International Journal of Agricultural Sciences ISSN 2167-0447 Vol. 5 (1), pp. 381-385, January, 2015. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full length Research paper

Response of Grain Sorghum(*Sorghum bicolor* L.) Cultivars to different fertilizer levels under rainfed condition

[1]P. Sujathamma, [2]K. Kavitha and [3]V. Suneetha

[1]Scientist (Agronomy), Regional Agril, Research Station, Palem-509215, Mahabubnagr, Telanagana, India.
[2]Scientist (Entomology), RARS, Palem-509215, Mahabubnagr, Telanagana, India.
[3]Assistant professor, APT, Palem-509215, Mahabubnagr, Telanagana, India.

Accepted 10 December, 2014

Sorghum cultivars are known to vary in their response to fertilizers. Therefore, a field study was conducted during *kharif* 2013 with eight sorghum cultivars (SPH 1703, SPH 1705, SPV 2110, SPV 2122, SPV 2061, CSH 16, CSV 20 and CSV 23) and three fertilizer levels (50% RDF, 75% RDF and 100% RDF). Effect of these treatments was observed on crop growth, yield attributes, yield, nutrient uptake and economics. Among the cultivars the highest grain yield (3.9 t ha^{-1}), gross returns (Rs 98.8x10^3 ha^{-1}), net returns (Rs 74.7x10^3 ha^{-1}) and benefit cost ratio (3.1) as well as the highest N, P, K uptake by grain was recorded with SPH 1703, which was on par with SPV 2122. Among the fertilizer levels, application of 100% RDF (N-P_2O_5-K_2O 80-40-40 kg ha^{-1}) recorded the highest grain (3.75 t ha^{-1}) and stover (14.3 t ha^{-1}) yields, gross returns (Rs 96.7 x 10^3 ha^{-1}), net returns (Rs 71.5 x 10^3 ha^{-1}) and benefit cost ratio (2.8) as well as the highest N, P, K uptake both by grain and stover.

Key words: Grain Sorghum, cultivars, fertilizer levels, monetary returns, NPK uptake.

INTRODUCTION

Sorghum is one of the major cereal crops consumed in India after rice and wheat (DES, 2007). India is the third largest producer of sorghum in the world with 7.0 m t during 2010-11. The crop is primarily produced in Maharashtra and Southern states of Karnataka and Telangana. Almost entire production of sorghum (95%) in the country comes from the above three states (Directorate of Economics and Statistics, Development of Agriculture and Cooperation, 2012).

Mahaboobnagar district is one among the three districts of Southern Telangana Zone of Telangana. This is semi arid region with 82% of area under rainfed condition. Red soils are predominant in the district occupying 94.7% of the net cultivated area. The normal rainfall of the district is 604 mm, out of which more than 93% is received during south west monsoon. The effective crop growing period is 90-100days. The temperature ranges from 16.9^{o}C to 45^{0}C during the year. Hence, sorghum is most suitable and predominant crop growing in an area of 1.0- 1.2 lakh ha every year.

Low productivity of sorghum is one of the major constraints. Reasons for which are identified as lack of improved high yielding cultivars, delayed sowing, low fertilizer use and improper adoption of management techniques. Hence, there is dire need to identify high yielding cultivars suitable for the region with optimum fertilizer dose.

Sorghum cultivars are known to vary in their response to fertilizers. Productivity of sorghum is limited by soil fertility. Kumar *et al*., (2010) reported that the increase in productivity of sorghum could be brought out both by genetic improvement as well as associated nutrient management intervention in a rainfed environment. Hence, there is a need to explore and evaluate the interaction of sorghum cultivars and fertilizers application in rainfed sorghum. The present study was planned to quantify the response of sorghum cultivars to fertilizer levels and so as to develop best management practices under rainfed conditions to achieve higher yields with low cost of production.

*Corresponding author.Email:psujathamm@yahoo.com
Tel: 09948813842

Table 1. Response of certain sorghum cultivars to different fertilizer levels on plant height (cm).

