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Association Analysis of Grain Yield with its Attributes and Growth Components in Winter Sorghum Under Dryland Conditions in Vertisols

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ABSTRACT

A filed experiment was conducted to study the association analysis of grain yield with its attributes and growth components in winter sorghum under dryland conditions in Vertisols during *rabi* season of 2002–03 at Research Farm of Central Soil and Water Conservation Research and Training Institute, Research Centre, Bellary, Karnataka State, India. Among the varieties evaluated, RSLG 262 (Mouli) recorded greater grain (2041 kg ha^{-1}) and straw yield (3.11 t ha^{-1}), followed by SPV 1591 (1919 kg ha^{-1}) and SPV 1546 (1832 kg ha^{-1}). Greater harvest index (42.8 and 39.6) and dry matter efficiency (0.471 and 0.366) was observed in SPV 1537 and Mouli varieties, respectively. Grain yield of winter sorghum was positively correlated with growth components *i.e.*, dry matter production and its distribution in leaf, stem and ear at harvest. Positive correlation was observed between grain yield and straw yield and yield components *i.e.*, panicle length, panicle diameter, grain mass per plant and 1000–grain mass. Grain yield and water use efficiency (WUE) was significantly and positively correlated (0.992).

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench), a coarse cereal grain crop is being preferred as staple food of a considerable proportion by the population; its stover being a major source of fodder for dairy cattle, a prime source of income in dryland region of Northern Karnataka. In India, sorghum ranks third in importance after rice and wheat, and is extensively cultivated over an area of 10.50 million hectares with a production of 9.50 million tones and a meager productivity of 905 kg ha^{-1} (FAO, 2000). Karnataka is a leading State next to Maharashtra in sorghum cultivation. In Karnataka, winter (*rabi*) sorghum alone is grown over an area of nearly 65% with 44%

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production (Birdar *et. al.*, 2002). Sorghum grown during winter season can withstand water stress and is drought tolerant. Economic yield in sorghum is a complex character it depends upon growth and yield attributes and environment. The knowledge on the association between yield and other biometrical traits and associating among the yield component traits themselves will be helpful in effecting selection for the yield through the components that have direct correlations to yield. The greater the magnitude of correlation co–efficient, the stronger is the association (Pooran Chand, 2000; Sankarapandian, 2000). Thus, in addition to genetic characteristics, climate and management practices finally determine the yield of winter sorghum in Vertisols of Semi–Arid Tropics in South India. A field experiment was conducted during winter season of 2002–03, under All India Coordinated Sorghum Improvement Project (AICSIP) to know the nature of association component characters with grain yield of winter sorghum.

MATERIAL AND METHODS

A field experiment was laid out at the Research Farm of Central Soil and Water Conservation Research and Training Institute, Research Centre, Bellary, Karnataka State, India, on lands having 0.5% slope with the objective to study the association analysis of grain yield with its attributes and growth components in a randomized block design in three replications under AICSIP, with 14 sorghum varieties including local (M35–1) in winter sorghum during 2002–03. Due to late onset of northeast monsoon and after 125.7 mm rainfall that fell from 8–17 October (Antecedent rainfall), the crop was sown on 20 October, when the top 45 cm soil profile was completely wet. The germination of all the varieties was uniform and was attributed to complete wetting of topsoil profile at sowing. Winter sorghum was sown to a depth of 5 cm with seeds spaced at 15 cm in rows of 45 cm apart and with application of 30 kg N and 30 Kg P_2O_5 per ha through urea and single super phosphate, respectively. Drought occurred at the reproductive stages of crop growth during 2002–03 were attributed to the small quantity of rainfall (9.8 mm) that fell during the cropping season. Crop was harvested on 15 February 2003. All the agronomic package of practices and plant protection measures were followed. Growth and yield components were recorded at harvest of the crop. Grain and straw yield from net plot was harvested; sun dried, weighed and further converted to either kg ha^{-1} or t ha^{-1}, respectively. Harvest index was calculated by using the formula suggested by Donald (1962). Dry matter efficiency is the ratio of harvest index to the duration of crop and was calculated by the formula as suggested by Krishnamurthy *et. al.*, (1973). Soil water was gravimetrically determined in 0–15, 15–30 and 30–60 cm soil depths in each treatment at sowing, at different stages of crop growth and at harvest. Soil water utilized was computed as the difference of soil water at sowing, at different stages of crop growth and at harvest. The consumptive use of water was worked out by taking the difference in the values of soil water content (cm) in top 60 cm soil profile between any two stages and further adding the rainfall and subtracting the runoff during the relevant period. The above procedure was repeated from sowing up to harvest at every stage and added to arrive at consumptive use of water in cm. Water use efficiency (WUE) was worked out by dividing economic yield by water utilized (cm) and expressed in kg ha^{-1} cm^{-1}. Statistical analysis for all the characters was worked out by the methods suggested by Gomez and Gomez (1984). The correlation analysis was carried out by the method suggested by Johnson *et. al.*, (1955).

