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Productivity, quality, nutrient use efficiency and economics of senna (*Cassia angustifolia*) as influenced by FYM and fertilizer nitrogen under rainfed conditions

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ABSTRACT

A field experiment was conducted for 4 consecutive rainy (*kharif*) seasons between 2000-2003 on alfisols of Hyderabad to study the influence of FYM (0 and 5 tonne/ha) and fertilizer N (0, 25, 50, 75 kg/ha) on productivity, profitability, and nutrient use efficiency in senna (*Cassia angustifolia* Vahl.). FYM application enhanced the senna leaf, pod and leaf equivalent yields significantly over its control. An increase of 54, 59, 70% in N, P and K uptake, respectively was recorded with FYM over control. FYM enhanced agronomic efficiency (AE) by 3.52 kg leaf equivalent yield / kg N; the apparent recovery efficiencies (ARE) of N P K increased from 40 to 53, 13.1 to 18.9 and 41.1 to 58.5%, respectively. The partial factor productivity (66.28 kg leaf equivalent yield / kg N) was improved with FYM. FYM application registered an additional net monetary return of Rs 4,190/ha. Nitrogen application improved the yield, sennoside content, ARE and monetary returns. Application of 25 kg N/ha recorded highest AE, ARE, and partial factor productivity (PFP) whereas the increasing levels of N beyond 25 kg/ha reduced the ARE, and PFP. 50 kg N/ha registered highest B: C ratio (2.3). The leaf yield of 2,733 kg/ha was recorded at economic optimum of dose (70.88 kg/ha) and the response to each kg-applied N was 37.5 kg.

Key words: Farm yard manure, Nitrogen, Nutrient use efficiency, Senna, Sennoside

Senna (*Cassia angustifolia* Vahl.) a non-nitrogen fixing member of Caesalpiniaceous, is included in the pharmacopoeias of United States of America, Germany, United Kingdom, India, etc. mainly for its cathartic properties. The primary active constituents of senna are two rheindianthrone-8, 8' di glycosides called sennoside A and B. Despite the availability of some synthetic products, sennoside formulations are increasingly used as safe laxatives (Al-Dakan *et al.,* 1995). Senna, however, has not received wide recognition as a crop in many countries except for India where it is grown in arid, nutrient-poor, sandy soils of Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat and Rajasthan. This is exported to around 55 countries and is a good foreign exchange earner. Indian senna can compete with Alexandrian senna in the international market, if it has higher sennoside content. Usually the crop is cultivated without fertilizer.

Soil fertility management is quite important in any crop production. The nutrient efficiency varies with species (Ramesh and Sammi Reddy, 2004) and efficiency of most crops ranges from 20 to 60%. The low recovery of N by crops is due to its loss in soil-plant system and or due to immobilization in the soil. Hence fertilizer use efficiency needs to be increased to sustain the productivity. Application of N along with FYM is a promising agro-technique to sustain yield, increase fertilizer use efficiency and restore soil fertility. Hence optimum fertilizer should be worked out to reduce cost of production, increase yield and sennoside content in senna by reducing the cost of cultivation so that it can compete in the international market. Hence, the present study was conducted with primary objective to optimize the FYM and N levels for senna.

MATERIALS AND METHODS

The field experiment was conducted during 4 consecutive rainy seasons of 2000-03 at Hyderabad situated at 17^0 18' N latitude, 78^0 36' E longitude at an elevation of 515 m above mean sea level. The climate of site is of semi-arid tropics with the average annual rainfall of 752 mm. The rainfall received during the experimental season was 520, 667, 425 and 749 mm during 2000-01, 2001-02, 2002-03, and 2003-04 respectively. The number of rainy days during *kharif* cropping period was 33, 43, 30 and 49 days in 2000, 2001, 2002 and 2003 respectively. The soil of the experimental site was shallow marginal alfisol (pH 7.0) with sandy loam texture (67.3, 17.2 and 15.5% sand,

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silt and clay respectively). The soil was low in organic carbon (0.3%), available nitrogen (250 kg/ha), phosphorus (10.2 kg/ha) and medium in potassium (210 kg/ha). The moisture content was 12.3 and 6.1% at field capacity and permanent wilting point respectively.