Fertilizer levels	Cultivars								
	SPH 1703	SPH 1705	SPV 2110	SPV 2122	SPV 2061	CSH 16	CSV 20	CSV 23	Mean
50% RDF (N-P_2O_5-K_2O 40-20-20 kg ha^{-1})	184.3	207.7	260.0	238.0	225.0	209.7	219.7	215.7	220.0
75% RDF (N-P_2O_5-K_2O 60-30-30 kg ha^{-1})	215.0	220.0	257.3	244.3	261.7	228.7	239.0	254.0	240.00
100% RDF(N-P_2O_5-K_2O 80-40-40 kg ha^{-1})	257.0	228.0	264.3	259.7	270.7	229.7	252.3	265.7	253.4
Mean	218.8	218.6	260.6	247.3	252.4	222.7	237	245.1	
SEm±	Fertilizer levels : 2.61		Cultivars: 4.26		C X F =7.37				
CD (P=0.05)	Fertilizer levels : 7.4		Cultivars: 12.1		C X F =21.0				

MATERIALS AND METHODS

The field experiment was conducted during *kharif* 2013 at Regional Agricultural Research Station, Palem, Telangana. The experimental site is situated at (16°35”N to 78°1”E with altitude of 642m above the mean sea level). The soil was sandy clay loam in texture, slightly alkaline (P^H 8.07), medium in organic carbon (0.38%), low in available N (213 kg ha^{-1}) and P (24 kg ha^{-1}) and high in available K (708 kg ha^{-1}). The seasonal mean temperature ranged between 27.4° C and 37.6° C (Max) and 20.1° and 24.4° (Min). Total rainfall of 579.4 mm was distributed over 44 rainy days. Twenty four treatment combinations *viz*., eight sorghum cultivars (SPH 1703, SPH 1705, SPV 2110, SPV 2122, SPV 2061, CSH 16, CSV 20 and CSV 23) and three fertilizer levels 50% RDF, 75% RDF and 100% RDF were laid out in a factorial randomised block design with three replications. Among the cultivars SPH 1703, SPH 1705 are test hybrids and SPV 2110, SPV 2122, SPV 2061 were the test inbred lines, CSH 16 is check hybrid and CSV 20 and CSV 23 are the check inbred lines.

The recommended dose of fertilizer was N-P_2O_5-K_2O 80-40-40 kg ha^{-1}. The fertilizer sources used were urea for N (46 % N), single super phosphate for P (16% water soluble P_2O_5), muriate of potash for K (60 %). As per the treatments entire dose of P and K and half of the N were applied at the time of sowing. The remaining dose of N was applied at 30 DAS. Seed rate was 7.5 kg ha^{-1}. The seed was sown manually by labourers on 11.06.2013 with a spacing of 45cm between rows and 15 cm between plants. The crop was harvested on 19-09-2013. The cultivation practices were followed as per the guide lines of crop production given by Directorate of Sorghum Research (Chari Appaji and Raghavendra Rao, 2010). The growth and yield parameters as well as yield at harvest were recorded as per standard procedures. The nutrient content in soil and uptake by crop were analysed through prescribed laboratory procedures. The amount of inputs and outputs per hectare were multiplied with a wage or price of the unit to consolidate all of them in one unit (Rs ha^{-1}) to find out the economic indices *viz*., total cost of production, gross returns, net returns and benefit cost ratio. The data were analysed statistically by using analysis of variance according for a factorial randomised block design (2 factors) (Gomez and Gomez 1984) and the differences of means were identified by critical difference (CD) at P ≥ 0.05, by using MSTAT – C package, version 1.47.

RESULTS AND DISCUSSION

Crop-growth parameters

The results presented in Table (1) on response of certain cultivars of sorghum to different levels of fertilizers on plant height indicated that there was significant response of all the tested cultivars of sorghum to levels of fertilizers applied on plant height. In general, cultivar SPV 2061 responded at 100% recommended dose of fertilizer application resulting in a maximum plant height of 270.7 cm compared to SPH1703 with a minimum plant height of 184.3 cm. The variation in plant height in sorghum varieties at different levels of fertilizer application was also earlier reported by George Yakubu Mahama (2012). Among the cultivars there was variation in plant height and the cultivars, SPV 2110 and SPH 1705 recorded a maximum (260.6 cm) and minimum (218.6 cm) plant height respectively. Similarly there was increase in plant height with increase in levels fertilizer application with a maximum (253.4 cm) and minimum (220 cm) pant height at 100% and 50% recommended dose of fertilizer levels respectively. This could be attributed to soil enrichment with higher level of nutrients which owing to provide sufficient nutrients that are essentially required to various metabolic processes and finally resulting in plant growth.

Among the cultivars, time for days to 50%flowering ranged from 58 to 70 days (Table 2). Among cultivars, SPH 1703 flowered 6 days earlier than check hybrid CSH 16. Inbred lines generally flowered late relative to the hybrids. Variation in phenology of grain sorghum was

Table 2. Effect of fertilizer levels, cultivars and their interaction on yield attributes, grain and stover yields as well as harvest index of sorghum.