RESULTS AND DISCUSSION

A meager amount of rainfall received during September (6.4 mm) as against the mean average rainfall of 118.9 mm (mean of 1956–2000) resulted in late sowing of sorghum crop (20 October) during winter season of 2002–03. Antecedent rainfall of 125.7 mm received from 8–17 October resulted in uniform wetting of soil profile (top 45 cm) at the time of sowing. This has resulted in uniform germination and crop stand at the initial stages of crop growth. In general, the performance of all the varieties of winter sorghum was more than the expected even though the crop season rainfall was only 9.8 mm in one rainy day was attributed to clear weather with minimum incidence of pests and diseases to the sorghum crop. The performance of short duration and drought tolerance varieties was better than the varieties with long duration and sensitive to water stress. The SPV 1589 was considered as control due to its lower grain and straw yields. The local variety (M35–1) and the variety which yielded lower yield (CSV 216 R) were not considered as control because, (i) The local variety is drought tolerant and is suitable and recommended for late sowing with excellent grain and fodder quality. ii) Phulae Yashoda (CSV 216 R) recorded the lower grain yield and higher straw yield during 2002–03 and its performance under normal and above normal years was good both on farm and on station in Vertisols during 2001–02 (Anon. 2002).

Among the varieties evaluated during winter season of 2002–03, RSLG 262 (Mouli) recorded significantly greater grain (2041 kg ha^{-1}) and straw yield (3.11 t ha^{-1}) over rest of the varieties (Table 1). There was not much significant variation in the grain yields of SPV 1591 (1919 kg ha^{-1}) and SPV 1546 (1832 kg ha^{-1}) as compared to Mouli, indicating that they are also suitable for late sowing (October 2nd fortnight) with drought tolerance especially the late drought (at grain filling). The varieties that recorded greater grain and straw yield utilized greater amount of soil water in top 60 cm soil profile from 60 DAS upto physiological maturity and resulted in good crop growth with higher dry matter production per plant and its translocation to ear. Greater harvest index (42.8) was observed in SPV 1537, followed by Mouli (39.6) (Table 1). Shorter plant with greater dry matter translocation to ear in SPV 1537 resulted in

Table 1: Grain Yield, Straw Yield, Harvest Index and Dry Matter Efficiency of Sorghum Varieties Cultivated During Winter Season of 2002–03 in Vertisols

Varieties	Grain yield (kg ha^{-1})	Per cent increase over SPV 1589	Straw yield (t ha^{-1})	Harvest Index	Dry matter efficiency
SPV 1537	1705	8.7	2.27	42.8	0.471
SPV 1546	1832	16.8	3.05	37.5	0.341
SPV 1548	1534	–2.2	2.56	37.3	0.349
SPV 1549	1521	–3.0	2.74	35.7	0.303
SPV 1587	1761	12.3	2.98	37.1	0.323
SPV 1588	1659	5.8	2.76	37.3	0.315
SPV 1591	1919	22.4	3.14	37.9	0.368
SPV 1592	1681	7.2	2.90	36.6	0.330
SPV 1595	1600	2.0	2.67	37.4	0.319
CSV 14R	1732	10.5	2.93	37.2	0.331
CSV 216R	1516	–3.3	2.95	34.1	0.289
RSLG 262 (Mouli)	2041	30.2	3.11	39.6	0.366
M35–1	1659	5.8	2.94	36.1	0.325
SPV 1589	1568	—	2.54	38.2	0.338
S.Em.±	99	—	0.125	1	0.009
CD (P=0.05)	289	—	0.362	2.9	0.027

greater harvest index even though it produced the lower grain yield (1705 kg ha^{-1}). Significantly greater dry matter efficiency was observed in SPV 1537 (0.471) as compared to other varieties. This was mainly attributed to shorter duration of crop (91 days) as compared to the better–performed varieties as they matured late *i.e.*, Mouli (0.366 and 108 days), SPV 1591 (0.368 and 103 days) and SPV 1546 (0.341 and 110 days).

