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Physiological growth parameters, forage yield and nitrogen uptake of sorghum (*Sorghum bicolor*) as influenced with legume intercropping, harvesting time and nitrogen level

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) seasons of 1998 and 1999, to study the effect of intercrops, harvesting times and levels of nitrogen on growth, yield and quality of forage sorghum [*Sorghum bicolor* (L.) Moench] under rainfed conditions. Intercropping of sorghum with cowpea [*Vigna unguiculata* (L.) Walp.] recorded significantly higher leaf-area index, leaf: stem ratio, crop-growth rate, relative growth rate, net assimilation rate, forage and crude protein yield and nitrogen uptake of sorghum compared to sorghum alone and its intercropping with clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] during both the years. Forage and crude protein yields and nitrogen uptake of sorghum were also significantly increased with harvesting at 75 days after sowing than harvesting at 45 days after sowing, but being statistically at par with harvesting at 60 days after sowing. However, significantly higher leaf : stem ratio was recorded with harvesting at 45 days after sowing than harvesting at 60 and 75 days after sowing. Nitrogen application @ 80 kg/ha significantly increased the leaf-area index, leaf : stem ratio, crop-growth rate, relative growth rate, net assimilation rate, forage and crude protein yield and nitrogen uptake compared to the control and 40 kg N/ha during both the years.

Key words : Sorghum, Legume, Intercropping, Harvesting times, Nitrogen, Growth parameters, Forage yield

Dairy farming supported by intensive forage production is quite profitable alternative to current arable cropping system. Availability of nutritious feed and forage is vital to the development of dairy. However, the present feed and forage resources of the country are able to meet only 46% of the requirement with vast deficit of 64 and 16 % in green and dry forage respectively. Sorghum is one of the most important forage crops. Intercropping cereal with legume is an effective approach for boosting the production and quality of forage crops (Rao and Willey, 1980). Harvesting times is an important management practice which not only influences the yield but also quality of forage. The forage crops, should therefore, be harvested at appropriate growth stage to obtain more green forage with acceptable dry-matter content and nutrients, particularly protein. Nitrogen has the key role in growth of cereals and is the most limiting nutrient in Indian soils. Nitrogen application increases the forage yield and improves the quality of forage particularly the level of crude protein (Menhi Lal and Tripathi, 1987). Hence an experiment was conducted to study the effect of harvesting times and nitrogen levels on growth, yield and quality of forage sorghum when intercropped with cowpea and clusterbean.

MATERIALS AND METHODS

The field experiment was carried out during the rainy *(kharif)* seasons of 1998 and 1999 at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad. The experiment was laid out in split-plot design, keeping the combinations of 3 intercrops, viz. sorghum alone, sorghum + cowpea and sorghum + clusterbean, and 3 harvesting times, viz harvesting at 45 days after sowing, 60 DAS and 75 DAS in main plots, and 3 levels of nitrogen, viz. control, 40 and 80 kg/ha, in subplots and replicated 3 times. Sorghum variety hybrid 'SSG 5000' (Sudan grass) was sown in line 30 cm apart using a seed rate of 40 kg/ha. Sorghum was intercropped with cowpea variety 'Russian Giant' ('Type 2') and clusterbean variety 'Bundel Guar 2' in 1 : 1 sorghum : legumes alternate rows 15 cm apart in additive series

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using the recommended seed rates. Cowpea and clusterbean were sown @ 30 kg and 25 kg seed/ha respectively. The uniform dose of 30 kg P_2O_5/ha and 30 kg K_2O/ ha was applied to all the treatments at the time of last ploughing. The crop was maintained under rainfed environment.

The soil of the experimental field was silt loam, low in organic carbon and nitrogen and medium in phosphorus and rich in potassium. The values of pH and electrical conductivity of the experimental field were 8.5 and 0.3 dS/m during 1998 and 8.3 and 0.37 dS/m during 1999 respectively. The total rainfall of 836.40 mm and 1,083.70 mm was received in entire growth period of crop during 1998 and 1999 respectively.

