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EVALUATION OF SORGHUM (*SORGHUM BICOLOR*) GENOTYPES FOR QUALITATIVE AND QUANTITATIVE PARAMETERS UNDER PADDY FALLOWS

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ABSTRACT

The experiment was carried out to evaluate the performance of sorghum genotypes under paddy fallows during *rabi* summer, 2019-20 in the farmer's field, Raichur district, Karnataka, India. It was conducted in Randomized Complete Block Design (RCBD) with fifteen genotypes and three replications. Observations were made on both qualitative and quantitative parameters. The results revealed that, among the genotypes evaluated for qualitative parameters, the genotypes had shown absence of leaf sheath anthocyanin colouration, anthocyanin colouration of stigma and yellow colouration of stigma. The highest pollen sterility (42.68%) and pollen viability (73.12%) percentage was observed in CSV 42 and LAILA, respectively. For quantitative parameters, the highest plant height was recorded in the genotype VJH 15 @ 60, 90 DAS and at maturity (199.67 cm, 217.33 cm and 229.33 cm, respectively), genotype JIVA 96 had recorded the lowest (54.0) number of days to 50 per cent flowering, highest panicle length (17 cm) and panicle weight (63.16 g). LAILA genotype has recorded the highest panicle width (17 cm), seed set percentage (77.20 %), grain yield per plant (35.28 g) and grain yield per hectare (5227.31 kg / ha). CSH 16 genotype has recorded the highest test weight (2.98 g).

Key words : Sorghum, Genotype, Pollen fertility, Pollen viability, Grain yield.

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] ranks the fifth most important food crop in the world and is a dietary staple for over 500 million people in over 30 countries. It belongs to the family Poaceae and tribe Andropogoneae (Harlan and de Wet, 1972) and is popularly known as *jowar* in India.

Paddy fallows basically imply to those lowland *kharif* sown rice areas, which remain uncropped during *rabi* (winter) due to various reasons such as lack of irrigation, cultivation of long-duration varieties of rice, early withdrawal of monsoon rains leading to soil moisture stress at planting time of winter crops, waterlogging and excessive moisture in November / December months, lack of appropriate varieties of winter crops for late planting and socio-economic problems like stray cattle, blue bulls etc (Ali *et al.*, 2012). India accounts for 79 per cent (11.65 million ha) of the total paddy fallows of South Asia (15.0 million ha). The coastal region of Andhra Pradesh, Karnataka and Tamil Nadu forms an important paddy fallows ecology in peninsular India.

Anthocyanins are the major group of phenolic pigments and the most significant group of water-soluble pigments in plants (Andersen and Jordheim, 2006; He and Guisti, 2010) responsible for the red, purple and blue colours found in numerous fruits, vegetables, cereal grains, millets and flowers. Anthocyanins has distinctive physicochemical properties that separate them by its unique colour and stability (Pina *et al.*, 2012 and Pina *et al.*, 2015 and Silva *et al.*, 2017). They are highly reactive molecules and also sensitive to degradation reactions.

Sorghum in paddy fallows is gaining popularity among the farmers and the crop is exclusively cultivated in paddy fallows under zero tillage condition (Mishra and Chapke, 2009). It is now grown in more than 14,000 ha area in paddy fallows with an average productivity of 6.9 t per ha. Its cultivation under zero tillage has many economic and environmental benefits over conventional tillage, such as lower labour and fuel needs, reduced soil erosion, reduced runoff, increased soil organic carbon contents and increased soil biological activity (Anonymous, 2018). So the present investigation was undertaken to evaluate the sorghum genotypes suitable for Raichur district condition under paddy fallows.

