Effect of Integrated Nutrient Management on Growth and Fibre Yield of Sisal (Agave *sisalana*) in North Coastal Zone of Andhra Pradesh

ABSTRACT

Sisal (Agave *sisalana*) historically an important crop grown in marginally degraded soils in north coastal zone of Andhra Pradesh. The leaf fiber from sisal is used for multiple purposes. The semi- perennial xerophytic sisal crop is significantly responding to nutrient management practices in rainfed soils. Pooled results of the field experiment conducted during 2020-21 to 2021-22 at Agricultural Research station, Amadalavalasa, Andhra Pradesh under All India Network Project on Jute and Allied Fibres revealed that, the growth and fibre yield parameters are responding positively to nutrient management practices. Combined application of 90: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} increased number of leaves / plant by 50.4% as compared to control. Same treatment combination influenced the leaf length and width to the tune of 26% and 14% respectively compared to control. Among the treatments imposed in the experiment, the higher green leaf (49.2%) and dry fibre yield (49.4%) was recorded with 90: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} over control. The effect of integrated application of nutrients to sisal was reflected in higher soil available nitrogen, phosphorus and potassium status compared to only NPK application and control treatments. Overall the sisal crop growth, green leaf yield, dry fibre yield and post-harvest soil fertility status was significantly higher with conjunctive use of organic and inorganic sources of nutrients compared to inorganic NPK alone. Hence, the integrated nutrient management proved to be highly rewarding in marginal, nutrient depleted and degraded soils, particularly in rainfed, semi-perennial crops like sisal.

Key words: Organic manures, Inorganic fertilizers, INM, Fibre yield, Soil fertility.

1. INTRODUCTION

Sisal (Agave *sisalana*) is an important leaf fiber producing xerophytic, monocarp, semi-perennial plant belonging to Asparagaceae family, commonly known as Agave. In India, sisal crop is mainly grown in arid and semi-arid regions and generally on marginal lands having poor soil fertility status. It is majorly found in Andhra Pradesh, Orissa, Bihar, Karnataka, Maharashtra, and West Bengal (1). Sisal is a very hardy crop, can be grown in large plantations or by the tribal farmers in their small stretch of degraded soils. Generally, sisal crop grown as live fence in wild conditions, as erosion control or afforestation measure in degraded lands reduces soil erosion through its extensive root system and contributes positively to watershed management and yields fibre for 10-12 years without much care (2-4).

Several species of sisal are indigenous to India and they are *Agave sisalana, A. cantala, A. veracruz, A. amanuensis, A. angustifolia,* and *A. fourcryodes.* Among these, *A. sisalana* contributes nearly 85% of total sisal fibre production. It has been estimated that, healthy sisal plant produces 500 -750 leaves in about 10-12 years of its life span. One tonne of sisal leaves removes 23.5 kg of N, 3.5 kg P, 35 kg K, 81 kg Ca and 30 kg Mg from soil (4). Therefore, replenishment of soil nutrients through the application of both organic and inorganic sources is inevitable for sustainable fibre production. Sisal fibre is used for multiple purposes and its uses ranged from domestic to industrial purposes including high strength requiring long lasting geo-textile, speciality composites and commonly used in shipping industry. Therefore, renewed interests has been noticed in recent times to grow sisal primarily for its quality fibre having great demand in the country (3).

Further, some pockets of north coastal region of Andhra Pradesh are having undulated terrain, poor soil fertility, low water retention capacity, where no other arable crop could be grown by the resource poor farmers. If Sisal cultivation is promoted in this kind of arid ecosystem and sustained the productivity through critical technological interventions like varietal introduction, comprehensive package of nutrient management, it goes in a long way in improving the family economy of resource poor farm households. Therefore, a field experiment was conducted at ARS, Amadalavalasa to develop an integrated nutrient management schedule for enhancing the productivity of sisal plantations in north coastal zone of Andhra Pradesh.

2. MATERIALS AND METHODS

Field experiment was conducted during *kharif* and *rabi* 2020-21 and 2021-22 at Agricultural Research Station, Amadalavalasa ANGRAU, Andhra Pradesh under All India Network Project on Jute and Allied Fibres. Geographically, the experimental field is situated at latitude / longitude of 18.4°N, 83.89°E with an altitude of 35 m above mean sea level. The soil of the experimental field was sandy clay loam in texture. The pre sowing soil fertility status of the experimental field and nutrient content in applied manure is presented in Table 1.

Experiment was laid out in factorial randomized block design with three replications. The treatments comprising two factors. Factor 1 comprising the varieties of sisal (V1: Bamra local and V2: Leela hybrid) and factor 2 comprising the fertilizer levels. The treatment combinations imposed in the experiment are presented in Table 2.

