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RESEARCH PAPER

Optimization of seed rate and planting geometry for genotypes of browntop millet (*Brachiaria ramose* L.)

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Abstract: A field study was conducted during *Kharif* 2020 at ICAR-Krishi Vigyan Kendra, Hanumanamatti, Haveri, Karnataka, India, under rainfed condition in red sandy loamy soil. The experiment was laid out in split-split plot design with three replications. The treatments comprise three planting geometry (30, 45 and 60 cm row spacing) in main plots, two genotypes (Dharwad local and IIMR Y II) in sub plots and three seed rates (5, 7.5 and 10 kg ha^{-1}) in sub-sub plots. Planting geometry of 45 cm row spacing recorded significantly higher growth parameters like, number of tillers per meter row length (157.56), leaf area (447.13 cm^2 $plant^{-1}$), dry matter production (15.02 g $plant^{-1}$) and yield attributes like number of effective tillers per m^2 (333.08), ear head length (15.1 cm), grain yield (624.2 kg ha^{-1}), straw yield (1370.1 kg ha^{-1}) and economic values as compared to 30 cm row spacing, which was on par with 60 cm row spacing. Genotypes had no significant effect on growth, yield parameters and yield. However, genotype IIMR Y II recorded higher growth attributes, yield attributes, grain yield (575.4 kg ha^{-1}), straw yield (1297.6 kg ha^{-1}) and economic values when compared to Dharwad local. Among different seed rates, seed rate of 7.5 kg ha^{-1} recorded significantly higher number of tillers per meter row length (153.88), leaf area (443.21 cm^2 $plant^{-1}$), dry matter production (14.49 g $plant^{-1}$), number of effective tillers per m^2 (327.43), ear head length (15.07 cm) grain yield (585.6 kg ha^{-1}), straw yield (1321.8 kg ha^{-1}) and economic value than the rest of the seed rates. Interaction effect of planting geometry, genotypes and seed rates were found non-significant.

Key words: Browntop millet, Genotypes, Grain yield, Planting geometry

Introduction

Browntop millet (*Brachiaria ramose* L.) is one of the rare crops among millets belonging to family Poaceae. It is an annual warm-season grass and majorly used in forage management systems. It is originated in Southeast Asia. It is mainly grown in Western Asia, Africa, China, Arabia and Australia (Clayton *et al*., 2006). From India, it was introduced to the United States in 1915 (Oelke *et al*., 1990). In India, browntop millet spread out from the Deccan Plateau to Tamil Nadu in the south. It is locally called as 'korale' in Kannada and 'anda korra' in Telugu. It grows well in the dryland tracts of Karnataka-Andhra Pradesh border areas, covering regions of Tumkur, Chitradurga and Chikkaballapura districts in Karnataka and Anantapuram district in Andhra Pradesh (Sujata *et al.,* 2018). It appears to have been a major staple crop in the late prehistory of the wider region of the Deccan (Fuller *et al.,* 2004). In several parts of India, browntop millet is known by local names which translate to relative of little millet (*Panicum sumatrense*). Nutritional composition of browntop millet is better in comparison with other millets. The grain is a rich source of natural fibre (12.5 %), protein (11.5 %), minerals (6.21 %), calcium (18 %) and iron (8.9 %). It is a food for patients suffering from diabetes. Colour of the millet is also appealing and it is well accepted by the farmers as well as consumers when compared to kodo millet and finger millet. Browntop millet is also used in the traditional food preparations in few parts of Karnataka. Hence, it not only provides an answer to climate change crisis but also stands as the best solution to deal with malnutrition among the rural poor and lifestyle diseases among the urban and semi-urban regions due to its high nutritional value and also serves as potential crop for agri entrepreneurship (Reddy and Prasad, 2017).

Appropriate row spacing and seed rate are the two most important management factors affecting agronomic character of the crops. When plant density exceeds an optimum level, competition among plants for light above the ground and nutrients below ground becomes severe. However, very low plant density may not be enabling to attain the yield plateau. Hence, determining optimum spacing and seed rate has an importance on growth of the plant in access of nutrients, competition with weeds, access available water content and use of sun light. Yield can be maximized up to a certain level through agronomic management practices. Selection of suitable genotype is a non-cash input that greatly influences the yield levels when all other inputs supplied are constant. Keeping these points in view, field experiment was carried out with the objective to optimize seed rate and planting geometry in browntop millet genotypes.