Materials and Methods

Field experiment was conducted during *rabi summer* 2019-20 at farmer's field, Bichale camp, Gillesugur village, Raichur district, Karnataka, India. The experiment was conducted with fifteen genotypes *viz*., CSV 37, CSV 42, DSV 6, SPH 1883, CSH 14, CSH 16, CSH 25, CSH 41, CSH 9, LAILA, KSSH 186, SONAL, VJH 15, SARPANCH and JIVA 96 comprising of public, private hybrids and varieties in a randomized complete block design with three replications under paddy fallows. As the experiment was conducted under zero till condition, no ploughing and levelling operations were carried out during the cropping period. After the harvest of the previous rice crop, the area was divided into the required number of plots as per the layout of the plan. Seeds were treated with imidacloprid 7 gm per kg and were shade dried, sown with a spacing of 45 cm between rows and 15 cm between plants. Recommended fertilizer dose of 80:100:120 N P K kg per ha in the form of urea, single super phosphate and muriate of potash was applied in a single dose at the time of sowing and nitrogen was applied in split doses as per the recommended package of practices. The remaining nitrogen was applied in 2 equal splits at flowering and grain filling stage. The observations were taken on qualitative parameters *viz*., Anthocyanin colouration of stigma, yellow colouration of stigma, pollen sterility and pollen viability and quantitative parameters *viz*., days to 50% flowering, plant height (cm) at 60 DAS, at 90 DAS and at maturity, seed set (%), panicle width (cm), panicle length (cm), panicle weight (g), test weight (g), grain yield per plant (g) and grain yield per ha (Kg). Observations on pollen sterility and viability were made in laboratory, Department of Seed Science and Technology, College of Agriculture, UAS, Raichur. The statistical analysis was done as per the procedure described by Panse and Sukhatme (1985).

Results and Discussion

Sorghum genotypes evaluated has shown absence of leaf sheath anthocyanin colouration, anthocyanin colouration of stigma and yellow colouration of stigma. In the present study all the genotypes were showed absence of anthocyanin content (Table 1). These studies were in line with the findings of Raghuvanshi *et al*. (2014) who characterized the seventeen forage sorghum genotypes varieties were classified into green and purple based on the anthocyanin pigment of coleoptile. Out of seventeen varieties, twelve varieties had green colour of coleoptile and rest five showed purple colour. Likewise, Su *et al*. (2017) assessed the phenotypic pigmentation in sorghum genotypes from the anthocyanin pigment and the genotypes were categorized into Red, Brown, Yellow and White. Similarly, Neha *et al*. (2018) characterized the 25 sorghum genotypes based on anthocyanin and classified as 11 yellow green and 14 greyed purple genotypes.

The anthocyanin colouration of stigma is also used for identifying the morphological characters of genotypes. On the basis of anthocyanin colouration of stigma, the genotype was categorized as absence and present. In all the fifteen genotypes, anthocyanin colouration of stigma was absent (Table 1). Neha *et al*. (2018) evaluated the twenty five sorghum genotypes on basis of anthocyanin colouration of stigma and confirmed ten genotypes were negative to anthocyanin, while remaining were positive to anthocyanin colouration. In all the fifteen genotypes,yellow colouration of stigma was absent (Table 1). Similar results were reported by Neha *et al*. (2018). She evaluated the twenty five sorghum genotypes on basis of yellow colouration of stigma and confirmed 14 genotypes were negative to yellow colouration of stigma, while remaining were positive to yellow colouration.

The overall results on the anthocyanin and yellow colouration of stigma in the sorghum genotypes evaluated under paddy fallows revealed that all the genotypes were shown the negative reaction to anthocyanin pigmentation. Which means no pigmentation was observed in all the genotypes taken for the study.

Among the genotypes evaluated in the paddy fallows, the significant difference for pollen sterility was observed due to different genotypes. Significantly the highest (42.68%) pollen sterility percentage was observed in CSV 42, which was on par with DSV 6 (41.40 %). Whereas, the lowest (26.88%) pollen sterility percentage was observed in LAILA (Table 3). In the current study as the temperature reached above 40^{o}C during flowering stage, which resulted in the increase in pollen sterility.

Table 1 : Characterization of sorghum genotypes for qualitative characters under paddy fallows.