RESULTS AND DISCUSSION

Leaf-area index

Sorghum intercropped with cowpea resulted in significantly higher leaf-area index as compared to sorghum alone and its intercropping with clusterbean during both the years. This was owing to more number of leaves and their better growth because of the N supplemented by cowpea to the sorghum. These results are in line with those of Barik *et al.* (1998). Sorghum in association with clusterbean gave similar leaf-area index, as it was found in case of sorghum alone (Table 1). Sorghum harvested at 60 DAS gave significantly higher leaf-area index than sorghum harvested at 45 DAS and 75 DAS during both the years. Harvesting at 75 DAS also resulted in statistically higher leaf-area index than at 45 DAS (Table 1). This was due to optimum period available for the full development of leaves in size as well as in number at 60 DAS. The decrease in leaf-area index at 75 DAS might be due to reduction in turgidity and succulency of leaves because of the development of leaves towards maturity. These results are in agreement with the findings of Malik *et al.* (1992) and Prasad (1994). Application of 80 kg N/ha recorded significantly higher leaf-area index over the control and 40 kg N/ha. Similarly, nitrogen application @ 40 kg/ha also caused significant increase in leaf-area index compared with the control during both the years (Table 1). These results corroborate to the findings of Malik *et al.* (1992) and Barik *et al.* (1998).

Leaf : stem ratio

Intercropping of sorghum with cowpea exhibited significantly higher leaf : stem ratio than sorghum alone and its intercropping with clusterbean during both the years. During 1998, sorghum intercropped with clusterbean resettled in significantly higher leaf : stem ratio than sorghum alone. However, during 1999, both were found at par in term of leaf : stem ratio of sorghum (Table 1). The higher leaf : stem ratio under sorghum + cowpea treatment was might be due to nitrogen contributed by cowpea resulting in increase in number and size of leaves which led to higher leaf : stem ratio under this treatment. The leaf : stem ratio was recorded significantly higher with harvesting of crop at 45 DAS than harvesting at 60 DAS and 75 DAS. The leaf : stem ratio recorded with harvesting at 60 DAS was also significantly higher than harvesting at 75 DAS. This was so because at earlier growth stage sorghum contains more leafy growth than stem. These results

Table 1. Physiological growth parameters of sorghum as influenced by intercrops, harvesting times and nitrogen levels

Treatment	Leaf-area index at harvest		Leaf : stem ratio at harvest		CGR(g/m²/day) 20–40 DAS		RGR (g/g/day × 10^{-3}) at 20–40 DAS		NAR (g/m²/day × 10^{-4}) at 20–40 DAS	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Intercrop										
Sorghum alone	5.85	6.21	0.33	0.35	12.91	14.20	63.44	63.72	3.73	3.86
Sorghum + cowpea	6.89	7.41	0.42	0.43	16.57	18.19	70.12	71.85	4.43	4.67
Sorghum + clusterbean	6.16	6.70	0.36	0.37	13.46	14.85	64.45	65.22	3.87	3.97
CD (P=0:05)	0.45	0.48	0.026	0.028	0.99	1.19	1.60	1.61	0.20	0.20
Harvesting time (DAS)										
45	5.43	5.91	0.44	0.45	14.37	15.92	66.95	67.81	4.06	4.19
60	7.01	7.45	0.38	0.39	13.66	15.93	65.41	66.69	3.92	4.23
75	6.46	6.96	0.29	0.31	14.62	15.22	66.38	65.98	4.07	4.07
CD (P=0.05)	0.45	0.48	0.026	0.028	NS	NS	NS	NS	NS	NS
Nitrogen (kg/ha)										
0	5.32	5.76	0.33	12.03	13.57	63.11	63.84	3.70	3.78	
40	6.40	6.88	0.37	0.39	14.36	15.83	66.20	67.09	4.01	4.03
75	7.18	7.68	0.41	0.43	16.55	17.84	68.70	69.87	4.30	4.32
CD (P=0.05)	0.37	0.41	0.023	0.018	0.93	1.12	1.35	1.37	0.21	0.22

comform those of Malik *et al.* (1992). Application of 80 kg N/ha significantly increased leaf : stem ratio of sorghum over 40 kg N/ha and control (Table 1). The increase in leaf : stem ratio with increasing levels of N might be due increase in number, size and succulency of leaves with these treatments. The findings confirm the observations of Malik *et al.*, (1992).

Crop growth rate, relative growth rate and net assimilation rate

Intercropping of sorghum with cowpea gave significantly higher crop growth rate, relative growth rate and net assimilation rate than sorghum alone and sorghum + clusterbean intercropping. This was due to increase in plant height, leaves/plant and leaf area which led to higher dry matter accumulation per unit time under sorghum+ cowpea treatment due to N supplemented by cowpea. Intercropping of sorghum with clusterbean and sorghum alone recorded statistically similar crop growth rate, relative growth rate and net assimilation rate of sorghum (Table 1). Harvesting treatments had non-significant influence on crop growth rate, relative growth rate and net assimilation rate of sorghum. This was so, because harvesting treatment was not given up to these stages of crop growth. Application of 80 kg N/ha recorded significantly higher crop growth rate, relative growth rate and net assimilation rate compared with the control and 40 kg N/ha (Table 1). This might be due to rapid cell division and cell alongation which have increased the dry matter per unit time with increasing levels of N.