Material and methods

A field experiment was carried out during *Kharif* season of 2020-21 on red sandy loam soil at ICAR- Krishi Vigyan Kendra, Hanumanamatti, Haveri, Karnataka, India, which is located at 14.39' N latitude, 75°33' E longitude and at an altitude of 594.36 m above mean sea level (MSL) falling under Northern Transition Zone of Karnataka.

Soil of the experimental site was red sandy loam in texture with pH of (5.36) and electrical conductivity of (0.32 dS m^{-1}). The soil was high in organic carbon (3.61 g kg^{-1}) and low in available nitrogen (216.20 kg ha^{-1}), medium in available phosphorous (25.57 kg ha^{-1}) and low in available potassium (111.50 kg ha^{-1}). The experiment was laid out in split-split plot design with three replications. The experiment consists of three planting geometry (30, 45 and 60 cm row spacing) in main plots, two genotypes (Dharwad local and IIMR Y II) in sub plots and three seed rates (5, 7.5 and 10 kg ha^{-1}) in sub-sub plots. The furrows were opened at 30, 45 and 60 cm apart with the help of pickaxe and rope as per the different spacing treatment. The seeds were sown in rows and covered with soil. The sowing was carried out in respective plots in second week of June 2020 according to the treatments. Well decomposed farm yard manure (6 t FYM ha^{-1}) was applied two weeks prior to sowing of the crop. Fertilizers at 30:15:15 kg N: P_2O_5: K_2O ha^{-1} were applied at the time of sowing as basal application. All other agronomic practices were kept normal and uniform. Biometric observations *viz.,* plant height was measured from base of the stem at ground level to the tip of the main shoot having fully opened top leaf, number of tillers per meter row length and dry matter production were recorded in each plot at harvest. Leaf area per plant and leaf area index were recorded. Yield parameters like ear head length was recorded from the five randomly selected plants at the time of harvest. Number of effective tillers per square meter in net plot were recorded. Grain yield and straw yield of browntop millet was obtained from net plot is computed for hectare and expressed in kilogram $hectare^{-1}$. Harvest index was determined by dividing the economic yield by the total biological yield and expressed as per cent.

Results and discussion

Performance of browntop millet genotypes

Genotype IIMR Y II recorded maximum plant height (85.70 cm) at harvest over Dharwad local (84.88 cm) but not to the level of significance. The difference in plant height between the genotypes might due to genetic and morphological characteristic of varieties in exploiting climatic optima at important crop growth stages. Higher leaf area (437.59 cm^2 $plant^{-1}$) and higher leaf area index (1.15) at 60 days after sowing was attained under genotype IIMR Y II. At harvest genotype IIMR

Table 1. Effect of planting geometry and seed rates on growth parameters of browntop millet genotypes