Growth Components

Significant and positive correlation was observed in grain yield with dry matter production and its distribution to stem and ear at harvest indicating their strong association with the grain yield. Grain yield was significantly correlated with ear mass per plant (0.837^{**}), dry matter production per plant (0.731^{**}), followed by stem mass per plant (0.569^{*}) (Table 2). Among the growth components, ear mass per plant with dry matter production per plant was significantly correlated (0.952^{**}), followed by stem mass with dry matter production per plant (0.923^{**}), leaf mass per plant with dry matter production per plant (0.858^{**}) and stem mass per plant with ear mass per plant (0.771^{**}) (Table 2). It was earlier observed in pearl millet that the plant height and grain mass per plant was significantly and positively correlated with grain yield (Anarse and Ugale, 2001 and Veerabadhiran and Kennedy, 2001). In cotton, dry matter accumulation per plant at 80, 100 and 120 days after sowing was significantly and positively correlated with grain yield, indicating that greater the dry matter production per plant greater is the grain yield per plant (Venugopalan and Blaise, 2001). Khajan Singh and Lata Choudry (2000) quoted that stover yield per plant indicated positive and significant correlation with plant height, number of leaves per plant, leaf area per plant and flag leaf area per plant in sorghum. The results of the present studies indicate that the dry matter production and ear mass per plant ultimately determines the winter sorghum yield per unit area.

Yield Components

Grain yield was positively and significantly correlated with water use efficiency, straw yield and yield components *i.e.*, grain mass per plant, ear length, ear diameter and 1000–grain mass (Table 3). The magnitude of correlation coefficient was greater with water use efficiency (WUE) and grain yield (0.992^{**}), thereby, indicating that every unit of water available in the soil profile was efficiently utilized to produce greater grain yield especially

Table 2: Estimates of Correlation Coefficient Among Growth Components and Grain Yield of Winter Sorghum in Vertisols

	Plant height (cm)	50 per cent flowering	Leaf mass per plant (g)	Stem mass per plant (g)	Ear mass per plant (g)	Dry matter production per plant (g)	Grain yield (kg ha^{-1})
Plant height (cm)	1.000	0.512	0.162	0.205	0.130	0.180	0.153
50 per cent flowering		1.000	–0.142	–0135	–0.324	–0.235	–0.450
Leaf mass per plant (g)			1.000	0.671**	0.850**	0.858**	0.512
Stem mass per plant (g)				1.000	0.771**	0.923**	0.569*
Ear mass per plant (g)					1.000	0.952**	0.837**
Dry matter production per plant (g)						1.000	0.731**
Grain yield (kg ha^{-1})							1.000

Note: * – Significant at 5%; ** – Significant at 1%.

Table 3: Estimates of Correlation Coefficient Among Grain Yield, Yield Components, Consumptive Use and Water Use Efficiency of Winter Sorghum in Vertisols

	Grain yield (kg ha^{-1})	Straw yield	Harvest index	Dry matter efficiency	Panicle length (cm)	Panicle diameter (cm)	Grain mass per plant (g)	1000 grain mass (g)	Grains per ear	Consumptive use (cm)	Water use efficiency (kg ha^{-1} cm–1)
Grain yield (kg ha^{-1})	1.000	0.585*	0.452	0.380	0.574*	0.812**	0.812**	0.953**	0.042	–0.207	0.992**
Straw yield (t ha^{-1})		1.000	–0.456	–0.449	0.637*	0.326	0.574*	0.606*	0.252	–0.428	0.621*
Harvest Index			1.000	0.933**	–0.053	0.549	0.292	0.391	–0.182	0.234	0.404
Dry matter efficiency				1.000	–0.076	0.513	0.338	0.352	–0.019	0.277	0.333
Panicle length (cm)					1.000	0.483	0.730**	0.556*	0.519	–0.707**	0.642*
Panicle diameter (cm)						1.000	0.647*	0.794**	0.011	–0.118	0.797**
Grain mass per plant (g)							1.000	0.815**	0.567*	–0.434	0.838**
1000 grain mass (g)								1.000	0.027	–0.187	0.941**
Grains per ear									1.000	–0.544*	0.110
Consumptive use (cm)										1.000	–0.329
Water use Efficiency (kg ha^{-1} cm^{-1})											1.000

Note: *– Significant at 5%; **– Significant at 1%.

