Indian Journal of Agricultural Sciences **80** (2): 146–50, February 2010

Response of kenaf (*Hibiscus canabinus*) to integrated nutrient management in relation to its fibre productivity, nutrient uptake and soil properties

A R SAHA[1], D N MAITRA[2], B MAJUMDAR[3], S SAHA[4] and H CHOWDHURY[5]

Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata, West Bengal 700 120

Received: 21 November 2008; Accepted: 7 October 2009

ABSTRACT

A field experiment was undertaken during 2005–06 to study the effect of combined application of inorganic fertilizer, organic manure and biofertilizer on the productivity, nutrient uptake of kenaf and soil properties. Seventy-five per cent of recommended NPK applied in conjunction with organic manures (poultry manure or farm yard manure) and biofertilizer (*Azotobacter*) significantly increased kenaf fibre yield over 100% NPK. Highest fibre yield (3 308 kg/ha) was recorded in 75% NPK + poultry manure + *Azotobacter*. The highest N (75.39 kg/ha) and P (25.18 kg/ha) uptake was recorded in 75% NPK + poultry manure + *Azotobacter* while the highest K (260.96 kg/ha) uptake by kenaf was recorded in 75% NPK + farmyard manure + *Azotobacter* treatment. Post harvest soil analysis revealed that soil fertility status was enriched in respect of organic carbon, available N, P and K where inorganic fertilizer was incorporated in association with organic manures and biofertilizer. Highest soil available N (22.22% higher than control), P (1.66 times higher than control) and K (20% higher than control) were recorded in 50% NPK+ farmyard manure + *Azotobacter*, 50% NPK + poultry manure + *Azotobacter* and 75% NPK + farmyard manure + *Azotobacter*, respectively. Integrated use of 75% NPK + poultry manure + *Azotobacter* or 75% NPK+ farmyard manure + *Azotobacter* was found equally good for kenaf fibre production and maintenance of soil fertility under Typic Ustochrept. Total microbial and *Azotobacter* populations also improved with integrated nutrient management.

Key words: *Azotobacter*, Farmyard manure, Kenaf, N, P, K, Poultry manure, Productivity, Soil fertility

Mesta is one of the most important bast fibre crops of economic importance. Fibre is generally extracted from two types of mesta plants, known as kenaf (*Hibiscus cannabinus*) and roselle (*H. sabdariffa*). Among these kenaf is adaptable to various soil types and *p*H. It grows profusely under adverse conditions where jute cannot be grown (Sarma 1967). Kenaf occupies an area of about 1 million ha in Andhra Pradesh, Bihar, Orissa and part of Uttar Pradesh and West Bengal. Growth rate of kenaf is faster than roselle. Productivity of kenaf is also higher as compared to roselle. Kenaf fibres can be used for making coarse bags and can also be blended with synthetic fibres for making carpet, rope, net etc. Like jute, kenaf is also grown by marginal farmers. Imbalanced use of chemical fertilizers not only lowers productivity but also adversely affects soil health by decreasing soil organic carbon, microbial flora and hardening of soil. The integrated nutrient management ensures higher productivity, minimizes expenditure on costly fertilizer inputs, improves physical properties of soil, improves efficiency of added fertilizers and at the same time ensures good soil health (Bandyopadhyay and Puste 2002, Laxminarayana and Patiram 2006). Combined application of chemical fertilizers, organic manures and biofertilizer improved roselle fibre production (Saha *et al*. 2008). But the information on integrated nutrient management of kenaf is very meagre. Hence, a study was undertaken to observe influence of inorganic fertilizers, organic manure and bioagent on the productivity, nutrient uptake of kenaf and also on the soil properties.

MATERIALS AND METHODS

The field experiment was conducted during 2005–06 in Gangetic alluvial soil at the experimental farm of the CRIJAF, Barrackpore, West Bengal. The soil was Typic Ustochrept and the experimental site is geographically situated at 22° 45′N latitude, 80°26′E longitude with an altitude of 9.2 m above mean sea level. The soil of the experimental field was sandy loam with *p*H 7.1, organic carbon 6.0 g/kg and available N, P and K 313, 31.5 and 205 kg/ha, respectively. Average rainfall received during cropping year was 1 336.5 mm.