Treatment	Plant height at harvest (cm)	No. of tillers per meter row length at harvest	Leaf area at 60 DAS (cm^2 $plant^{-1}$)	Leaf area index at 60 DAS	Total dry matter production at harvest (g $plant^{-1}$)
Main plot (Planting geometry)					
P_1: 30 cm	87.42	136.58	417.91	1.29	12.71
P_2: 45 cm	85.57	157.56	447.13	1.14	15.02
P_3: 60 cm	82.88	149.81	435.63	0.99	14.46
S. Em. ±	0.85	3.46	4.65	0.04	0.45
C.D. (p=0.05)	3.33	13.57	18.27	0.16	1.77
Sub plot (Genotypes)					
G_1: Dharwad local	84.88	147.11	429.53	1.13	13.91
G_2: IIMR YII	85.70	148.85	437.59	1.15	14.21
S. Em. ±	0.77	2.06	3.00	0.03	0.22
C.D. (p=0.05)	NS	NS	NS	NS	NS
Sub-sub plot (Seed rates)					
S_1: 5 kg ha^{-1}	83.76	144.06	427.16	1.07	13.74
S_2: 7.5 kg ha^{-1}	84.61	153.88	443.21	1.23	14.49
S_3: 10 kg ha^{-1}	87.50	146.00	430.30	1.12	13.96
S. Em. ±	1.02	2.48	4.39	0.03	0.15
C.D. (p=0.05)	2.98	7.23	12.82	0.08	0.45
Interaction (P x G x S)					
$P_1G_1S_1$	85.53	134.00	414.60	1.23	12.07
$P_1G_1S_2$	85.87	142.13	422.28	1.39	12.93
$P_1G_1S_3$	89.83	133.17	415.53	1.24	12.50
$P_1G_2S_1$	86.13	131.17	414.13	1.23	12.67
$P_1G_2S_2$	87.07	145.67	422.43	1.40	13.27
$P_1G_2S_3$	90.07	133.33	418.47	1.26	12.83
$P_2G_1S_1$	82.87	152.33	432.41	1.06	14.70
$P_2G_1S_2$	85.13	160.67	457.65	1.18	15.33
$P_2G_1S_3$	87.20	153.00	432.77	1.15	14.63
$P_2G_2S_1$	84.07	153.33	441.40	1.08	14.83
$P_2G_2S_2$	85.13	167.00	469.20	1.21	15.50
$P_2G_2S_3$	89.00	159.00	449.37	1.17	15.11
$P_3G_1S_1$	81.67	146.83	425.23	0.90	14.20
$P_3G_1S_2$	82.00	153.17	438.97	1.05	14.77
$P_3G_1S_3$	83.83	148.67	426.29	0.94	14.10
$P_3G_2S_1$	82.27	146.67	435.15	0.92	13.97
$P_3G_2S_2$	82.47	154.67	448.73	1.13	15.13
$P_3G_2S_3$	85.07	148.83	439.40	0.98	14.60
S. Em. ±	2.50	6.07	10.76	0.07	0.38
C.D. (p=0.05)	NS	NS	NS	NS	NS

Y II recorded maximum number of tillers (148.85) and maximum (14.21 g plant^{-1}) dry matter production than Dharwad local but not up to the level of significance (Table 1). This was due to increase in morphological characters which are responsible for photosynthetic capacity of plant there by increasing the biological yield. Higher translocation of photosynthates was possible due to better sink capacity of IIMR Y II than Dharwad local. The better sink capacity might be attributed to the better dry matter production due to better photosynthetic capacity of the plant during both vegetative and reproductive phase of crop as shown by higher LA, LAI and number of tillers in IIMR Y II. The results of present investigation were in confirmation with fundings of Nandini and Shridhar (2019), where foxtail millet genotype SIA 2644 at harvest, recorded higher plant height and number of tillers hill^{-1} compared to local and HMT-1 genotypes. Jyothi (2015) in foxtail millet also found that foxtail millet variety SIA 3156 recorded higher plant height and dry matter production at harvest.

The genotype IIMR Y II recorded higher effective tillers (308.26), ear head length (14.71 cm) and test weight (3.14 g) as compared to that of Dharwad local (301.84, 14.61 cm and 3.04 g, respectively) (Table 2). It might be due to higher genetic potential, better partitioning of assimilates from source to sink and genetic characteristics of more tillering capacity of IIMR Y II. These results were in accordance with findings of Jyothi (2015), who found that SIA 3085 variety recorded higher length of the panicle and test weight as compared to other foxtail millet varieties. Anusha (2017) in little millet found that OLM-203 genotype recorded higher panicle length and test weight as compared to other genotypes. Genotype IIMR Y II recorded higher grain and straw yield (575.4 and 1297.6 kg ha^{-1}, respectively) as compared to genotype Dharwad local (541.4 and 1218.7 kg ha^{-1}, respectively) but not to the level of significance. This might be due to its better growth and yield attributing parameters primarily dry matter production, number of effective tillers and ear head length. This can be attributed to their genetic potentiality to utilize and translocate photosynthates from source and sink. Higher straw yield of IIMR Y II might be due to better vegetative growth of the variety, which was reflected through higher straw yield governed by genetic makeup of the variety and climatic conditions. These findings were in conformity with the findings of Anusha (2017) in little millet where hiriyur local recorded higher grain and straw yield as compared to BL-6 and OLM-203.