The experiment was laid out in split plot design with 3 replications. The treatments comprised two levels of FYM (0 and 5 tonne/ha) in main plots and 4 N levels (0, 25, 50 and 75 kg/ha) in sub-plots. The well-decomposed FYM was applied on the plot uniformly as per the treatment and incorporated in the field 15 days before sowing. The nutrient content of FYM was 0.5, 0.2, and 0.65 % N, P and K, respectively on oven dry basis. The FYM along with half of the N and recommended dose of P (25 kg/ha) and K (40 kg/ha) was applied as basal and the remaining half N was applied as top dressing at 40 DAS. Senna cv. 'sona' was sown in the second fortnight of July at a spacing of 30 cm x 10 cm. Senna is an annual crop and it gives 2-3 cuts in rainfed regions. First cutting of leaf was done at 90 DAS and subsequently 3 cuts were done at 50 days interval. The leaf was dried, weighed and recorded as leaf yields. Immature pods when they turn golden yellow before seed formation were harvested as they have higher sennoside content when compared with mature pods.

The N, P and K content in senna leaves and pods were estimated as per the standard procedures. Nutrient uptake and apparent recovery of applied N and P were calculated, as per the procedure. Largrangian interpolation technique was used at 2 points for adequate expression of the quadratic equation and then regression equation was established accordingly. To quantify the effect of FYM, nitrogen fertilizer on the nutrient use efficiency (agronomic and physiological efficiency), recovery fraction, and factor productivity were calculated using the standard equations.

Economic parameters like cost of cultivation, net returns and B: C ratio were worked out for each treatment. For better comparison, the pod yield is also converted into leaf equivalent yields using prevailing market prices of leaf (Rs 15, 13, 14 and 11 /kg in first, second third and fourth year, respectively) and pods (Rs 20, 18, 17 and 18 /kg in I, II, III and IV year, respectively) during experimentation.

RESULTS AND DISCUSSION

Seasonal variation

The effect of the seasons was found significant and variable on leaf, pod, leaf equivalent yields, sennoside content, yield and nutrient uptake (Table 1). Such effect could primarily be ascribed to variation in the amount and distribution of rainfall received during the experimental period and the soil moisture content. The yields were highest during rainy seasons 2001-02 and 2003-04 when compared with 2000-01 and 2002-03. Higher rainfall (667 and 749 mm) and better distribution of rainfall in 2001-02 and 2003-04 is responsible for higher yields (r = 0.886).

Crop productivity

FYM and nitrogen application gave significantly higher leaf, pod and leaf equivalent yields. Interaction between FYM and nitrogen was non significant. Mean data of 4 seasons showed that application of 5 tonne of FYM increased leaf, pod and leaf equivalent yields by 39.9, 25.4 and 35.9% respectively over its control. The increase in leaf, pod and leaf equivalent yields might be due to beneficial effect of FYM in improving the soil environment which inturn encourages the proliferous root growth resulting in better absorption of moisture, nutrients and thus producing higher biomass.

Nitrogen application @ 75 kg/ha gave significantly higher leaf, pod and leaf equivalent yields over control and 25 kg/ha. The yields at 50 and 75 kg N /ha were at par with each other. However, the pooled analysis showed that 75 kg N/ha recorded higher yields when compared with 0, 25 and 50 kg N/ha. The mean yield of 4 seasons showed that there was an increase of 176, 72 and 139% leaf, pod and leaf equivalent yields, respectively with 75 kg N/ha when compared to control. The results corroborate the findings of Ilangovan *et al*. (1990).

The leaf equivalent yields have revealed that the yields were significantly influenced by nitrogen application (Table 1). An increase of 87, 119 and 139% was recorded with application of 25, 50, 75 kg N/ha, respectively over control on pooled basis. The increase in leaf equivalent yields due to N application might be due to the fact that N fertilization increases the availability of N and water uptake of plant which helped in accelerated photosynthetic rate leading to production of more carbohydrate and accumulation of biomass (Singh and Agarwal, 2004).

Sennoside content

Higher sennoside content (3.6%) was recorded in pods than leaves (2.3%). Similar results were reported by Azam *et al.* (2003). The leaf, pod sennoside content and sennoside yields increased with FYM application. There was an increase of 20, 28.9, 67 and 60% leaf, pod, sennoside content and yields, respectively with FYM application.