[1,3,5]Senior Scientist (e mail: amitsaha60 @yahoo.co.in, bmajumdar@crijaf.org.in, hemantac1 @rediffmail.com), [2]Scientist (Selection Grade) (e mail: dnmaitra @yahoo.co.in), [4]Principal Scientist (e mail: ssahacrijaf @rediffmail.com), Division of Crop Production.

Table 1 Treatments used in the experiment

Treatment	Details of combination
T_1	Control (no N P K)
T_2	100% of the recommended dose of NPK
T_3	50% of the recommended dose of NPK
T_4	75% of the recommended dose of NPK
T_5	50% of the recommended dose of NPK+ PM
T_6	50% of the recommended dose of NPK+ FYM
T_7	50% of the recommended dose of NPK+ AZ
T_8	50% of the recommended dose of NPK+PM+ AZ
T_9	50% of the recommended dose of NPK+ FYM + AZ
T_{10}	75% of the recommended dose of NPK + PM
T_{11}	75% of the recommended dose of NPK+ FYM
T_{12}	75% of the recommended dose of NPK+AZ
T_{13}	75% of the recommended dose of NPK+ PM + AZ
T_{14}	75% of the recommended dose of NPK + FYM + AZ

PM, Poultry manure, FYM, farmyard manure; AZ, *Azotobacter*

The experiment was laid out in a randomized complete block design with three replications and 14 treatments (Table 1) comprising inorganic fertilizers (NPK), organic manures (poultry manure and farmyard manure) and biofertilizer *(Azotobacter*) in different combinations. The recommended dose of NPK for kenaf was N: P: K: : 40: 20: 20 kg/ha. Sources of nitrogenous, phosphatic and potassic fertilizers were urea, single superphosphate and muriate of potash, respectively. Phosphorus and potassium fertilizers were applied as basal doses. Nitrogen fertilizer was applied in 2 equal splits at weeding and thinning (21 days after sowing) and at 2 (two) weeks after 1st application. Organic manures were added on the basis of nitrogen percentage (oven dry weight). Well decomposed poultry manure and farmyard manure containing 1.6, 1.5 and 2.41% and 0.60, 0.30 and 0.72% of N, P and K, respectively were incorporated and mixed well in the soil 15 days prior to sowing of the crop. The quantity of poultry manure was 1.26 and 0.63 tonnes/ha where 50 and 25% of the inorganic nitrogen were supplemented by poultry manure, respectively. The corresponding values for farmyard manure were 3.34 and 1.67 tonnes/ha, respectively. *Azotobacter chroococcum* was added through seed inoculation. The rate of inoculation was 2 kg/ha.

'HC 583' was sown in line with a row-to-row spacing of 30 cm. The crop was sown in the 2nd week of May. Weeding and thinning was done at 21 days crop age. The same procedure was maintained in second year also. Irrigation was given to the crop as and when necessary. The crop was harvested at maturity (140 days).

The plant samples were collected at harvest and dried in oven (±70°C), processed, thoroughly mixed and analyzed for total nitrogen, phosphorus and potassium following standard procedures (Tandon 1993). Initial and post harvest soil samples after 2 years were collected from 0 to 15 cm depth, dried, processed and analyzed for oxidizable organic carbon by Walkley and Black method, available N by alkaline permanganate method, available P by Olsen's method and available K by flame photometer, following standard procedures (Jackson 1973).

Total microbial and *Azotobacter* populations of soil samples were estimated by serial dilution technique immediately after collection.

RESULTS AND DISCUSSION

Dry fibre yield

Pooled analysis of 2 years data (Table 2) showed that dry fibre yield decreased considerably in control (no fertilizer application). Application of 50 or 75% NPK recorded significantly higher dry fibre yield than control but lower compared to 100% NPK. Incorporation of 50% NPK in association with organic manures and biofertilizer *(Azotobacter*) recorded fibre yield which was at par with 100% NPK. Combined application of 75% NPK and organic manure, in presence or absence of *Azotobacter*, significantly increased dry fibre yield of kenaf. Application of 75% NPK + poultry manure + *Azotobacter* recorded the highest fibre yield (3 308 kg/ha) which was 10.9% higher over 100% NPK. In both the years 75% NPK + organic manure + *Azotobacter* significantly improved dry fibre yield of kenaf over 100% NPK. The fibre yield obtained through 100% NPK was either at par or lower than the yield through organic manure or biofertilizer or organic manure + biofertilizer along with 75% NPK. It indicated that organic manure or biofertilizer saved at least 25% NPK in kenaf. This might be attributed to favourable effect of organic manures and biofertilizer in

