Forage Res., **42** (3) : pp. 166-171 (2016) **http://forageresearch.in**

EFFECTS OF VARYING SEED RATES OF INTERCROPS ON FORAGE YIELD OF SWEET SORGHUM

BRAJKISHOR PRAJAPATI* AND KEWALANAND

Department of Agronomy
G. B. Pant University of Agriculture & Technology,
Pantnagar-263 145 (Uttarakhand), India
**(e-mail : brajkishorprajapati1@gmail.com)*

(Received : 13 October 2016; Accepted : 24 December 2016)

SUMMARY

The experiment was conducted at G. B. Pant University of Agriculture & Technology, Pantnagar, U. S. Nagar, Uttarakhand, India during **kharif** seasons of 2013 and 2014 (sown on 10th June and 15th June) to test intercropping treatments for optimizing seed rate. The experiment was laid out in randomized block design consisting of nine treatments (sole sorghum, sole cowpea, sole ricebean, intercropping of cowpea and ricebean each with at 25, 50 and 75 per cent of recommended seed rates) with sweet sorghum. The recommended fertilizers viz., nitrogen (N) and P_2O_5 120 and 60 kg/ha for sole sorghum, 20 and 60 kg/ha for sole legumes and 80 and 60 kg/ha for intercropping systems, respectively, were applied. In sole sorghum 2/3 N along with all phosphorus were applied as basal and the remaining 1/3 N top dressed at 30 DAS. In legume crops, whole nitrogen along with phosphorus was applied as basal. The findings revealed that intercropping of cowpea with 25 per cent seed rate maintained higher green forage, dry fodder and digestible dry matter yield in sweet sorghum as well as the system productivity compared to remaining treatments, however, it was at par with sweet sorghum+cowpea (50%) intercropping treatment. Intercropping system reduced green forage, dry fodder, crude protein yield and crude protein content of cowpea and ricebean but enhanced the digestible dry matter yield. However, the digestible dry matter content of cowpea and ricebean remained unaffected.

Key words : Cowpea, sorghum, seed rate, rice bean

Intercropping of cereals with legumes is a recognized practice for economizing the use of nitrogenous fertilizers and increasing the productivity, quality, palatability and profitability per unit area and time. However, sweet sorghum, even having good palatability, is poor in quality due to low protein content and presence of hydrocyanic acid. Forage legume, cowpea (*Vigna unguiculata* L.), is commonly grown with maize and sorghum. Being deep rooted crop and slow growing in early growth stage, during which the more rapidly growing wide spaced crops like sweet sorghum for fodder can be conveniently intercropped to utilize the natural resources more efficiently. Cowpea enhances the fodder productivity and improves nutritive value of fodder. Ricebean (*Vigna umbellata* L.) another forage legume, intercropped with wide spaced row crops, is a promising multipurpose legume with a good potential to be used as food, fodder, green manure and cover crop (Ayub *et al.*, 2004) and its dry herbage meets scarcity of green forage during lean periods. Only 40 per cent green forages are available from various sources to feed livestock which shows higher gap between supply and demand for fodder. Hence, efforts need to be made to intensify forage productivity and production per unit area and time to achieve maximum qualitative yield. Poor planting pattern, as practised in most farmers' fields, leads to low plant growth due to reduced light, mineral elements, as well as other growth factors either as a result of insufficient plants or too many plants per unit area leading to plant-to-plant or species-to-species competition thereby low yield (Hauggaard *et al.*, 2006). Keeping this in view, the experiment was conducted to find out optimum seed rate of intercrops grown with sweet sorghum.

MATERIALS AND METHODS

The experiment was conducted at G. B. Pant University of Agriculture & Technology, Pantnagar, U. S. Nagar, Uttarakhand, India during **kharif** seasons of 2013 and 2014 (sown on 10th June and 15th June). The soil of experimental field was high in organic carbon