Genotypes	Leaf sheath anthocyanin colouration	Anthocyanin colouration of stigma	Yellow colouration of stigma	Pollen viability (%)	Pollen sterility (%)
G_1: CSV 37	Absent	Absent	Absent	60.30	39.70
G_2:CSV 42	Absent	Absent	Absent	57.32	42.68
G_3: DSV 6	Absent	Absent	Absent	58.60	41.40
G_4: SPH 1883	Absent	Absent	Absent	64.23	35.77
G_5: CSH 14	Absent	Absent	Absent	68.35	31.65
G_6: CSH 16	Absent	Absent	Absent	63.15	36.85
G_7: CSH 25	Absent	Absent	Absent	62.47	37.53
G_8: CSH 41	Absent	Absent	Absent	65.70	34.30
G_9: CSH 9	Absent	Absent	Absent	63.80	36.20
G_{10}: LAILA	Absent	Absent	Absent	73.12	26.88
G_{11}: KSSH 186	Absent	Absent	Absent	66.12	33.88
G_{12}: SONAL	Absent	Absent	Absent	66.90	33.10
G_{13}: VJH 15	Absent	Absent	Absent	64.10	35.90
G_{14}: SARPANCH	Absent	Absent	Absent	67.60	32.40
G_{15}: JIVA 96	Absent	Absent	Absent	71.40	28.60
C. D at 1%				**3.187**	**3.19**
S.Em ±				**1.095**	**1.10**
Mean				**64.88**	**35.12**

The pollen viability and pollen sterility were compared with temperature during the cropping period. The high temperature decreased the pollen viability, whereas, it increased the pollen sterility. The increased pollen sterility may be due to the effect of high temperature on pollen and high levels of reactive oxygen species, decreased antioxidant enzyme activity and phospholipid. Unsaturation was observed in pollen leading to pollen sterility. Similarly, findings were reported in sorghum by Prasad *et al.* (2006) and Djanaguiraman *et al.* (2018).

The pollen viability was ranged from 57.32 to 73.12 per cent. The highest pollen viability of 73.12 per cent recorded in LAILA genotype, which was statically on par with genotype JIVA 96 with a pollen viability of 71.40 per cent. Whereas, the lowest of 57.32 per cent pollen viability was observed in CSV 42 (Table 1). The variation in the pollen viability may be due to the changes in the day and night temperature, as the pollen viability was highly sensitive to temperature >36 ^{0}C (Singh *et al.*, 2015). During the current study, the temperature from panicle emergence to floret set was ranged with an average temperature of 38^{0}C to 40.5^{0}C. The temperature above 36^{0}C resulted in the decreased pollen viability. Similar observations were observed in sorghum by Prasad *et al.* (2006), Jain *et al.* (2007), Nguyen *et al.* (2013) and Djanaguiraman *et al.* (2014).

Sorghum genotypes evaluated for quantitative characters has shown significant differences under paddy fallows. Plant height (cm), days to 50% flowering, panicle length (cm), panicle width (cm), panicle weight (g) and seed set percentage are important determinants that decide the yield potential of crop plant. Among the genotypes VJH 15 significantly recorded the highest plant height (199.67 cm, 217.33 cm and 229.33 cm) @ 60, 90 DAS and at Maturity compared to other genotypes. However, SARPANCH (214.33 cm) and JIVA 96 (204.66 cm) genotypes were found to be on par with VJH 15. Whereas, the lowest (150.0 cm) plant height was recorded in CSV 37 (Table 2). The variation in plant height of sorghum genotypes under paddy fallows may be due to genetic makeup or varietal characteristics, which would be related on several factors like genetic makeup, nutrient availability, environmental or climatic condition and regional adaptability. At maturity stage, difference in plant height could be due to variation in genetic makeup or the hormonal balance and cell division rate that results in changes in the plant height of different sorghum genotypes (Ullah *et al.*, 2007 and Jameel *et al.*, 2019). Similar findings were obtained in sorghum by Ghasemi *et al.* (2012), Yaqoob *et al.* (2015), Attiya (2015), Mishra *et al.* (2015) and Kishor (2017).

Days to 50 per cent flowering differed significantly between the genotypes. The less (54.0) number of days to 50 per cent flowering was recorded in genotype JIVA

Table 2 : Mean performance of sorghum genotypes for morphological characters under paddy fallows.