Effect of planting geometry on growth and yield of browntop millet

At harvest, significantly taller plants were recorded in 30 cm row spacing (87.42 cm) compared to wider spacing of 60 cm row spacing (82.88 cm) and was on par with 45 cm row spacing (85.57 cm) (Table 1). Higher plant population bring certain morphological changes such as increase in plant height. This may be due to the competition between plants for light, moisture and nutrients. Increase in height was mainly for the point of light interception. Thakur *et al.* (2018) in browntop millet had found that spacing of 22.5 x 10 cm was recorded higher plant height as compared to other wider spacings. At harvest significantly maximum number of tillers per meter row length (157.56) and higher dry matter production (15.02 g plant^{-1}) was obtained under 45 cm row spacing which was on par with 60 cm row spacing (149.81 and 14.46 g plant^{-1}, respectively) and lowest was obtained under 30 cm row spacing (136.58 and 12.71 g plant^{-1}, respectively) (Table 1). This might be due to less competition between plants for solar radiation, space and efficient utilization of resource that helps in better growth and also due to less availability of space in narrow spacing; there was competition for growth resources resulting in lesser leaf area compared to wider spacing. These results were in agreement with the findings of Prakash *et al.* (2018) in finger millet where wider spacing of 60 x 60 cm with 100 % RDF recorded higher number of tillers plant^{-1} and dry matter production as compared to other spacings and levels of NPK. Rathore (2006) in pearl millet also found that wider spacing of 60 x 12 cm recorded higher number of tillers plant^{-1} and dry matter production plant^{-1} as compared to other spacings. Significantly higher leaf area (447.13 cm^2 plant^{-1}) was recorded under 45 cm row spacing at 60 days after sowing. LAI was recorded in 30 cm row spacing (1.29) compared to 60 cm row spacing (0.99) and was on par with 45 cm spacing (1.14) at 60 days after sowing. This might be due to small soil surface exposed to the sun is relatively more in wider spacing than closer spacing. Narayan (2017) in finger millet also found the similar results, at 60 days after sowing spacing of 30 x 10 cm recorded higher leaf area index as compared to 30 x 30 cm and 45 x 30 cm spacing.

Row spacing of 45 cm at harvest had recorded significantly higher number of effective tillers per m^2 (333.08) and ear head length (15.11 cm) which was on par with 60 cm (301.57 and 14.74 cm, respectively) and lowest were observed in 30 cm row spacing (280.49 and 14.13 cm, respectively) (Table 2). The difference in yield components due to planting geometry was mainly due to availability of space, moisture, light and nutrients. The higher yield components are resultant of higher growth parameters obtained throughout the crop period. Anitha (2015) also reported more number of productive tillers m^{-2} and higher length of finger under spacing of 20 x 20 cm as compared to other spacings. Mane *et al.* (2018) also reported that spacing of 25 x 10 cm recorded higher ear head length and other yield attributing characters compared to other spacings in finger millet. Grain yield in crop is the resultant of a number of complex morphological and physiological processes affecting each other and occurring at different growth stages during vegetative period. Significantly higher grain and straw yield (624.2 and 1370.1 kg ha^{-1}, respectively) of browntop millet was recorded in 45 cm row spacing over 30 cm row spacing (491.7 and 1164.9 kg ha^{-1}, respectively) and it was on par with 60 cm row spacing (559.3 and 1239 kg ha^{-1}, respectively) (Table 2). It was mainly because of higher yield attributes, more space, moisture, light and nutrient availability in wider planting geometry resulted in higher yield. Mar (2005) also found that in finger millet 30 x 7.5 cm spacing recorded higher grain yield over other spacings. Swathi (2019) in pearl millet found that spacing of 45 x 15 cm recorded higher grain and straw yield over other spacings. Influence of planting geometry on test weight and harvest index was non-significant. However, numerically higher test weight (3.19 g) and harvest index (31.30 %) was attained under 45 cm row spacing compared to that of 30 and 60 cm row spacing (Table 2).