(0.84-0.86%), medium in available nitrogen (278.48–279.90 kg/ha), available phosphorus (27.7–28.0 kg/ha) and available potassium (232.8-233.1 kg/ha) with neutral in reaction (pH 7.6). The experiment was laid out in randomized block design consisting of nine treatments (sole sorghum, sole cowpea, sole ricebean, intercropping of cowpea and ricebean each with at 25, 50 and 75 per cent of recommended seed rates) with sweet sorghum. The recommended fertilizers viz., nitrogen (N) and P_2O_5 120 and 60 kg/ha for sole sorghum, 20 and 60 kg/ha for sole legumes and 80 and 60 kg/ha for intercropping systems, respectively, were applied. In sole sorghum, 2/3 N along with all phosphorus was applied as basal and the remaining 1/3 N top-dressed at 30 DAS. In legume crops, whole nitrogen along with phosphorus was applied as basal. The sources of nitrogen and phosphorus were urea and single super phosphate (SSP). Sole and intercrops were harvested at soft dough stage of sweet sorghum. The N content of fodder on dry weight basis was estimated by micro Kjeldhal method (Jackson, 1973), crude protein was calculated from N content values. The *in vitro* dry matter digestibility was determined by nylon bag method given by Lowery (1969).

RESULTS AND DISCUSSION

Yield

Green fodder yield : The system productivity was significantly higher when sweet sorghum intercropped with cowpea at 50 per cent seed rate was compared to sole cowpea, sole ricebean, sweet sorghum+cowpea (75%), sweet sorghum+ricebean (25%) and sweet sorghum+ricebean (75%). Reduction in system productivity of sole crops was 4.87, 46.65 and 37.24 per cent, respectively, for sole sorghum, sole cowpea and sole ricebean compared to sweet sorghum+cowpea (50%). Comparing individual crops it was noticed that higher reduction in sweet sorghum yield (70.8%) was when intercropped with ricebean at 75 per cent seed rate. The highest yield due to sweet sorghum+cowpea (20-50% seed rate) might be due to more favourable completion for growth and development of both the crops. Green fodder yield of sorghum grown in association of legumes remained lower than sole crop due to completion among plants for space and suppression/alleleopathic effect of legume intercrops (Singh and Jadhav, 2003; Angadi *et al*., 2004; Ahmad *et al*., 2007). The fodder yield of both the legumes was statistically similar irrespective of seed rates but significantly less compared to sole crops yield. The highest cowpea yield was under sweet sorghum+cowpea (50% seed rate) registering a reduction of 19-28 per cent, yield of ricebean. It was highest under sweet sorghum+ricebean (75% seed rate) which registered 21-32 per cent reduction in yield. The least reduction in yield of rice bean over highest seed rate (75%) might be due to reduction in yield of sweet sorghum (Table 1). The taller cereal like sorghum reduced biological nitrogen fixation and yield of the associated legumes due to shading effect, poor dry matter production ability of legume crops and vigorous growth of main cereal crops like sorghum (Barik *et al*., 1996). The results indicated that cowpea at 50 per cent reduced seed rate was much more compatible with sorghum compared to ricebean as intercrops.

Dry matter yield : Reduction in system productivity of dry matter was least (15.2%) due to sweet sorghum+cowpea (25%) compared to sole sweet sorghum. The system productivity of intercropping system was highest in sweet sorghum+cowpea (25%), which remained at par with all other treatments but significantly higher than sole cowpea and ricebean. This might be due to highest sweet sorghum yield in sweet sorghum+cowpea (25%) intercropping system (Table 1). Among individual components of intercropping treatments, the dry fodder yield of sweet sorghum was highest, being statistically at par with sweet sorghum+cowpea (50 and 75%) and sweet sorghum+ricebean (50%) and significantly more compared to other intercropping treatments. Factors affecting green fodder yield also affected the dry matter yield. It is in conformity with findings of Barik *et al*. (1996) notifying that significant reduction in green and dry matter production of legumes intercropped may be due to poor dry matter production ability of legume crop and vigorous growth of main cereal crop like sorghum. The findings of Thippeswamy and Alagundagi (2001a) in sorghum + field bean and Patel and Rajagopal (2001) in sorghum+cowpea intercropping also conform results of present investigation. Although, intercropping system reduced sole crops fodder yield, intercropping of protein rich leguminous crops with sorghum improved the forage

TABLE 1
Green, dry fodder, digestible dry matter and crude protein yield as influenced by the treatments (Average of two years)