Table 2 Effect of inorganic fertilizers, organic manures and biofertilizer on fibre yield of kenaf

Treatment	Fibre yield (kg/ha) Year		
	2005	2006	Mean
No NPK (Control)	2038	1420	1729
100% NPK	3315	2651	2983
50% NPK	2705	2200	2453
75% NPK	2960	2404	2682
50% NPK + PM	3076	2442	2759
50% NPK + FYM	3011	2378	2695
50% NPK + AZ	3024	2290	2657
50% NPK + PM + AZ	3096	2560	2828
50% NPK + FYM + AZ	3102	2500	2801
75% NPK + PM	3261	2804	3033
75% NPK + FYM	3253	2750	3002
75% NPK + AZ	3160	2670	2915
75% NPK + PM + AZ	3693	2922	3308
75% NPK + FYM + AZ	3529	2855	3192
CD (P= 0.05)	351	265	214

PM, Poultry manure; AZ, *Azotobacter*; FYM, Farmyard manure supply of additional nutrients through mineralization and improvement in physico-chemical properties of soil. Similar results in increasing yield of groundnut with combined application of NPK and organic manures like farmyard manure, pig manure and poultry manure were also reported earlier (Laxminarayana and Patiram 2005).

Nutrient uptake

Pooled analysis of 2 years data revealed that various combinations of NPK or NPK with manures and biofertilizer significantly increased the nutrient uptake over control (Table 3). Application of 75% NPK increased nutrient uptake by kenaf considerably over 50% NPK but the increase was not significant. Addition of 75% NPK with organic manure and biofertilizer could record significantly higher nutrient uptake as compared to 50% NPK + organic manure + biofertilizer. Organic manures and biofertilizer along with NPK indicated the higher nutrient uptake as compared to NPK only. Results of both the years showed the same trend. The higher nutrient uptake with organic manure might be attributed to solubilization of native nutrients, chelation of complex intermediate organic molecules produced during decomposition of added organic manures, mobilization and accumulation of different nutrients in different plant parts (Dosani *et al.* 1999). The highest N (75.39 kg/ha) and P (25.18 kg/ha) uptakes were recorded with 75% NPK+ poultry manure + biofertilizer. The highest K uptake was recorded with 75% NPK + farmyard manure + biofertilizer (260.96 kg/ha). The nutrient uptake at 100% NPK was at par with nutrient uptake at 75% NPK+ poultry manure/farmyard manure + *Azotobacter* indicating 25% NPK can be supplemented through combination of manures (poultry manure and farmyard manure) and biofertilizer (*Azotobacter*). This could be due to stimulated microbial growth and favoured root growth under improved soil physical condition (Kachot *et al.* 2001).

Soil fertility status

Soil fertility status after kenaf crop improved due to various treatments. Organic C content increased (Table 4) with inorganic fertilizers in combination with organic manures and biofertilizer but the increase was not significant. The highest organic carbon content was recorded in 50% NPK + poultry manure + *Azotobacter,* closely followed by 50% NPK+ farmyard manure + *Azotobacter*. Addition of different organic manures directly resulted in increase in organic carbon content in the soil.

The available nitrogen of the soil increased significantly with the integrated application of NPK and organic manures over only NPK. This might be attributed to the mineralization of N from organic manures. Higher available N was recorded in 50% NPK+ farmyard manure + *Azotobacter* and 75% NPK + poultry manure + *Azotobacter*. The increase in available N was 22.22 and 21.85% respectively, over control which may be because of higher biological N-fixation by *Azotobacter* (Majumdar *et al.* 2007). Increase in available nitrogen status under integrated treatments might also be attributed to greater multiplication of soil microbes as a result of which organically bound nitrogen converted to mineralizable form of nitrogen.

The available phosphorus of the soil increased with integrated use of inorganic fertilizers and organic manures. Higher available P was recorded where poultry manure was added in combination with inorganic fertilizers. The highest available P was recorded in 50% NPK + poultry manure + *Azotobacter* which was 1.66 times higher than control. Organic material forms a protective cover on sesquioxide and thus reduces phosphate-fixing capacity of the soil.