Genotype	Days to 50% flowering	Plant height at 60 DAS (cm)	Plant height at 90 DAS (cm)	Plant height at maturity (cm)
G_1: CSV 37	72.66	120.33	138.00	150.00
G_2: CSV 42	70.66	149.67	167.33	179.33
G_3: DSV 6	74.66	157.67	175.33	187.33
G_4: SPH 1883	58.66	142.67	160.33	172.33
G_5: CSH 14	61.66	127.33	145.00	157.00
G_6: CSH 16	66.00	140.67	158.33	170.33
G_7: CSH 25	70.00	136.00	153.67	165.67
G_8: CSH 41	63.66	154.33	172.00	184.00
G_9: CSH 9	58.66	154.67	172.33	184.33
G_{10}: LAILA	61.66	141.67	159.33	171.33
G_{11}: KSSH 186	61.66	141.33	159.00	171.00
G_{12}: SONAL	61.66	154.67	172.33	184.33
G_{13}: VJH 15	67.33	199.67	217.33	229.33
G_{14}: SARPANCH	66.33	184.67	202.33	214.33
G_{15}: JIVA 96	54.00	175.00	192.67	204.67
Mean	**64.62**	**152.02**	**169.69**	**181.69**
S.Em ±	**1.15**	**10.78**	**10.78**	**10.78**
C.D at 5%	**3.33**	**31.22**	**31.22**	**31.22**

96. Whereas, more (74.66) number of days to 50 per cent flowering was recorded in genotype DSV 6 (Table 2). The difference in genotypes may be due to higher concentration and uptake of nutrients by plants with sufficient fertilization might have resulted into greater synthesis of protein and early flower primordial development which ultimately resulted into earlier flowering and maturity in sorghum (Siddartha Naik *et al*., 2018). The observations were on par with the observation of Noor *et al*. (2012) and Shivaprasad *et al*. (2019) and the trait is highly influenced by genotype and environmental interaction.

Panicle length was varied significantly among the genotypes. Significantly the highest (17 cm) panicle length was recorded in genotype JIVA 96. However, the lowest (74.66) panicle length was observed in genotype DSV 6 (Table 3). The differentiation in the panicle length among the genotypes might be attributed to the variation in the genetic constitution of different genotypes. These results were in conformity with Mishra *et al.* (2011), Chapke *et al*. (2014) and Ghosh *et al*. (2015) in sorghum. Significantly the highest (63.16 g) panicle weight was recorded in genotype JIVA 96, which was on par (60.86 g) with genotype KSSH 186. However, the lowest (44.20 g) panicle weight was observed in genotype DSV 6 (Table 3). Ghosh *et al.* (2015) and Shivaprasad *et al.* (2019) noticed similar results while working in sorghum genotypes. The highest (17 cm) panicle width was recorded in genotype LAILA. However, lowest (3.11 cm) panicle width was observed in genotype CSV 42 (Table 3). The cause of variation is due to genotypic and the phenotypic variance in sorghum and the results were similar with Mishra *et al*. (2011) and Shivaprasad *et al.* (2019).

Significantly the highest (77.20%) seed set percentage was recorded in genotype LAILA, which was on par with JIVA 96, CSH 14, SARPANCH and SONAL (76.1%, 75.8%, 75.2% and 73.80%, respectively). However, the lowest (64.5%) seed set percentage was observed in genotype CSV 42 (Table 3). Seed set per cent is associated with pollen viability, hence increase in pollen viability increases seed set percentage andsimilar observations in sorghum were made by Prasad *et al.* (2006), Jain *et al*. (2007), Nguyen *et al*. (2013), Djanaguiraman *et al*. (2014) and Singh *et al.* (2015).

Significantly the highest (35.28 g) grain yield per plant and grain yield per hectare (5227.31 kg/ha) was recorded in genotype LAILA, which, was on par (34.55 g/plant and 5119.68 kg/ha) with JIVA 96. However, the genotype CSV 42 recorded the lowest (19.67 g/plant) grain yield per plant and grain yield per hectare (2915.13 kg/ha) (Table 3). The increase in yield was due to the increased length of panicle. These were in line with Al-Lahham *et al.* (2013), who reported that the variation in sorghum grain yield among the cultivars may be attributed to many

Table 3 : Mean performance of sorghum genotypes on yield and yield attributes under paddy fallows.