Treatment	Yield of different crops			
	Sweet sorghum	Cowpea	Ricebean	System productivity
		Green fodder yield (q/ha)		
Sole sweet sorghum	411.5	-	-	411.5
Sole cowpea	-	230.8	-	230.8
Sole ricebean	-	-	271.5	271.5
Sweet sorghum+Cowpea 25%	240.0	172.2	-	412.2
Sweet sorghum+Cowpea 50%	246.2	186.3	-	432.6
Sweet sorghum+Cowpea 75%	191.6	163.1	-	354.7
Sweet sorghum+Ricebean 25%	149.4	-	194.6	344.0
Sweet sorghum+Ricebean 50%	180.0	-	190.5	370.5
Sweet sorghum+Ricebean 75%	120.0	-	213.6	333.5
S. Em±	28.7	14.8	12.7	26.2
C. D. (P=0.05)	83.9	45.5	39.2	75.6
		Dry fodder yield (q/ha)		
Sole sweet sorghum	150.2	-	-	150.2
Sole cowpea	-	45.1	-	45.1
Sole ricebean	-	-	56.0	56.0
Sweet sorghum+Cowpea 25%	92.4	34.6	-	127.2
Sweet sorghum+Cowpea 50%	74.5	36.9	-	111.3
Sweet sorghum+Cowpea 75%	81.6	36.3	-	117.9
Sweet sorghum+Ricebean 25%	54.6	-	48.8	103.4
Sweet sorghum+Ricebean 50%	72.6	-	47.0	119.6
Sweet sorghum+Ricebean 75%	44.1	-	57.4	101.5
S. Em±	10.9	3.9	3.5	9.5
C. D. (P=0.05)	31.9	12.1	NS	27.5
		Digestible dry matter yield (q/ha)		
Sole sweet sorghum	70.4	-	-	70.4
Sole cowpea	-	28.4	-	28.4
Sole ricebean	-	-	36.3	36.3
Sweet sorghum+Cowpea 25%	44.8	21.8	-	66.8
Sweet sorghum+Cowpea 50%	33.1	23.6	-	56.8
Sweet sorghum+Cowpea 75%	37.8	23.5	-	61.3
Sweet sorghum+Ricebean 25%	23.6	-	31.2	55.0
Sweet sorghum+Ricebean 50%	33.2	-	30.1	63.2
Sweet sorghum+Ricebean 75%	20.3	-	36.5	56.8
S. Em±	5.8	2.3	2.3	8.4
C. D. (P=0.05)	16.9	7.2	7.0	24.4
		Crude protein yield (q/ha)		
Sole sweet sorghum	9.9	-	-	9.9
Sole cowpea	-	5.0	-	5.0
Sole ricebean	-	-	5.3	5.3
Sweet sorghum+Cowpea 25%	6.9	3.1	-	10.0
Sweet sorghum+Cowpea 50%	5.8	3.2	-	9.1
Sweet sorghum+Cowpea 75%	6.7	3.3	-	10.0
Sweet sorghum+Ricebean 25%	5.0	-	4.7	9.7
Sweet sorghum+Ricebean 50%	6.3	-	4.5	10.8
Sweet sorghum+Ricebean 75%	4.0	-	4.7	8.7
S. Em±	0.9	0.4	0.4	1.1
C. D. (P=0.05)	2.7	1.1	NS	3.2

NS–Not Significant.

quality (Shankaranaryanan *et al*., 2005). Reduction in dry fodder yield of sweet sorghum under sweet sorghum+cowpea (25%) was least (38.5%) compared to other intercropping systems. Dry matter yield of sweet sorghum was more under ricebean intercropping compared to cowpea. Yield of legumes dry fodder remained unaffected due to various intercropping systems.

Digestible dry matter yield : Intercropping treatments reduced the digestible dry matter yield than sole crops. The least reduction in digestible dry matter yield (36%) of sweet sorghum was due to sweet sorghum+cowpea (25% seed rate), of cowpea was 16.9 per cent due to sweet sorghum+cowpea (50 % seed rate) and no reduction of ricebean dry matter digestibility was noticed under sweet sorghum+ricebean (75%) treatment. Least reduction in digestible dry matter yield of the intercropping system (5% of the sole sweet sorghum) was due to sweet sorghum+cowpea (25%) treatment. This might be due to digestible dry matter content (Table 1) which was comparable to the digestible dry matter yield of sole sweet sorghum system productivity. In conformity with this finding, Verma *et al*. (1997) reported that digestible dry matter yield increased significantly in sorghum+cowpea paired row intercropping. Legume-cereal composition was considered as a management strategy in producing both high quality and quantity forage. Legumes as good source of protein were intercropped with cereals to compensate their protein shortage (Gebrehiwot *et al*., 1996). Crops-wise comparison indicated that digestible dry matter yield of sweet sorghum was significantly more due to sweet sorghum+cowpea (25%) compared to sweet sorghum+ricebean (25 and 75%). The digestible dry matter yield of cowpea was similar in all the intercroppings but significantly less than sole cowpea crop. Digestible dry matter yield of sole ricebean was at par with sweet sorghum+ricebean (75%) and these two treatments caused significantly more digestible dry matter yield than other ricebean intercroppings. Cowpea (*Vigna sinensis*) and mungbean (*Vigna radiata*) which are also used for farm animal nutrition are used to improve the forage quality in intercropping with maize (*Zea mays*), because of low protein content of maize (Hamdollah, 2012).