Table 3 Effect of inorganic fertilizers, organic manures and biofertilizer on NPK uptake by kenaf

Treatment	N-uptake (kg/ha)			P-uptake (kg/ha)			K-uptake (kg/ha)		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
No NPK (control)	48.75	31.38	40.07	17.23	11.36	14.30	139.97	117.86	133.92
100% NPK	73.04	58.59	65.82	24.35	22.21	23.28	220.03	239.77	229.90
50% NPK	55.10	48.63	51.87	19.40	17.60	18.50	204.25	182.63	193.44
75% NPK	66.78	53.14	59.96	21.15	19.23	20.19	216.84	199.56	208.20
50% NPK + PM	53.37	55.98	54.68	20.16	20.54	20.35	199.07	197.35	198.21
50% NPK + FYM	63.85	54.55	59.20	20.82	19.02	19.92	228.82	202.71	215.77
50% NPK + AZ	57.92	50.62	54.27	21.45	18.32	19.89	190.10	187.18	188.64
50% NPK + PM + AZ	68.70	56.57	62.64	23.85	21.48	22.67	214.20	212.45	213.33
50% NPK + FYM + AZ	57.57	55.24	56.41	23.17	20.00	21.59	207.47	195.81	201.64
75% NPK + PM	65.44	61.98	63.71	25.20	22.43	23.82	245.49	232.76	239.13
75% NPK + FYM	64.07	60.78	62.43	23.51	22.00	22.67	261.95	228.28	245.12
75% NPK + AZ	69.12	56.35	62.74	24.70	20.40	22.55	249.27	211.62	230.45
75% NPK + PM + AZ	80.19	70.58	75.39	24.97	25.38	25.18	271.00	242.55	256.78
75% NPK + FYM + AZ	78.77	69.09	73.93	26.49	22.84	24.67	276.90	245.01	260.96
CD (P= 0.05)	NS	5.86	12.62	4.45	2.51	2.47	49.83	22.03	26.83

Table 4 Effect of integrated nutrient management on post kenaf soil properties

Treatment	Organic C (g/kg)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
No NPK (control)	6.0	270	28.7	200
100% NPK	6.4	310	38.8	236
50% NPK	6.2	280	33.1	225
75% NPK	6.3	305	35.8	230
50% NPK + PM	6.8	325	43.8	239
50% NPK + FYM	6.9	324	41.2	233
50% NPK + AZ	6.4	327	33.7	230
50% NPK + PM + AZ	7.1	324	47.7	238
50% NPK + FYM + AZ	7.0	329	43.5	235
75% NPK + PM	6.8	320	38.9	236
75% NPK + FYM	6.8	327	36.9	234
75% NPK + AZ	6.7	315	35.2	234
75% NPK + PM + AZ	6.9	327	40.6	237
75% NPK + FYM + AZ	7.0	330	39.3	240
Initial	6.0	313	31.5	205
CD (P=0.05)	NS	16.51	9.22	NS

Table 5 Total microbial population of post kenaf soil (per g of oven dry soil)

Treatment	Bacteria (cfu ×10^6)	Fungi (cfu ×10^3)	Actino-mycetes (cfu ×10^5)	Azoto-bacter (cfu ×10^3)
No NPK (control)	66.25	67.50	133.75	20.00
100% NPK	76.25	75.00	147.50	17.50
50% NPK	67.00	68.50	138.25	11.25
75% NPK	70.25	71.00	142.50	12.50
50% NPK + PM	85.00	100.00	175.00	14.00
50% NPK + FYM	62.50	92.50	168.75	16.25
50% NPK + AZ	81.25	62.50	132.50	17.00
50% NPK + PM + AZ	131.25	93.75	171.25	22.50
50% NPK + FYM + AZ	141.25	83.75	160.00	24.00
75% NPK + PM	76.25	35.00	111.25	17.50
75% NPK + FYM	81.25	70.00	152.50	21.25
75% NPK + AZ	88.75	82.50	153.75	26.25
75% NPK + PM + AZ	130.00	106.25	162.50	27.00
75% NPK + FYM + AZ	152.50	110.00	181.25	28.50
Initial	25.00	68.75	136.25	21.25
CD (P=0.05)	6.7	5.4	7.2	2.5

Integrated use of inorganic fertilizers and organic manures enriched soil available K content. The highest available K content was recorded in 75% NPK + farmyard manure + *Azotobacter*, followed by 50% NPK + poultry manure. These increases were 20 and 19.5% respectively over control. This might be due to the release of non-exchangeable K from the soil. This released K and also applied K not only met crop requirements but also built-up available K content in the soil. The results are in conformity with Laxminarayana and Patiram (2006).