Application of nitrogen significantly improved the sennoside content and yields. Similar results were reported by Ratnayaka and Kincaid (2005). Highest sennoside content was observed with 75 kg N/ha (Table 2). An increase of 23, 34 and 39% in sennoside content was recorded with 25, 50, 75 kg N/ha, respectively over control. Application of 75 kg N/ha increased the sennoside yields by 271, 44 and 12.8% over control, 25 and 50 kg N/ha (Table 3). Higher sennoside content and yield at higher nitrogen level is due to higher economic yield, which in turn is due to increased photosynthetic rate with better nutrition.

Nutrient uptake

FYM application augmented nutrient uptake of N P K by 54, 59, 70%, respectively over no FYM application. FYM apart from supply of nutrients enhances the availability of nutrients by way of slow release of nutrients in to match the uptake pattern of crop at different stages for longer duration and this has reflected in higher yield and sennoside content.

The uptake of N, P and K by senna enhanced significantly with N application, maximum being at 75 kg N/ha (Table 2). Application of N registered increase in N, P and K uptake by 105, 129, 94.6% with 25 kg N/ha; 183, 235, 137% with 50 kg N/ha and 231, 296 and 169% with 75 kg N/ha, respectively over control. The increase in N, P and K uptake with nitrogen application might be because nutrient uptake is correlated with yield, which in turn resulted in increase in dry matter, and nutrient uptake. Patidar and Mali (2002) also reported similar results.

Nutrient use efficiency

Application of 5 t/ha FYM increased agronomic effi-

Table 1. Influence of FYM and nitrogen levels on productivity (kg/ha) of senna

Treatment	Leaf yield					Pod yield					Equivalent yield				
	I	II	III	IV	Mean	I	II	III	IV	Mean	I	II	III	IV	Mean
FYM (t/ha)															
5	1,476	2,436	1,033	2,275	1,834	428	548	333	389	424	2,118	3,293	1,611	2,863	2,471
0	1,065	1,843	745	1,719	1,311	370	482	271	225	338	1,559	2,361	1,253	2,100	1,818
SEm ±	68	90	47	110	31	9	18	12	16	6	78	64	41	59	33
CD (P=0.05)	291	389	204	475	71	41	NS	53	40	14	338	277	178	255	75
N level (kg/ha)															
0	575	1,120	403	888	746	270	345	190	268	268	981	1,633	782	1,198	1,148
25	1,321	2,138	930	2,030	1,599	405	507	298	267	369	1,888	2,698	1,449	2,580	2,153
50	1,527	2,430	1,070	2,500	1,882	455	602	345	312	428	2,144	3,258	1,679	3,018	2,524
75	1,658	2,866	1,160	2,567	2,063	467	605	375	394	460	2,341	3,720	1,822	3,129	2,753
SEm ±	81	212	56	186	69	27	24	12	73	9	91	191	60	164	69
CD (P=0.05)	175	461	123	406	139	60	52	27	164	18	199	417	130	357	138
Seasons mean	1,271	2,109	889	2,022		379	479	362	308		1,838	2,827	1,432	2,481	
SEm ±			63					11					68		
CD (P=0.05)			155					27					166		

I, II, III and IV are rainy seasons of 2000, 2001, 2002 and 2003

Table 2. Influence of different treatments on sennosoide content (%), sennosoide yield (kg/ha) and nutrient uptake (kg/ha) of senna

Treatment	Sennoside (%)		Sennosoide yield					Nutrient uptake					
	Leaf	Pod	I	II	III	IV	Mean	N				P	K
								I	II	III	IV		
FYM (t/ha)													
5	2.56	4.10	56.40	87.8	37.2	88.9	67.6	29.9	49.4	22.2	39.9	11.3	43.2
0	2.13	3.20	32.52	49.8	26.2	55.2	40.9	20.2	30.3	15.1	26.5	7.1	25.4
SEm ±	0.01	0.06	3.00	2.5	1.3	2.5	1.21	1.1	1.2	0.6	0.9	0.2	0.6
CD (P=0.05)	0.03	0.15	12.80	10.8	5.6	10.6	2.8	4.9	5.2	2.7	3.8	0.4	1.5
Nitrogen level (kg/ha)													
0	1.89	3.29	20.63	33.33	14.33	28	24	10.9	18.5	8.0	13.3	3.5	17.1
25	2.33	3.63	44.28	62.33	31.32	72.4	52.6	23.8	33.6	17.2	29.8	7.9	33.3
50	2.53	3.78	52.44	81.76	38.11	92.4	66.2	30.5	48.5	23.0	41.9	11.7	40.7
75	2.63	3.87	60.59	97.7	43.05	95.5	74.2	35.1	58.8	26.4	47.9	13.8	45.9
SEm ±	0.01	0.04	2.49	5.3	2.1	5.4	2.1	1.2	3.0	0.8	2.4	0.4	1.1
CD (P=0.05)	0.03	0.08	5.44	11.5	4.3	11.8	4.2	2.7	6.5	1.8	5.2	0.7	2.3