Genotypes	Seed set (%)	Panicle width (cm)	Panicle length (cm)	Panicle weight (g)	Grain yield per plant (g)	Grain yield per ha (kg)	Test weight (g)
G_1: CSV 37	66.30	3.18	10.00	44.60	21.04	3117.31	2.32
G_2: CSV 42	64.50	3.11	11.36	45.20	19.67	2915.13	2.29
G_3: DSV 6	65.59	2.85	11.70	44.20	20.99	3109.75	2.26
G_4: SPH 1883	72.20	3.59	16.06	53.33	23.17	3432.45	2.51
G_5: CSH 14	75.80	4.25	14.03	54.20	29.16	4320.72	2.90
G_6: CSH 16	71.30	3.51	15.76	53.90	22.14	3279.95	2.98
G_7: CSH 25	70.04	3.94	15.86	54.23	21.04	3117.31	2.83
G_8: CSH 41	73.50	3.88	15.70	54.26	25.42	3766.54	2.90
G_9: CSH 9	71.40	4.37	14.83	47.33	22.99	3405.28	2.48
G_{10}: LAILA	77.20	5.45	16.16	52.36	35.28	5227.31	2.51
G_{11}: KSSH 186	73.65	4.22	14.66	60.86	26.44	3917.58	2.56
G_{12}: SONAL	73.80	4.42	15.06	52.84	27.72	4106.71	2.58
G_{13}: VJH 15	73.20	4.16	15.86	54.24	23.07	3417.36	2.68
G_{14}: SARPANCH	75.20	4.11	15.36	53.25	28.75	4260.65	2.64
G_{15}: JIVA 96	76.10	4.42	17.00	63.16	34.55	5119.68	2.71
Mean	**71.98**	**3.96**	**14.63**	**52.53**	**25.43**	**3767.58**	**2.61**
S.Em ±	**1.20**	**0.06**	**0.24**	**0.90**	**0.45**	**67.30**	**0.04**
C.D at 5%	**3.48**	**0.19**	**0.70**	**2.61**	**1.31**	**194.98**	**0.12**

factors including the availability of nutrient in the soil and the gene responsible for the nutrient uptake. Bucheyeki *et al.* (2010), Mishra *et al.* (2011) and Ghosh *et al.* (2015) also found the similar genetic variation on sorghum yield. These results were in consonance with the results of Mishra *et al.* (2011). Jameel *et al.* (2019) found that addition of agricultural sulfur leads to reduction of the value of pH in soil and increase the availability of nutrients which led to improve the plant growth in sorghum. Significantly the highest (2.98 g) test weight was recorded in genotype CSH 16, which was on par with CSH 14, CSH 41 and CSH 25 (2.90, 2.90 and 2.83, respectively). However, lower (2.29 g) test weight was observed in genotype DSV 6 (Table 3). The variation may be due to the difference in genetic ability and so to the genotype response to environment. These results are in consistent with the findings in sorghum by Solag and Al-Ani (2011), Abdullah *et al.* (2012) and Jameel *et al.* (2019).

Conclusion

From the above results, it is concluded that genotypes had shown absence of leaf sheath anthocyanin colouration, anthocyanin colouration of stigma and yellow colouration of stigma. Among the genotypes evaluated for pollen sterility and pollen viability, significantly the highest (42.68%) pollen sterility percentage was observed in CSV 42 and significant the highest (73.12%) pollen viability was observed in LAILA compared to other genotypes. From the above results it is concluded that genotypes varied significantly for quantitative characters like plant height, days to 50 percent flowering, panicle length, panicle width, panicle weight, seed set percentage, grain yield per plant, grain yield per hectare and test weight. Reason for varied differences among the genotypes is due to genetic variation, genetic makeup, environmental factors (temperature) and nutrition availability among the genotypes. From this study LAILA and JIVA 96 are suitable for cultivation under paddy fallows based on yield and pollen sterility.

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