Soil microbial population

There was variable build-up (Table 5) of total microbial (bacteria, fungi and actinomycetes) and non-symbiotic N-fixing bacteria *Azotobacter* in the soil under various treatments. Integration of organic manure and biofertilizer with NPK not only increased microbial and *Azotobacter* populations in the soil but also increased organic carbon content and available N content of the soil (Tables 4, 5). The biological N-fixation by non-symbiotic N-fixing bacteria (*Azotobacter*) led to increase of organic C and available N content in the soil. Similar improvement in microbial activities, organic C and available N with integrated use of NPK, organic manure and biofertilizer were also reported by Majumdar *et al.* (2007). The highest microbial population as well as *Azotobacter* population was recorded in 75% NPK+ farmyard manure + *Azotobacter* as compared to other treatments under study.

It may be concluded that integrated use of NPK fertilizer, organic manure and *Azotobacter* improved productivity of mesta, reduced use of chemical fertilizers and at the same time enriched fertility status of the soil. Among organic manures both poultry manure and farmyard manure proved equally beneficial to kenaf. Total microbial population was also found improved in the integrated nutrient management approach.

REFERENCES

Bandyopadhyay S and Puste A M. 2002. Effect of integrated nutrient management on productivity and residual soil fertility status under different rice (*Oryza sativa*) – pulse cropping systems in rainfed laterite belt of West Bengal. *Indian Journal of Agronomy* **47** (1): 33–40.

Bhattacharjee A K, Sen H S, Sarkar S, Roy A and Nayak P. 2007. Improved production technology for mesta. *Technical Bulletin Series: 3 A*, 15pp. CRIJAF, Barrackpore.

Dosani A A K, Talashilkar S C and Mehta V B. 1999. Effect of poultry manure applied in combination with fertilizers on the yield, quality and nutrient uptake of groundnut. *Journal of Indian Society of Soil Science* **47** (1): 166–9.

Jackson M L. 1973. *Soil Chemical Analysis*, 485 pp. Prentice Hall of India Pvt. Ltd, New Delhi.

Kachot N A, Malavia D D, Solanki R M and Sagarika B K. 2001. Integrated nutrient management in rainy season groundnut *(Arachis hypogaea*). *Indian Journal of Agronomy* **46** (3): 516–22.

Laxminarayana K and Patiram. 2005. Influence of inorganic, biological and organic manures on yield and nutrient uptake of groundnut *(Arachis hypogaea*) and soil properties. *Indian Journal of Agricultural Sciences* **75** (4): 218–21.

Laxminarayana K and Patiram. 2006. Effect of integrated use of inorganic, biological and organic manures on rice productivity and soil fertility in Ultisols of Mizoram. *Journal of Indian Society of Soil Science* **54** (2): 213–20.

Manish Kumar, Singh R P and Rana N S. 2003. Effect of organic and inorganic sources of nutrition and productivity of rice (*Oryza sativa*). *Indian Journal of Agronomy* **48** (3): 175–7.

Majumdar B, Venkatesh M S and Saha R. 2007. Effect of nitrogen, farmyard manure and non-symbiotic nitrogen-fixing bacteria on yield, nutrient uptake and soil fertility in upland rice *(Oryza sativa*). *Indian Journal of Agricultural Sciences* **77** (6): 335–9.

Saha A R, Maitra D N, Majumdar B, Saha S and Mitra S. 2008. Effect of integrated nutrient management on roselle *(Hibiscus sabdariffa*) productivity, its mineral nutrition and soil properties. *Indian Journal of Agricultural Sciences* **78** (5): 418–21.

Sarma M S. 1967. Breeding procedure for *Hibiscus*. *Indian Council of Agricultural Research Bulletin No.* **11**: 1–50.

Tandon H L S. 1993. *Methods of Analysis of Soils*, *Plants*, *Water and Fertilizer*, pp. 140–55. Fertilizer development and Consultation Organization, New Delhi.