Crude protein yield : In general, crude protein yield was highest in ricebean compared with cowpea or sweet sorghum. Though, crude protein yield of ricebean was highest in sole crop but it remained at par in all intercropping treatments. The crude protein yield of sole crops was significantly more compared to intercropping treatments. There was 38 per cent reduction in crude protein yield due to intercropping compared to sole cowpea. Crude protein yield of sweet sorghum was significantly reduced due to sweet sorghum+ricebean (75%) treatment compared to sole sweet sorghum and sweet sorghum+cowpea (25%). Reduction in dry matter yield due to intercropping reduced crude protein yield of the system. Higher crude protein content was attributed to the contribution of nitrogen by legumes which enhanced nitrogen uptake and converted into protein leading to higher crude protein content. This finding corroborates the finding of Singh (2009) who observed significantly higher CPY of sorghum and higher CPY of phillipesara in sole crops and Mishra *et al*. (1997) indicating highest crude protein yield in sorghum-cowpea intercropping system. Least reduction in crude protein yield of sweet sorghum was due to sweet sorghum+cowpea (25%), which accounted for 30 per cent of the sole sorghum. On the other hand, in sweet sorghum+ricebean (75%) treatment, highest reduction in crude protein yield (60%) was observed.

Quality Parameters

Dry matter content : Dry matter content of sweet sorghum was significantly higher due to sweet sorghum+cowpea (75%) compared to other treatments during both the years, except during 2013, where it was at par with sweet sorghum+ricebean (50%) (Table 2). Dry matter content of sweet sorghum was significantly lower under sweet sorghum+cowpea (50%) intercropping, while dry matter content of cowpea was significantly higher under sweet sorghum+cowpea (75%) compared to other treatment during both the years. Dry matter content was significantly lower under sole cowpea which was at par with sweet sorghum+cowpea (25%) and sweet sorghum+cowpea (50%). Dry matter content of ricebean was significantly higher under sweet sorghum+ricebean (75%) and under lower sole ricebean during both the years. Better sink and source available to trap sunlight enhancing photosynthesis and thereby more accumulation of dry matter might have resulted in higher dry matter content.

Crude protein content : Crude protein content of sole sweet sorghum was significantly less compared to intercropping treatments during both the years. Among intercrop treatments, sweet sorghum+cowpea (25%), being at par with sweet sorghum+cowpea (50 and 75%), caused significant reduction in crude protein content compared to sweet sorghum+ricebean intercropping treatments during 2013, while during 2014 all sweet sorghum+ricebean intercroppings remained at par but caused significantly higher crude protein content compared to sweet sorghum+cowpea (25 and 50% seed rate). The crude protein content of sole cowpea was significantly higher compared to all sweet sorghum+cowpea intercropping treatments during both the years. In ricebean, crude protein content was at par