Effect of seed rate on growth and yield

Significantly higher plant height (87.50 cm) at harvest was noticed in 10 kg ha^{-1} seed rate and lowest (83.76 cm) was with 5 kg ha^{-1} seed rate, which was on par with 7.5 kg ha^{-1} seed rate (84.61 cm). This may be due to shading effect in high population causes the auxins to move from illuminated side to shade side and thus the imbalance of auxins causes more elongation of plants in shade with curvature compared to being in light. Since auxin is sensitive to light, shading prevents destruction of auxin and thus higher accumulation of auxin triggers its growth to height. These trends of plant height may be due to competition for resources like light and space. These results were in accordance with findings of Bitew and Asargew (2013) in finger millet wherein 25 kg ha^{-1} seed rate recorded higher plant height as compared to seed rates of 10, 15 and 20 kg ha^{-1}. Significantly higher leaf area (443.21 cm^2 plant^{-1}) and leaf area index (1.23) at 60 days after sowing was recorded in 7.5 kg ha^{-1} seed rate. At harvest, seed rate of 7.5 kg ha^{-1} recorded significantly higher number of tillers per meter row length (153.88) and dry matter production (14.49 g plant^{-1}) compared to other seed rates of 5 kg ha^{-1}(144.06 and 13.74 g plant^{-1}, respectively) and 10 kg ha^{-1} (146.00 and 13.96 g plant^{-1}, respectively) (Table 1). This may be due to better radiation use efficiency and the effectiveness of the existing plant to have maximum plant population is more in the optimum seed rate compared to lower or higher seed rates. Laxman (2015) in sorghum found that 10 kg ha^{-1} seed rate recorded higher dry matter production plant^{-1} and other growth parameters over 12.5 kg ha^{-1} seed rate. Gani *et al.* (2016) in finger millet found that seed rate of 3 kg ha^{-1} recorded higher number of tillers plant^{-1} and leaf area index as compared to other seed rates.

Table 2. Effect of planting geometry and seed rates on yield and yield parameters of browntop millet

Treatment	Effective tillers (m^{-2})	Ear head length (cm)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Main plot (Planting geometry)						
P_1: 30 cm	280.49	14.13	2.95	491.7	1164.5	29.67
P_2: 45 cm	333.08	15.11	3.19	624.2	1370.1	31.30
P_3: 60 cm	301.57	14.74	3.12	559.3	1239.5	31.16
S. Em. ±	8.20	0.19	0.06	16.98	33.32	0.42
C.D. (p=0.05)	32.18	0.73	NS	66.68	130.82	NS
Sub plot (Genotypes)						
G_1: Dharwad local	301.84	14.61	3.04	541.4	1218.7	30.66
G_2: IIMR YII	308.26	14.71	3.14	575.4	1297.6	30.76
S. Em. ±	3.57	0.08	0.07	11.90	26.25	0.27
C.D. (p=0.05)	NS	NS	NS	NS	NS	NS
Sub-sub plot (Seed rates)						
S_1: 5 kg ha^{-1}	289.38	14.32	3.00	536.3	1211.9	30.64
S_2: 7.5 kg ha^{-1}	327.43	15.07	3.19	585.6	1321.8	30.81
S_3: 10 kg ha^{-1}	298.33	14.59	3.07	553.3	1240.8	30.68
S. Em. ±	5.77	0.09	0.08	10.59	27.14	0.33
C.D. (p=0.05)	16.85	0.28	NS	30.91	79.22	NS
Interaction (P x G x S)						
$P_1G_1S_1$	263.43	13.83	2.83	467.0	1124.0	29.34
$P_1G_1S_2$	295.27	14.50	2.97	518.0	1193.0	30.26
$P_1G_1S_3$	284.23	13.90	2.87	479.3	1134.3	29.72
$P_1G_2S_1$	273.57	13.77	2.83	472.3	1135.7	29.36
$P_1G_2S_2$	309.53	14.60	3.23	520.7	1238.0	29.58
$P_1G_2S_3$	256.90	14.17	2.97	493.0	1164.7	29.76
$P_2G_1S_1$	305.30	14.47	3.10	572.0	1258.0	31.26
$P_2G_1S_2$	353.07	15.53	3.17	643.0	1414.3	31.25
$P_2G_1S_3$	324.27	14.90	3.13	603.3	1315.7	31.44
$P_2G_2S_1$	319.27	15.00	3.17	625.3	1375.7	31.25
$P_2G_2S_2$	358.50	15.57	3.40	678.0	1496.7	31.51
$P_2G_2S_3$	338.10	15.17	3.20	623.3	1360.0	31.43
$P_3G_1S_1$	284.07	14.47	3.03	515.7	1134.3	31.39
$P_3G_1S_2$	309.07	15.13	3.13	542.3	1236.0	30.68
$P_3G_1S_3$	297.83	14.77	3.10	532.3	1158.7	31.18
$P_3G_2S_1$	290.67	14.40	3.03	565.3	1243.7	31.25
$P_3G_2S_2$	339.17	15.07	3.27	611.7	1352.7	31.14
$P_3G_2S_3$	288.63	14.63	3.13	588.7	1311.7	31.00
S. Em. ±	14.14	0.23	0.19	25.94	66.49	0.81
C.D. (p=0.05)	NS	NS	NS	NS	NS	NS