Treatment	Days to 50% flowering	Panicle length (cm)	No. of grains panicle^{-1}	Test weight. (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest Index (%)
Cultivars							
SPH 1703	58	27.5	1679	3.2	3.90	13.01	23.2
SPH 1705	65	26.2	1585	2.9	3.27	14.51	18.4
SPV 2110	64	24.2	1568	3.1	3.55	13.51	21.0
SPV 2122	66	25.0	1606	3.1	3.84	13.13	22.7
SPV 2061	67	24.6	1501	3.1	2.95	11.97	19.8
CSH 16	64	27.9	1547	4.4	3.75	10.18	27.3
CSV 20	68	22.6	1445	3.3	2.94	14.01	17.4
CSV 23	70	22.6	1450	3.1	2.45	13.76	15.1
SEm±	0.3	0.62	29.6	0.13	0.11	0.58	0.87
CD (P=0.05)	0.9	1.76	84	0.4	0.32	1.67	2.5
Fertilizer levels							
50% RDF	66	23.3	1426	3.1	2.94	11.94	19.9
75% RDF	65	25.5	1551	3.2	3.31 (12.6%)	12.78	20.9
100% RDF	63	26.4	1666	3.4	3.75 (27.6%)	14.32	21.0
SEm±	0.2	0.38	18.1	0.08	0.07	0.36	0.53
CD (P=0.05)	0.6	1.08	52	0.2	0.20	1.02	NS
Interaction							
SEm±	0.6	1.1	51.3	0.23	0.20	1.01	1.51
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

100% RDF (N-P_2O_5-K_2O 80-40-40 kg ha^{-1}).

also reported by George Yakubu Mahama (2012). Days to 50% flowering differed significantly with increase in fertilizer levels. Application of 100% RDF (N-P_2O_5-K_2O 80-40-40 kg ha^{-1}) reduced the number of days required for 50% flowering (63days) compared to 50% RDF (66 days).

Yield attributes

Yield attributes *viz.,* panicle length, number of grains panicle^{-1} and test weight were significantly influenced by cultivars and fertilizer levels (Table 2). The interaction failed to influence them significantly. Among the cultivars, test hybrid SPH 1703 and test inbred line SPV 2122 recorded longer panicles and higher number of grains panicle^{-1}. The highest test weight was recorded with CSH 16 (4.4 g). Panicle length, number of grains panicle^{-1} and test weight were increased with increasing levels of fertilizers (Table 2). Maximum yield attributes were observed with the application of higher dose of fertilizer i.e. 100% RDF. This might be due to higher sink at higher level of nutrition manifested yield attributes to the maximum.

Grain and stover yields

Sorghum cultivars exhibited significant difference in grain and stover yield (Table 2). Among the cultivars, hybrid SPH 1703 recorded the higher grain yield but which was on par with SPV 2122. The hybrids generally performed better than the inbred lines. Better yield of these cultivars manifested in seed number. The highest stover yield was recorded with SPH 1705, which on par with SPV 2110, SPV 2122 and SPH 1703. Increasing fertilizer levels significantly enhanced grain yield. Application of 100% RDF recorded the highest grain (3.7t ha^{-1}) and stover (14.3 t. ha^{-1}) yields. Application of 100% RDF (N-P_2O_5-K_2O 80-40-40 kg ha^{-1}) recorded 27.6% and 12.6% increa-

Table 3. Effect of fertilizer levels, cultivars and their interaction on economics of sorghum.

Treatment	Gross returns ($x10^3$ Rs ha^{-1})	Net returns ($x10^3$ Rs ha^{-1})	Benefit : cost ratio
Cultivars			
SPH 1703	98.8	74.7	3.1
SPH 1705	86.4	62.3	2.6
SPV 2110	91.4	67.6	2.8
SPV 2122	97.5	73.7	3.1
SPV 2061	76.9	53.1	2.2
CSH 16	92.7	68.6	2.8
CSV 20	78.5	54.7	2.3
CSV 23	67.0	43.7	1.8
SEm±	2.7	2.7	0.11
CD (P=0.05)	7.69	7.6	0.3
Fertilizer levels			
50% RDF	76.3 (26.7%)	53.8 (33%)	2.4
75% RDF	85.5 (13.1%)	61.6 (16%)	2.6
100% RDF	96.7	71.5	2.8
SEm±	1.65	1.64	0.07
CD (P=0.05)	4.71	4.66	0.2
Interaction			
SEm±	4.68	4.6	0.20
CD (P=0.05)	NS	NS	NS

100% RDF (N-P_2O_5-K_2O 80-40-40 kg ha^{-1}).

se in grain yield over 50% RDF (N-P_2O_5-K_2O 40-20-20 kg ha^{-1}) and 75% RDF (N-P_2O_5-K_2O 60-30-30 kg ha^{-1}) respectively. Increased grain and stover yields at 100% RDF could be due to an increase in N, P and K uptake and also it may be due to enhanced number of grains panicle-1 and test weight. Such improvements with increasing fertilizer levels were also reported by Chouhan and Dighe, 1999, Wani *et al*., 2004, Buah and Mwinkaara 2009, Uchino *et al*., 2013 and Sami *et al*., 2014.