ciency (AE) to 31.5 from 27.9 kg (Table 3). FYM application enchanced the AE by 3.5 kg equivalent yield/kg N. Reduced losses of N and higher availability of nutrients due to increased microbial activity with FYM application probably led to improvement in biomass and pod yield, which consequently led to higher AE. Higher AE was recorded at 25 kg N/ha over control. Increase in N dose from 25 to 75 kg N/ha reduced the AE. The AE was improved by 12.7, 18.8 kg equivalent yield/kg N with 25 kg N/ha over 50 and 75 kg N/ha, respectively. Sharma (2002) reported enhanced AE with application of N compared to control.

Physiological use efficiency (PUE) of NPK decreased by 10.5, 51.1, 13.2 kg leaf equivalent yield/kg N, P and K absorbed respectively with FYM as compared to control (Table 3). Application of 25 kg N/ha recorded highest PUE of N, P and K than 50 and 75 kg N/ha. The PUE of N,P,K reduced by 20.7, 86.1, 5.78 kg leaf equivalent yield/ kg N, P and K absorbed respectively with 75 kg N/ha over 25 kg N/ha.

Recovery efficiency (RE) of N, P and K increased from 40 to 53, 13.1 to 18.9, and 41.4 to 58.5% respectively with FYM application over control. Nitrogen application significantly showed improvement in nutrient RE (Table 3). Application of 25 kg N/ha recorded significantly higher N,P,K RE over 50 and 75 kg N (Table 3). Application of 25 kg N/ha resulted in 27.7, 23.4 and 39.4% higher RE of N,P and K than 75 kg N/ha. Higher RE of nutrients with FYM application might be due to release of organic compounds and synthesis of growth promoting substances during decomposition. This helps in more absorption and utilization of nutrients. Lower losses and increased availability of nutrients has led to higher nutrient use efficiency (Choudhary and Gautam, 2007).

The partial factor productivity (PFP) increased with application of FYM (66.28 kg equivalent/kg N) when compared with control. Application of 25 kg N/ha recorded highest PFP (86.2 kg leaf equivalent yield/kg N) and decreased with increasing dose of N. Application of 25 kg N/ha registered an increase of 35.71 and 49.49 kg leaf equivalent yield /kg N than 50 and 75 kg N/ha, respectively (Table 3).

Table 4. Economics (Rs/ha) as influenced by different treatments

Treatments	Cost of cultivation	Net returns	B:C ratio
FYM (t/ha)			
5	8,000	16,714	2.02
0	6,600	11,587	1.69
SEm ±		1,114	0.04
CD (P=0.05)		2,568	0.10
Nitrogen level (kg/ha)			
0	6,850	4,637	0.64
25	7,150	14,387	1.96
50	7,450	17,797	2.34
75	7,750	19,784	2.50
SEm ±		1,470	0.09
CD (P=0.05)		2,955	0.18

Response function

The functional relation between leaf equivalent yields of senna and levels of nitrogen was analyzed for different seasons, and pooled analysis was done by fitting regression equation for obtaining optimum dose of nitrogen. The response was best fitted by the equations. The optimum dose of nitrogen was 68.5, 62.9, 69.5 and 61.9 kg N/ ha and the yields were 2,307, 3,789, 2,210 and 3,184 kg N/ha during 2000, 2001, 2002 and 2003 respectively. The economic optimum of N was 68.78, 61.68, 67.88 and 61.32 kg N/ha and optimum yield was 2,324, 3,788, 1,811, and 3,184 respectively. Pooled over seasons, the response function was $Y = 1172.6 + 44.024x - 0.3104x^2$ (R^2 = 0.992). The optimum N dose was 70.91 kg N/ha. Yield at optimum N dose was 2,733 kg/ha. The economic optimum was 69.75 kg N /ha and the response to each kg-applied nitrogen was 37.5 kg.

