.22%, respectively over N_1- 0 kg N ha^{-1}.

Yield is the function of growth parameters and yield attributes. Early sown crop was exposed to favorable weather parameters (cardinal temperatures, sunshine hours and relative humidity) that helped to express full potential through higher assimilates translocation towards and adequate nitrogen fertilization resulted in higher dry matter accumulation and N uptake that helped towards sufficient space for accommodation of greater number of grains per panicle and seed yield. Contradictory to this, lower yield with delayed sowing might be due todry spells, higher temperatures and coincidence of vegetative reduced photosynthetic activity, mobilization of nutrients and resulted in lower biomass accumulation and yield attributes. These results are in line with those of [12-13].

Table 1. Growth parameters and yield attributes of browntop millet as influenced by sowing dates and nitrogen levels

Treatment	Plant height (cm)			Tillers m^{-2}			Leaf area (cm^2 plant^{-1})			Dry matter accumulation (kg ha^{-1})			Effective tillers m^{-2}	Panicle length (cm)	Panicle weight (g)	Grains panicle^{-1}
Factor 1: Sowing dates																
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	Post-harvest observations			
D$_1$ - June 15th	52.46	96.53	126.35	99.0	203.25	258.75	682.5	1380.0	1530.0	2482.5	4235.0	5402.5	217.1	17.82	2.13	147.92
D$_2$ - June 30th	46.16	90.03	120.45	89.0	185.5	240.75	647.5	1320.0	1447.0	2182.5	3925.0	5010.0	200.4	16.03	1.81	137.42
D$_3$ - July 15th	39.18	83.51	114.08	80.0	165.5	200.50	590.0	1278.0	1370.0	1842.5	3555.0	4677.5	183.8	14.22	1.54	127.00
D$_4$ - July 30th	33.38	77.58	107.61	71.2	147.0	176.25	510.0	1203.7	1302.0	1517.5	3215.0	4327.5	167.8	12.33	1.26	120.17
SEm ±	1.38	1.48	2.00	2.81	5.29	5.52	11.93	12.18	17.93	8.6.0	103.9.	108.9	4.66	0.38	0.06	1.96
CD (P=0.05)	3.97	4.28	5.79	8.11	15.27	15.94	34.46	35.17	51.79	238.6	299.9	31.4.6	13.98	1.09	0.18	5.65
Factor 2: Nitrogen levels																
N$_1$ - 0 kg ha^{-1}	33.09	77.84	105.81	63.75	144.5	177.25	435.0	1110.0	1200.0	1502.5	2905.0	4195.0	161.1	10.29	1.30	109.58
N$_2$ - 20 kg ha^{-1}	42.07	86.30	113.45	76.50	164.0	199.75	555.0	1252.5	1380.0	1805.0	3587.5	4825.0	193.8	13.45	1.56	123.50
N$_3$ - 40 kg ha^{-1}	46.69	90.75	122.88	96.25	189.5	241.75	705.0	1395.0	1510.0	2290.0	4122.5	5165.0	205.1	17.58	1.86	147.00
N$_4$ - 60 kg ha^{-1}	49.33	92.76	126.33	102.75	203.25	257.50	735.0	1425.0	1560.0	2427.5	4315.0.	5232.5	215.9	19.08	2.03	152.42
SEm ±	1.38	1.48	2.00	2.81	5.29	5.52	11.93	12.18	17.93	82.6	103.8	108.9	4.66	0.38	0.06	1.96
CD (P=0.05)	3.97	4.28	5.79	8.11	15.27	15.94	34.46	35.17	51.79	238.6	299.9	314.6	13.98	1.09	0.18	5.65
Interaction (D x N)																
SEm ±	2.75	2.96	4.01	**5.61**	10.57	11.04	23.86	24.36	35.86	165.2	207.7	217.9	9.66	0.75	0.13	3.91
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**NS**	NS	NS	NS

Want is LSD and the other acronyms used in the table? A table should be self-explanatory

Table 2. Yield, nitrogen uptake and economics of browntop millet as influenced by sowing dates and nitrogen levels