Forage yield

Sorghum intercropped with cowpea recorded significantly higher green forage, dry matter and sorghum green forage yield equivalent than sorghum alone and sorghum + clusterbean combination. Intercropping of sorghum with clusterbean was also found significantly superior in term of green forage dry matter and sorghum green forage yield equivalent than sorghum alone. The higher green forage and dry matter yield with intercropping of sorghum with cowpea may be attributed to compensatory effect of cowpea which supplemented nitrogen to sorghum and better utilization of environmental resources by sorghum+ cowpea system. Similar findings were also reported by Sood and Sharma (1992) and Barik *et al., (1998).*

Harvesting of sorghum at 75 days yielded significantly higher green forage and dry matter of sorghum over the harvesting at 45 days but being statistically at par in term of green forage yield and significantly higher in regards of dry matter yield with harvesting at 60 days (Table 2). This might be due longer duration which increased the value of growth parameters due to more source available for the synthesis of metabolites. These results are in agreement with the findings of Noor Mohammad *et al.* (1988) and Ramamurthy and Vinod Shankar (1998). Harvesting at 75 days significantly increased the sorghum green forage equivalent compared to harvesting at 45 days during both years and harvesting at 60 days during 1998 only.

Table 2. Forage yield, crude protein yield and nitrogen uptake by sorghum as influenced by various treatments

Treatment	Green forage yield (q/ha)		Dry matter yield (q/ha)		Sorghum green forage yield equivalent (q/ha)		Total crude protein yield (kg/ha)		Nitrogen uptake (kg/ha)	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
Intercrop										
Sorghum alone	359.14	382.52	87.87	96.11	359.14	382.52	650.39	748.22	104.07	119.78
Sorghum + cowpea	421.43	452.79	104.18	110.56	548.35	577.39	1,190.36	1,294.70	144.61	156.28
Sorghum+clusterbean	376.37	406.50	92.47	100.72	422.53	456.59	822.35	959.22	114.50	130.64
CD (P=0.05)	28.82	28.53	6.43	7.02	28.77	33.96	78.59	105.15	10.56	14.40
Harvesting time (DAS)										
45	234.00	267.58	49.90	59.40	290.00	318.44	584.39	717.18	74.65	92.55
60	448.87	475.80	108.01	116.21	501.38	534.71	1,002.17	1,119.78	139.42	152.60
75	474.06	498.44	126.61	131.78	634.95	563.19	1,076.54	1,165.18	149.10	161.56
CD (P=0.05)	28.82	28.53	6.43	7.02	28.77	33.96	78.59	105.15	10.56	14.40
Nitrogen (kg/ha)										
0	312.05	342.12	78.49	86.65	373.01	398.84	673.71	795.12	88.63	103.13
40	391.39	417.74	95.69	103.31	447.92	477.12	886.67	992.39	119.79	135.35
80	453.50	481.95	110.34	117.42	509.11	540.52	1,102.72	1,214.64	154.76	168.23
CD (P=0.05)	25.71	21.25	5.67	5.29	22.73	23.84	73.69	75.32	10.76	11.01

Sorghum green forage yield equivalent obtained with harvesting at 60 days was also significantly higher than harvesting at 45 days (Table 2).

Application of N @ 80 kg/ha significantly increased green forage, dry matter and sorghum green forage yield equivalent compared with the control and 40 kg/ha. Nitrogen application @ 40 kg/ha also proved significantly superior to control treatment in terms of green forage, dry matter and sorghum green forage yield equivalent during both the years. This was because of the fact that nitrogen involved in increasing the protoplasmic constituents and accelerating the process of cell division and elongation which in term give luxuriant vegetative growth for higher productivity. These findings confirm the results of Sood and Sharma (1992) and Barik *et al.* (1998).