Table 3. Effect of planting geometry, genotype and seed rate on economics of browntop millet cultivation.

Treatment	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:Cost ratio
Main plot (Planting geometry)			
P_1: 30 cm	30682	10270	1.50
P_2: 45 cm	38823	18411	1.90
P_3: 60 cm	34790	14378	1.70
S. Em. ±	1056.30	1056.30	0.05
C.D. (p=0.05)	4147.56	4147.56	0.20
Sub plot (Genotypes)			
G_1: Dharwad local	33710	13298	1.65
G_2: IIMR YII	35820	15408	1.75
S. Em. ±	740.48	740.48	0.04
C.D. (p=0.05)	NS	NS	NS
Sub-sub plot (Seed rates)			
S_1: 5 kg ha^{-1}	33389	13112	1.65
S_2: 7.5 kg ha^{-1}	36457	16045	1.79
S_3: 10 kg ha^{-1}	34449	13902	1.68
S. Em. ±	658.72	658.72	0.03
C.D. (p=0.05)	1922.67	1922.67	0.09
Interaction (P x G x S)			
$P_1G_1S_1$	29144	8867	1.44
$P_1G_1S_2$	32316	11904	1.58
$P_1G_1S_3$	29911	9364	1.46
$P_1G_2S_1$	29476	9199	1.45
$P_1G_2S_2$	32482	12070	1.59
$P_1G_2S_3$	30761	10214	1.50
$P_2G_1S_1$	35578	15301	1.75
$P_2G_1S_2$	39994	19582	1.96
$P_2G_1S_3$	37527	16980	1.83
$P_2G_2S_1$	38896	18619	1.92
$P_2G_2S_2$	42171	21759	2.07
$P_2G_2S_3$	38771	18224	1.89
$P_3G_1S_1$	32074	11797	1.58
$P_3G_1S_2$	33733	13321	1.65
$P_3G_1S_3$	33111	12564	1.61
$P_3G_2S_1$	35164	14887	1.73
$P_3G_2S_2$	38046	17634	1.86
$P_3G_2S_3$	36615	16068	1.78
S. Em. ±	1613.53	1613.53	0.08
C.D. (p=0.05)	NS	NS	NS