TABLE 2
Quality traits of fodder as influenced by the treatments

Treatment	Quality parameters of different crops					
	Sweet sorghum		Cowpea		Ricebean	
	2013	2014	2013	2014	2013	2014
			Dry matter (%)			
Sole sweet sorghum	36.5	38.7	-	-	-	-
Sole cowpea	-	-	19.6	20.7	-	-
Sole ricebean	-	-	-	-	20.6	21.8
Sweet sorghum+Cowpea 25%	38.5	40.8	20.1	21.3	-	-
Sweet sorghum+Cowpea 50%	30.3	32.1	19.8	21.0	-	-
Sweet sorghum+Cowpea 75%	42.6	45.1	22.2	23.6	-	-
Sweet sorghum+Ricebean 25%	36.6	38.8	-	-	25.1	26.6
Sweet sorghum+Ricebean 50%	40.3	42.8	-	-	24.7	26.1
Sweet sorghum+Ricebean 75%	36.8	39.0	-	-	26.9	28.5
S. Em±	0.7	0.7	0.4	0.4	0.4	0.4
C. D. (P=0.05)	2.2	2.3	1.2	1.3	1.1	1.2
			Crude protein (%)			
Sole sweet sorghum	6.6	6.9	-		-	-
Sole cowpea	-	-	11.1	11.7	-	-
Sole ricebean	-	-	-	-	9.5	10.0
Sweet sorghum+Cowpea 25%	7.5	7.8	9.0	9.5	-	-
Sweet sorghum+Cowpea 50%	7.9	8.2	8.8	9.2	-	-
Sweet sorghum+Cowpea 75%	8.3	8.7	8.9	9.4	-	-
Sweet sorghum+Ricebean 25%	9.1	9.4	-	-	9.7	10.2
Sweet sorghum+Ricebean 50%	8.7	9.6	-	-	9.8	10.2
Sweet sorghum+Ricebean 75%	9.1	9.5	-	-	8.2	8.6
S. Em±	0.3	0.3	0.3	0.3	0.2	0.2
C. D. (P=0.5)	0.8	0.9	0.8	0.8	0.6	0.7
			Dry matter digestibility (%)			
Sole sweet sorghum	47.1	50.4	-	-	-	-
Sole cowpea	-	-	63.2	67.7	-	-
Sole ricebean	-	-	-	-	65.1	69.6
Sweet sorghum+Cowpea 25%	48.8	52.2	63.4	67.8	-	-
Sweet sorghum+Cowpea 50%	44.7	47.8	64.4	68.9	-	-
Sweet sorghum+Cowpea 75%	46.5	49.8	65.2	69.7	-	-
Sweet sorghum+Ricebean 25%	43.5	46.5	-	-	64.3	68.8
Sweet sorghum+Ricebean 50%	46.0	49.2	-	-	64.4	68.9
Sweet sorghum+Ricebean 75%	46.3	49.5	-	-	63.8	68.3
S. Em±	0.5	0.5	0.5	0.5	0.4	0.4
C. D. (P=0.5)	1.4	1.5	1.4	1.5	1.3	1.4

in sole ricebean, sweet sorghum+ricebean (25 and 50%) registering significantly higher crude protein content compared to sweet sorghum+ricebean (75%). The higher crude protein content of mixture over the sorghum alone was observed. It might be due to higher protein content of the legume crop (Eskandari and Ghanbari, 2009). Thus, the forage quality of cowpea decreased by intercropping. Ayub *et al*. (2004) opined that the ricebean sown alone contained significantly higher crude protein content and sorghum sown alone contained significantly lower protein content.

Digestible dry matter : Digestible dry matter content of sweet sorghum was significantly higher when intercropped with cowpea (25%) compared to the other treatments. Sole sweet sorghum fodder registered significantly higher digestibility compared to its intercropping with cowpea (50 and 75%) and all ricebean intercropping treatments during both the years. Digestible dry matter content of cowpea was significantly higher under sweet sorghum+cowpea (75%) compared to other treatment except sweet sorghum+cowpea (50%). Significantly lower digestible dry matter content was obtained under sole cowpea, which was at par with sweet sorghum+cowpea (25 and 50%) in both the years. Sood and Sharma (1992) observed fodder sorghum intercropped with legume like cowpea and soybean produced high quality forage as indicated by high crude

protein content compared to sole sorghum, with higher *in vitro* digestibility. Digestible dry matter content of ricebean was higher under sole ricebean, which was at par with remaining treatments in both the years. Intercropping of legumes maintained the characteristics of good fodder maize yield and high digestibility (Emine *et al*., 2010; Asangla and Gohain, 2016).

On the basis of results obtained from the present study, it was concluded that the intercropping of cowpea with 25 per cent seed rate maintained higher green fodder, dry fodder and digestible dry matter yield in sweet sorghum as well as of intercropping system compared to remaining treatments, however, it was at par with sweet sorghum+cowpea (50%) intercropping treatment. Intercropping system reduced green forage, dry fodder and crude protein yield of sole crops. The quality of fodder also improved under intercropping system.