during drought years when sown late (October 2nd fortnight). The magnitude of correlation coefficient between grain and straw yield was significant (0.585^{*}) and was attributed to significant and positive correlation existed between grain yield and leaf and stem mass and dry matter production per plant. This indicates that better plant growth results in greater grain yield. greater ear size *i.e.,* ear length (0.574^{*}) and ear diameter (0.812^{**}) with greater dry matter accumulation in ear *i.e.,* grain mass per plant (0.812) and 1000–grain mass (0.953^{**}), ultimately determines the grain yield in winter sorghum. It is therefore, advised to manipulate the environment (management practices) that improves the above characters in winter sorghum under dryland conditions in Vertisols of Semi–Arid Tropics of South India and increase the sorghum yields in addition to manipulation in genetic characters. The findings of present investigation coincide with the earlier results observed in sorghum by Navale *et. al.,* (2000), Pawar and Jadav (1996) and Veerabadhiran and Kennedy (2001) and in pearl millet by Anarase and Ugale (2001) and Patil (1994). Harvest index and dry matter efficiency was positively significantly and correlated (0.933^{**}). This indicates that shorter the duration of varieties with greater dry matter production and its translocation to ear that escapes the terminal drought especially when crop is sown late during drought years are better than the varieties that mature late and experience late drought with lower of dry matter translocation to ear.

Among the yield components, greater correlation coefficient was observed between 1000–grain mass and grain mass per plant (0.815^{**}), followed by 1000–grain mass and panicle diameter (0.794^{**}), grain mass per plant and panicle length (0.730^{**}). These results indicates that in sorghum, both genetic and environment (crop management practices) should be such that in the initial vegetative growth stages plant should grow better with higher dry matter accumulation in leaf and stem and in later reproductive stages it should be translocated to ear resulting in greater ear and grain size that finally results in higher grain yield.

CONCLUSION

The greater dry matter production per plant is an indication of accumulation of greater amount of carbohydrates during the vegetative phase and its subsequent translocation in reproductive parts during later stages results in greater grain yield. This was indicated by the significant correlation existed between dry matter production per plant and dry matter accumulation in ear with larger ear size *i.e.*, ear length and ear diameter that influence the grain yield in winter sorghum under dryland conditions in Vertisols. These characters must be given more importance in breeding programmes to evolve drought resistant varieties in winter sorghum in Vertisols under dryland conditions.

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References

1. Anarse, S. A. and Ugale, S. D. 2001. Correlation and path–coefficient analysis in pearl millet. *Madras Agric. J.* 88: 528–530.
2. Biradar, B. D., Honyal, S. C., Vastrad, S. M., Balikai, R. A. and Jahagiradar, S. 2002. SPV 1380–A promising *rabi* sorghum variety. *Crop Res.* 23: 34–39.
3. Donald, C. M. 1962. In search of yield. *J. Australian Instt. Agric. Sci.* 28: 171–178.
4. FAO. 2000. FAO Bull. Statistics 1 (2): 162 pp.
5. Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research, 2nd Edition, Wily–InterScience Publication, New York.
6. Johnson, H.W., Robinson, H. F. and Comstock, R. F. 1955. Estimates of genetic and environmental variability in soybeans. *Agron. J.* 47: 314–318.
7. Khajan Singh and Lata Chaudhary. 2000. Component analysis for stover yield in sorghum. *Ann. Arid Zone* 39: 195–197.
8. Krishnamurthy, K., Bommegouda, A., Venugopal, N., Jagannath., Raghunath, C. and Rajashekhar, B. G. 1973. Investigations on the varietal differences on the growth components of maize and sorghum. *Mysore J. Agric. Sci.* 7: 377–384.
9. Pooran Chand. 2000. Correlation in forage sorghum *J. Res. ANGARU.* 4: 87–88.
10. Navale, P. A., Nimbalkar, C. A. and Gandhi, H. T. 2000. Correlation and regression analysis in *rabi* sorghum. *J. Maharashtra agric. Univ.* 25: 320–321.
11. Patil, B. D. 1994. Studies on gene action and transgressive segregation in pearl millet (*Pennisetum americanum* (L.) Leelal) *Ph. D. Thesis*, M.P.K.V., Rahuri, Maharashtra, India.
12. Pawar, K. P. and Jadav, A. S. 1996. Correlation and path analysis in *rabi* sorghum. *J. Maharashtra agric. Univ.* 25: 344–347.

13. Sankarapandian, R. 2000. Correlation and path analysis of quantity and quality traits of fodder sorghum hybrids and their parents. *The Andhra Agric. J.* 47: 191–196.

14. Veerabadhiran, P. and Kennedy, V. J. F. 2001. Correlation and path analysis studies in selected germplasms of sorghum. *Madras Agric. J.* 88: 309–310.

15. Venugopalan, M. V. and Blaise, D. 2001. Effect of planting density and nitrogen level on canopy spectral reflectance and productivity of upland cotton (*Grossypium hirsutum*). *Indian J. Agric. Sci.* 71: 618–620.