Table 3. Nutrient use efficiency of senna as influenced by different organic and inorganic fertilizers

Treatment	Agronomic efficiency (kg equivalent yield added/kg N)	Factor productivity (kg equivalent yield/kg N)	Recovery efficiency (%)			Physiological efficiency (kg equivalent yield/kg nutrient absorbed)		
			N	P	K	N	P	K
FYM (t/ha)								
5	31.2	66.3	53	18.9	58.5	58.6	186.5	53.5
0	27.9	49.3	40	13.1	41.4	69.1	237.6	66.7
Nitrogen level (kg/ha)								
25	40.2	86.2	54	17.9	64.7	76.3	252.6	62.9
50	27.5	50.5	47	16.3	46.9	59.7	198.9	60.1
75	21.4	36.7	39	13.7	39.2	55.5	184.5	57.2

Economics

Application of 5t FYM recorded higher net returns and benefit cost ratio. Additional net returns of Rs. 4,190, respectively were obtained with 5 t/ha of FYM. Application of N enhanced the returns. The net returns and B: C ratio increased with application of N up to 75 kg/ha but 50 and 75 kg N/ha were at par with each other. The pooled data showed that there was an additional net return of Rs 3,943, 11,285, 13,272 with 25, 50 and 75 kg N/ha, respectively over control. This increase in returns due to FYM and nitrogen were due to positive effect of these on the yield (Table 4).

It was concluded that FYM @ 5 t/ha and 50 kg/ha N recorded higher yield, sennoside content and is the most remunerative and effective integrated approach. The optimum dose of nitrogen is 70 kg/ha.

REFERENCES

Al-Dakan, A.A., Tuffail, M. Al. and Hannan, M.A.1995. Cassia senna inhibits mutagenic activities of benzo[a]-pyrene, aflatoxin B_1, shamma and methyl methanesulfonate. *Pharmacological Toxicology* **77**: 288–292.

Azam, M.M., Sharma, A. K. and Amtul Waris. 2003. Variation in sennosides content and dry matter yield of senna (*Cassia angustifolia* Vahl.) grown under arid conditions of Rajasthan. *Journal of Medicinal and Aromatic Plant Sciences* **25:** 651–655.

Choudary, R.S. and Gautam, R.C. 2007. Effect of nutrient management practices on growth and yield of pearl millet (*Pennisectum glaucum*)**.** *Indian Journal of Agronomy* **52**(1)**:** 64–66.

Ilangovan, R., Subbiah, R. and Natrajan, S. 1990. Effect of spacing, nitrogen and phosphorus on certain growth parameters of senna (*Cassia angustifolia* Vahl.)**.** *South Indian Horticulture* **38**(1): 53–54.

Patidar, M. and Mali, A.L. 2002. Residual effect of farmyard manure and fertilizer biofertilizer on succeeding wheat (*Triticum aestivum*). *Indian Journal of Agronomy* **47**(10): 26–32.

Ratnayaka, H.H. and Kincaid, D. 2005. Gas exchange and leaf ultra structure of Tinnevelly senna (*Cassia angustifolia* Vahl.) under drought and nitrogen stress. *Crop Science* **45:** 840–847.

Ramesh, P. and Sammi Reddy, K. 2004. Productivity and nutrient use efficiency of soybean (*Glycine max*) and sorghum (*Sorghum bicolor*) intercropping at different levels of nitrogen in rainfed deep vertisols. *Indian Journal of Agronomy* **49**(1): 31–33.

Singh, R. and Agarwal, S.K. 2004. Effect of levels of farmyard manure and nitrogen fertilization on grain yield and use efficiency of nutrients in wheat (*Triticum aestivum*). *Indian Journal of Agricultural Sciences* **75**(7): 408–413.

Sharma, S.N. 2002. Nitrogen management in relation to wheat (*Triticum aestivum*) residue management in rice (*Oryza sativa*). *Indian Journal of Agricultural Sciences* **72**(8): 449–452.