REFERENCES

Ahmad, A., R. Ahmad, N. Mahmood, and A. A. Tanveer. 2007 : Performance of forage sorghum intercropped with forage legumes under different planting patterns. *Pak. J. Bot.*, **39** : 431-439.

Angadi, V. V., A. Y. Hugar, B. Basavaraj, and N. Y. Nayakar. 2004 : Intercropping studies in **kharif** sorghum under rainfed condition. *Karnataka J. Agric. Sci.*, **17** : 444-447.

Asangla, H. K., and T. Gohian. 2016 : Effect of fodder yield and quality attributes of maize (*Zea mays* L.)+cowpea (*Vigna unguiculata*) intercropping and different nitrogen levels. *Int. J. Agril. Sci. & Res.*, **6** : 349-356.

Ayub, M., A. Tanveer, M. A. Nadeem, and S. M. A. Shah. 2004 : Studies on the fodder yield and quality of sorghum grown alone and in mixture with rice bean. *Pak. J. Life and Social Sci.*, **2** : 46-48.

Barik, A. K., A. K. Mukherjee, and B. K. Mandal. 1996 : Growth and yield of sorghum (forage) and groundnut grown as sole and intercrops with levels of nitrogen. *Forage Res.* **22** : 25-34.

Emine, B. C., N. Celik, and G. Bayram 2010 : Yield and quality of forage maize as influenced by plant density and nitrogen rates. *Turkish J. Field crops* **15** : 128-132.

Eskandari, H., and A. Ghanbari. 2009 : Intercropping of maize (*Zea mays*) and cowpea (*Vigna sinensis*) as whole-crop forage : Effect of different planting pattern on total dry matter production and maize forage quality. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, **37** : 152-155.

Gebrehiwot, L., M. C. Grow, and G. Assefu. 1996 : Forage yield and quality profile of three annual legumes in the tropical highlands of Ethiopia. *J. Trop. Agric.*, **73** : 83-98.

Hamdillah, E. 2012 : Yield and quality of forage produced in intercropping of maize (*Zea mays*) with cowpea (*Vigna sinensis*) and mungbean (*Vigna radiate*) as double cropped. *J. Basic Appl. Sci. Res.*, **2** : 93-97.

Hauggaard, N. H., M. K. Andersen, B. Jørnsgaard, and E. S. Jensen. 2006 : Density and relative frequency effects on competitive interactions and resource use in pea-barley intercrops. *Field Crops Res.*, **95** : 256-267.

Jackson, M. L. 1973 : *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi. pp. 111-204.

Lowery, R. S. 1969 : The nylon bag techniques for estimation of the forage quality. In : Proc. National Conference on Forage Quality, Evaluation and Utilization. Nebaraska, Ctr. for continuing education, Licoln. pp. 1-2.

Mishra, R. K., S. K. Chaudhary, and A. K. Tripathi. 1997 : Intercropping of cowpea (*Vigna unguiculata*) and horsegram (*Macrotyloma uniflorum*) with sorghum for fodder under rainfed condition. *Indian J. Agronomy* **42** : 405-408.

Patel, J. R., and S. Rajagopal, 2001 : Production potential of forage maize with legumes under intercropping system. *Indian J. Agron.* **46** : 211-215.

Shankaranaryanan, K., A. Salaimalai, and N. Sankaran. 2005 : Intercropping of legumes in fodder sorghum. *Agric. Rev.* **2693** : 217-222.

Singh, P. K., and A. S. Jadhav. 2003 : Intercropping of sorghum with pigeonpea, groundnut and soybean under varying planting geometry. *Indian J. Dryland Agric. Res. and Dev.* **18** : 126-129.

Singh, S. 2009 : Studies on integrated nutrient management in sweet sorghum and phillipesara intercropping system. Ph. D. thesis (Agronomy), Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, U. S. Nagar (Uttarakhand), India.

Sood, B. R., and V. K. Sharma, 1992 : *Indian J. Agron.*, **37** : 642-644.

Thippeswamy, and S. C. Alagundagi. 2001a : Intercropping of legumes with sweet sorghum for higher green forage production. *Karnataka J. Agric. Sci.* **14** : 605-609.

Verma S. S., V. Singh, and Y. P. Joshi, 1997 : Effect of spatial arrangement and fertility levels on the forage yield and quality of sorghum and cowpea in a sorghum–cowpea intercropping system. *Forage Res.*, **22** : 207-214.