Harvest index (HI)

Among the cultivars studied, there was significant variation in harvest index range from 18.4 to 27.3. The highest harvest index (27.3%) was recorded with CSH 16 (Table 2). The variation found for harvest index dynamics could be largely explained by difference in assimilation during grain filling and remobilization of pre–anthesis assimilates. Genetic variation for this trait has been reported in different crop types (Slafer and Savin, 1994; Kumudini *et al*., 2002; Papakosta and Gagianas, 1991; Royo and Blanco, 1999; Bonnett and Incoll, 1993). Harvest index was not significantly influenced by fertilizer levels from 50% to 100% RDF (Table 2).

Economics

Gross returns, net returns and B:C ratio were significantly influenced by cultivars and fertilizer levels (Table 3). Among the cultivars, test hybrid SPH 1703 and check hybrid CSH 16 were on par in gross and net returns where as in test inbred lines SPV 2122 and SPV 2110 recorded higher gross and net returns as compared to their corresponding checks. The highest B: C ratio was recorded with SPH 1703 among the hybrids and with SPV 2122 among the inbred lines. The highest net returns and B:C ratio were observed with 100% RDF (N-P_2O_5-K_2O 80-40-40 kg ha^{-1}) followed by 75% RDF (Table 3). Application of 100% RDF recorded 26.7% and 13.1% increase in gross returns as well as 33% and 16% increase in net returns compared to 50% and 75% RDF. The results confirm the findings of Mishra *et al.* (2009).

Table 4. Effect of cultivars, fertilizer levels and their interaction on nutrient uptake.

Treatment	Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})	
	Grain	Stover	Grain	Stover	Grain	Stover
Cultivar						
SPH 1703	50.63	62.62	11.40	16.16	10.75	176.46
SPH 1705	42.09	69.21	10.10	18.17	8.56	180.01
SPV 2110	46.58	56.76	10.61	16.36	9.50	164.18
SPV 2122	50.33	60.66	11.10	16.64	10.01	176.21
SPV 2061	39.87	50.92	8.71	14.67	7.35	144.71
CSH 16	49.20	43.89	10.74	12.53	9.54	121.68
CSV 20	39.06	55.29	7.34	16.98	6.70	178.94
CSV 23	33.01	56.90	5.81	16.43	5.72	177.18
SEm±	1.55	3.22	0.32	0.82	0.17	7.41
CD (P=0.05)	4.42	9.16	0.92	2.34	0.48	21.1
Fertilizer levels						
50% RDF	33.30	35.01	6.46	12.71	6.54	132.4
75% RDF	43.88	53.17	9.35	15.64	8.44	160.2
100% RDF	54.35	82.91	12.63	19.63	10.56	202.1
SEm±	0.95	1.97	0.20	0.50	0.17	4.54
CD (P=0.05)	2.70	5.66	0.56	2.34	0.48	12.92
Interaction						
SEm±	2.69	5.57	0.56	1.42	0.47	12.83
CD (P=0.05)	NS	NS	NS	NS	NS	NS

100% RDF (N-P_2O_5-K_2O 80-40-40 kg ha^{-1}).

Interaction between cultivars and fertilizer levels did not influence significantly on the gross returns, net returns and B: C ratio.

Nitrogen, phosphorus and potassium uptake of sorghum grain and stover were varied significantly by sorghum cultivars and fertilizer levels but their interaction did not influence them significantly (Table 4). Among the cultivars, the highest N, P, K uptake by grain was recorded with SPH 1703, which was on par with SPV 2122. The highest N, P, K uptake by stover was recorded with SPH 1705, which was on par with SPH 1703 and SPV 2122. This might be due to higher grain and stover yields of these genotypes. This concur with the findings of Dhugga and Waines (1989) who have showed that, genotypes with high yield potential accumulated more nutrients than genotypes with less yield potential. Among the three fertilizer levels, the highest N, P, K uptake both by grain and stover was recorded with 100% RDF. Nutrient uptake is a function of nutrient concentration and grain/ stover yields. Increase in the level of nutrients application caused a corresponding increase in nutrient concentration in both grain and stover.