Higher yield attributes like number of effective tillers per square meter (327.43 m^{-2}) and ear head length (15.07 cm) were significantly higher at 7.5 kg ha^{-1} seed rate compared to 5 kg ha^{-1} (289.38 m^{-2} and 14.32 cm, respectively) and 10 kg ha^{-1} seed rate (298.33 m^{-2} and 14.59 cm, respectively) (Table 2). This might be due to better supply of photosynthates from leaves to tillers due to better utilization of natural resources. Influence of seed rate on test weight of seeds was non-significant. Grain and straw yield were significantly higher at 7.5 kg ha^{-1} seed rate (585.6 and 1321.8 kg ha^{-1}, respectively) over the other seed rates of 5 kg ha^{-1} (536.3 and 1211.9 kg ha^{-1}, respectively) and 10 kg ha^{-1} (553.3 and 1240.8 kg ha^{-1}, respectively) (Table 2). Higher grain and straw yield with 7.5 kg ha^{-1} seed rate was mainly due to most efficient utilization of all the resource and optimum number of plants per hectare compared to lower and higher level of seed rate. The increase in yield with 7.5 kg ha^{-1} seed rate can be attributed to the optimum values of yield components like, number of effective tillers per square meter, ear head length and test weight and growth components like, plant height, dry matter accumulation, number of tillers per meter row length, leaf area per plant and leaf area index at all growth stages. Hasan *et al.* (2013) in foxtail millet also reported that seed rate of 10 kg ha^{-1} recorded higher grain yield as compared to other seed rate. Turaki *et al.* (2014) in foxtail millet also found that 10 kg ha^{-1} seed rate recorded higher grain yield over other seed rates. Influence of seed rate on harvest index was non-significant.

Interaction effect of genotypes, planting geometry and seed rates on growth and yield of browntop millet

Interaction effects between genotypes, planting geometry and seed rate were non-significant. However, genotype IIMR Y II sown at 45 cm planting geometry with 7.5 kg ha^{-1} seed rate recorded higher growth attributes like, number of tillers per meter row length (167.00) and dry matter production (15.50 g $plant^{-1}$) and yield attributes like, number of effective tillers (358.50 m^{-2}), ear head length (15.57 cm), test weight (3.40 g), grain (678.0 kg ha^{-1}) and straw yield (1496.7 kg ha^{-1}) as compared to other treatment combinations (Table 2). Increase in grain yield was attributed to increased growth and yield attributes. Increased growth indices were attributed to genetic constituent of genotype, availability of optimum space for crop growth and development. Increased yield parameters attributed to higher harvest index over other treatment combinations. Lower grain yield (467.0 kg ha^{-1}) and straw yield (1124.0 kg ha^{-1}) were recorded with genotype Dharwad local at 30 cm planting geometry with 5 kg ha^{-1} seed rate. This may be due to less spacing which increases competition for solar radiation that ultimately reduces the growth of plants at vegetative stage and they were unable to reach reproductive phase which resulted in low yield. Nigus and Melese (2018) in finger millet also reported that spacing of 30 cm with 15 kg ha^{-1} seed rate recorded higher grain yield as compared to other interactions of spacing and seed rates.

Effect of planting geometry, seed rates and genotypes on economics of Browntop millet

Among different planting geometries, significantly higher gross return (₹ 38,823 ha^{-1}), net return (₹ 18,411 ha^{-1}) and B:C ratio (1.90) were obtained under 45 cm planting geometry compared 30 cm planting geometry, which was on par with 60 cm planting geometry (Table 3). Similar findings were reported by Swathi (2019) in pearl millet, found that spacing of 45 x 15 cm recorded higher gross returns and net returns as compared to other spacings. Santosh (2019) in finger millet found that 30 cm row spacing recorded higher net returns and B:C ratio as compared to 20 and 40 cm row spacing. Among different seed rates significantly higher gross returns (₹ 36,457 ha^{-1}), net returns (₹ 16,045 ha^{-1}) and B:C ratio (1.79) were obtained with 7.5 kg ha^{-1} seed rate compared to 5 and 10 kg ha^{-1} seed rate (Table 3). Browntop millet genotypes had no significant effect of economic. However, IIMR Y II recorded higher gross returns (₹ 35,820 ha^{-1}), net returns (₹ 15,408 ha^{-1}) and B:C ratio (1.75) as compared to Dharwad local (Table 3). These findings were in line with the findings of Bhavani (2020) in little millet wherein, variety VS-25 recorded higher gross returns, net returns and B:C ratio as compared to other little millet varieties. Higher economic values were mainly attributed to higher grain and straw yield. Interaction effect was non-significant.

Conclusion

The present investigation indicated that IIMR Y II genotype of browntop millet found to be potential with higher grain yield and net returns under the planting geometry of 45 cm row spacing with a seed rate of 7.5 kg ha^{-1} in rainfed conditions.

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