Crude protein yield

Intercropping of sorghum with cowpea gave significantly higher crude protein yield than sorghum alone and sorghum intercropped with clusterbean. Sorghum alone and sorghum + clusterbean were found at par with each other in terms of crude protein yield (Table 2). The increase in dry mater yield and crude protein content of sorghum under sorghum + cowpea intercropping may be valid reason of higher crude protein yield under the same treatment. These findings confirm the results of Sood and Sharma (1992) and Raju *et al.* (1997). Harvesting at 75 days being at par with harvesting at 60 days gave significantly higher crude protein yield of sorghum than harvesting at 45 days (Table 2). The increased yield of dry matter with harvesting at 75 days and 60 days may be the reason of increase in crude protein yield. These results are in conformity with the findings of Noor Mohammad *et al.* (1988) and Ramamurthy and Vinod Shankar (1998). Increasing dose of N application from control to 40 kg/ha and from 40 to 80 kg/ha significantly increased crude protein yield of sorghum during both the years (Table 2). The higher crude protein yield was owing to increase in protein content and dry-matter yield with increasing levels of N. These results confirm the findings of Noor Mohammad *et al.* (1988), Sood and Sharma (1992) and Raju *at al.* (1997).

Nitrogen uptake

Maximum uptake of N was recorded when sorghum was intercropped with cowpea, which was significantly higher than alone and intercropping of sorghum with clusterbean. This might be due to higher N content in sorghum and more dry matter yield of sorghum in association with cowpea because of increased N supply in this system. These findings confirm the observations of Sunitha and Sreekantan (1994). Variation in N uptake by sorghum between sorghum alone and sorghum + clusterbean treatment was found to be non-significant (Table 2). Harvesting at 75 days recorded significantly higher N uptake than harvesting at 45 days which in turn did not vary significantly with harvesting at 60 days. Harvesting of sorghum at 60 days also showed significantly higher uptake of N than harvesting at 45 days was due to higher dry-matter yield of sorghum under these treatments. Application of 80 kg N/ha recorded significantly higher N uptake by sorghum over control and 40 kg N/ha. The increase in N uptake due to 80 kg N/ha was recorded by 74.61 and 29.19 % during 1998 and 63.12 and 21.29% during 1999 over control and 40 kg N/ha respectively (Table 2). The increased uptake of N with N application was mainly due to higher dry matter yield and N content under the treatment. These results are in agreement with the results obtained by Raju *et al.* (1997).

REFERENCES

Barik, A.K., Mukherjee, A.K. and Mandel, B.K. 1998. Growth and yield of sorghum (*Sorghum bicolor*) and groundnut (*Arachis hypogaea*) grown as sole and intercrops under different nitrogen regimes. *Indian Journal of Agronomy* **43**(1) : 27–32.

Malik, H.P.S., Singh, H. and Singh, O.P. 1992. Response of multicut fodder sorghum (*Sorghum bicolor*) cultivars to nitrogen and cutting management. *Indian Journal of Agronomy* **37**(3) : 470–473.

Menhi Lal and Tripathi, S.N. 1987. Role of fertilizer in production of forage and fodder crops--gaps and future. *Fertiliser News* **32**(12) : 77–83.

Noor Mohammad, Butt, N.M. and Qamar, I.A. 1998. Effect of nitrogen fertilization and harvesting intervals on the yield and nutritional value of Napier grass. *Pakistan Journal of Agricultural Research* **9** (4) : 487–482.

Prasad, L.K. 1994. Productivity of perennial Dinanath grass (*Pennisetum pedicellatum*) as influenced by interval and height of cutting. *Range Management and Agroforestry* **5**(2) : 145–149.

Raju, M.S., Srinivas, A. and Raju, V. 1997. Effect of nitrogen and legume intercropping on yield, crude protein and N, P and K uptake to forage maize (*Zea mays* L). *Forage Research* **23**(1,2) : 59–63.

Ramamurthy, V. and Vinod Shankar. 1998. Response of *Pennisetum* trispecific hybrid to nitrogen and harvesting dates. *Indian Journal of Agronomy* **43** (3) : 533–536.

Roa, M.R. and Willey, R.W. 1980. Preliminary studies of intercropping combination based on pigeopea or sorghum. *Experimental Agriculture* **16** : 24–40.

Sood, B.R. and Sharma, V.K. 1992. Effect of nitrogen level on the yield and quality of forage sorghum (*Sorghum bicolor)* intercropped with legumes. *Indian Journal of Agronomy* **37** (4) : 642–644.

Sunitha, S. and Sreekantan, L. 1994. Evaluation of cowpea + fodder maize intercropping under varying fertilizer levels in summer rice fallows. *Journal of Tropical Agriculture* **32** : 98–100.