It was concluded that among the hybrids, SPH 1703 and among the inbred lines, SPV 2122 was recommended for higher grain yields of sorghum. Application of 100% recommended dose of fertilizer (N-P_2O_5-K_2O 80-40-40 kg ha^{-1}) to all the cultivars of sorghum proved optimum for higher yields, gross and net returns.

REFERENCES

Bonnett GD, Incoll LD (1993). Effects on the stem of winter barley of manipulating the source and sink during grain–filling I. Changes in the composition of water–soluble carbohydrates of internodes. J. Exp. Bot. 44: 83 – 91.

Buah SSJ, Mwinkaara S (2009). Response of sorghum to nitrogen fertilizer and plant density in the Guinea Savanna zone. J. Agron. 8: 124-130.

Chari Appaji, Raghavendra Rao KV (2010).Pamphlet on Sorghum production technology, DSR doc. # 7-10/07.

Chouhan SS, Dighe JM (1999).Chemical composition, yield and yield attribute of sorghum genotypes under different fertility levels in Malwa region. Crop Res.17: 149- 152.

DES(2007). Agriculture Statistics at a Glance. Directorate of Economics and Statistics.New Delhi, India: Minisry of

Agriculture, Government of India. Available at http:// www. Agritech. Tnau.ac.in/pdf/statis/page% 201-37. Pdf.Accessed on 2 August 2014.

Dhugga KS, Waines JG (1989). Analysis of nitrogen accumulation and use in bread durum wheat. Crop Sci. 29:1232 – 1239.

Directorate of Economics and Statistics, Development of Agriculture and Cooperation 2012. New Delhi, India: Minisry of Agriculture, Government of India. Available at http:// www. Agritech. Tnau.ac.in/pdf/statis/page%201-37. Pdf. Accessed on 2 August 2014.

George Yakubu Mahama (2012). Variation among grain sorghum genotypes in response to nitrogen fertilizer. M. Sc. Thesis, submitted to Department of Agronomy, College of Agriculture, Kansas State University, Manhatton, Kansas.

Gomez KA, Gomez AA (1984). Statistical procedures for Agricultural Research. John Wiley and Sons, Inc. London, UK (2nd edtn.) 13-175

Kumar SR, Ramanjaneyulu AV, Krishna A (2010). A decadal analysis of improved sorghum (*Sorghum bicolor*) cultivar response to fertilizer application in rainy season and hypothetical grain production model.Indian J. Agric. Sci. 80(9): 786-90

Kumudini S, Hume DJ, Chu G (2002). Genetic improvement in short–season soybeans(*Glycine max L*.): II. Nitrogen accumulation, remobilization and partitioning. Crop Sci. 42:141 – 145.

Mishra JS, Raut MS, Singh, Pushpendra, Kalpana R, Khubsad VS, Lokhande OG, Patel ZN, Thakur NS, Nemade SM, Kumar, Pramod, Kewalanand (2009).Sorghum Agronomy – *Kharif* 2001. Agronomy Report. Directorate of Sorghum Research, (Indian council of Agricultural Research). Rajendranagar, Hyderabad, AP.

Papakosta DK, Gagianas AA (1991). Nitrogen and dry matter accumulation, remobilization, and losses for Mediterranean wheat during grain filling. Agron. J. 83: 864 – 870.

Royo, C., and Blanco, R. 1999. Growth analysis of five spring and five winter triticale genotypes. Agron. J. 91:305 – 311.

Sami IMN, Gabir, Manoj Khanna, Man Singh, Parihar, SS, Indra Mani, Das TK (2014). Effect of conservation practices and fertilizer on sorghum (*Sorghum bicolor*) yield under rainfed conditions of northern India. Indian J. Agron. 59(2): 301-305.

Slafer GA, Savin R (1994). Sink–source relationships and grain mass at different positions within the spike in wheat (*Triticum stivum* L.). Field Crops Res. 37: 39 – 49.

Uchino H, Watanabe T, Ramu K, Sahrawat KL, Marimuthu S, Wani SP, Ito O (2013). Effects of nitrogen application on sweet sorghum (Sorghum bicolor (L.) Moench) in the semi-arid tropical Zone of India. Jarq. 47 : 65-73.

Wani AG, Narkhede BN, Pachane DP (2004). Performance of *rabi* sorghum (*Sorghum bicolor* L.) genotypes under rainfed conditions at varying fertility levels. Indian J. of Dryland Agric. Res. Dev. 19(1): 61-63.