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	N uptake (kg ha^{-1})				Monetary returns		
				Tillering	Flowering	Grain	Straw	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Factor 1: Sowing dates										
D$_1$ - June 15th	2003	3930	33.77	45.53	98.25	108.35	60.33	104080	76680	2.79
D$_2$ - June 30th	1837	3764	32.08	36.01	84.78	86.54	50.29	95562	68162	2.48
D$_3$ - July 15th	1738	3618	32.45	28.01	71.4	73.06	40.35	88515	61115	2.23
D$_4$ - July 30th	1540	3466	30.76	20.03	61.41	63.38	34.98	80239	52840	1.92
SEm ±	27	50	0.50	1.72	1.25	1.88	1.27	2141	2149	0.07
CD (P=0.05)	77	143	NS	5.09	3.60	5.43	3.67	6184	6207	0.20
Factor 2: Nitrogen levels										
N$_1$ - 0 kg ha^{-1}	1569	3326	31.94	18.48	53.16	45.22	25.07	80458	50861	1.71
N$_2$ - 20 kg ha^{-1}	1773	3642	32.68	26.35	71.03	78.56	34.30	90747	60910	2.04
N$_3$ - 40 kg ha^{-1}	1855	3862	32.39	36.87	91.93	98.77	43.44	97743	67669	2.25
N$_4$ - 60 kg ha^{-1}	1921	3949	33.71	40.05	98.38	112.70	51.97	100014	69701	2.29
SEm ±	27	50	0.50	1.72	5.35	4.88	2.67	2141	2149	0.07
CD (P=0.05)	77	143	NS	5.09	15.60	14.43	8.67	6184	6207	0.20
Interaction (D x N)										
SEm ±	53	99	1.0	2.44	7.30	6.76	3.97	4282	4298	0.14
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	-	-	-

Fig. 1. General view of the field experiment

Fig. 2. Panicle length of browntop millet under D1N3, D2N3, D3N3 and D4N3

The effect of sowing dates, nitrogen levels as well as their interaction was found to be non-significant on harvest index.

3.4 Nitrogen Uptake

Amount of nitrogen amendments significantly influenced nitrogen uptake at all stages of crop growth (Table 2). However, the interaction effect of sowing dates and nitrogen levels on N uptake was non-significant.

Among the sowing dates, at tillering, flowering stage and at harvest (grain and straw) highest nitrogen uptake was recorded with D_1- June 15th over D_2 - June 30th, D_3 -July 15th (9.05 kg ha^{-1}) and D_4 -July 30th respectively.

With respect to nitrogen levels, at tillering, flowering stage and at harvest (grain and straw) highest nitrogen uptake was recorded with N_3- 40 kg ha^{-1} over N_2 and N_1 but, N_3 was statistically comparable with N_4- 60 kg ha^{-1}.

Nutrient uptake is the resultant of nutrient content and dry matter accumulation. Higher dry matter accumulation at different crop growth stages coupled with the higher grain and straw yield under treatments D1-June 15th sowing and N_3-40 kg N ha^{-1} resulted in significantly higher nitrogen uptake by crop. These findings corroborate with [14-15]

3.5 Economic Analysis

Besides yield advantage of different treatments, it is also important to assess the relative monetary returns from the treatments to determine relative degree of cost effectiveness. Gross returns, net returns and B:C ratio were significantly influenced by sowing dates and N levels but their interaction was non-significant (Table 2).

Among the different dates of sowing, June 15th registered higher gross returns, net returns and B:C ratio (104080, 76680 ₹ ha[-1] and 2.79) over other sowing dates *viz*; D_2- June 30th D_3- July 15th and D_4- July 30th July (Table 2).

Among nitrogen levels, application N_3- 40 kg ha^{-1} accrued highest gross returns, net returns and B:C ratio (97743, 676690 ₹ ha[-1] and 2.25) in comparison to N_2-20 kg ha^{-1} and N_1- 0 kg ha^{-1} but, N_3-40 was on par with N_4- 60 kg ha^{-1}. Similar results on higher monetary returns with early sowing and N application were reported by [16].

4. CONCLUSION

The experiment results revealed that on sandy loam soils of Telangana during monsoon season Brown top millet sown on June 15th fertilsed with 40 kg N ha^{-1} would realize higher yields and monetary returns.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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