Table 1: Initial nutrient status of soil and nutrient content of the applied organic manure

Soil / organic manure	pH	EC	O C	Avail. N	Avail. P_2O_5	Avail. K_2O
Initial Soil	5.16	0.03 (d S/m)	0.23 (%)	159.0 (kg/ha)	19.0 (kg/ha)	152.0 (kg/ha)
Sisal leaf waste	--	--	--	0.12 (%)	0.06 (%)	0.02 (%)
Vermi Compost	--	--	--	1.1 (%)	0.22 (%)	0.48 (%)
Poultry manure	--	--	--	1.2 (%)	0.8 (%)	0.65 (%)

Table 2. Details of the treatment combinations evaluated in the experiment

Treatments	Details of organic and inorganic combination
T1	Control (No fertilizer)
T2	30: 30: 60 kg $N:P_2O_5:K_2O$ ha^{-1}
T3	60: 30: 60 kg $N:P_2O_5:K_2O$ ha^{-1}
T4	90: 30: 60 kg $N:P_2O_5:K_2O$ ha^{-1}
T5	120: 30: 60 kg $N:P_2O_5:K_2O$ ha^{-1}
T6	60: 30: 60 kg $N:P_2O_5:K_2O$ ha^{-1} + sisal waste @ 20 t ha^{-1}
T7	90: 30: 60 kg $N:P_2O_5:K_2O$ ha^{-1} + sisal waste @ 20 t ha^{-1}
T8	60: 30: 60 kg $N:P_2O_5:K_2O$ ha^{-1} + vermicompost @ 2.5 t ha^{-1}
T9	90: 30: 60 kg $N:P_2O_5:K_2O$ ha^{-1} + vermicompost @ 2.5 t ha^{-1}
T10	60:30: 60 kg $N:P_2O_5:K_2O$ ha^{-1} + poultry manure @ 4 t ha^{-1}

Sources of nitrogen, phosphorus and potash nutrients were urea, single super phosphate and muriate of potash, respectively. N, P and K fertilizers were applied as split in two doses, one in June – July and another after six months from the first dose in January – February. Observations on number of leaves per plant, leaf length (cm), leaf width (cm) was recorded at physiological maturity. The green leaf / fresh yield and dry yield of fibre was recorded at harvest.

Initial and post-harvest soil samples were collected at 0-15 cm depth, dried under shade, processed and analysed for soil reaction, electrical conductivity, available N by alkaline permanganate method, available P by Olsen's method and available K by flame photometer by following standard procedures (5). All the observations recorded for different parameters were statistically analysed using analysis of variance (ANOVA) technique and results were presented at 5 % level of significance (P=0.05).

3. RESULTS AND DISCUSSION

3.1 Effect of INM on growth and fibre yield of sisal

The effect of integrated nutrient management on growth parameters of sisal crop is presented in Table 3. Pooled data of two years experiment with two sisal varieties and different levels of NPK and organic manure combination revealed that, two varieties of sisal crop (Bamra local and Leela hybrid) responded positively to the application of organic and inorganic source of nutrients. However, integrated application of nutrients significantly improved the growth attributes of sisal crop.

The number of leaves per plant were significantly higher with Leela (41) compared to Bamra (32). The mean number of leaves per plant in both the varieties of sisal was significantly higher with the application of 90: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} (T9) followed by 60: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} (T8) and 60:30: 60 kg NPK ha^{-1} + poultry manure @ 4 t ha^{-1} (T10), 90: 30: 60 kg NPK ha^{-1} + sisal waste @ 20 t ha^{-1}, (T7), 60: 30: 60 kg NPK ha^{-1} + sisal waste @ 20 t ha^{-1} (T6) as compared to inorganic treatments and lowest in control. The similar trend of results was followed pertaining to leaf length and width with the integrated application of nutrients as compared to sole NPK fertilizers and control. However, the interaction effect between varieties and different nitrogen levels was also significant with number of leaves per plant but the other growth parameters such as leaf length and width was non-significant.

Among the treatments considered in this experiment the increase with respect to mean number of leaves/plant was 50.4 %, leaf length was 26 % and leaf width was 14 % respectively, with the application of 90: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} as compared to control.

The number of leaves per plant is one of the major determinants of fibre yield in sisal which significantly increased under inorganic and organic combination @ 90: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} as compared to only NPK fertilizer at different levels. While the leaf length and width were also responded positively at the conjunctive application under same combination compared to sole NPK and control. The least performance of growth parameters was in control plots reflecting the nutrient deficient status of soil. The results obtained are in agreement with the findings of (4, 6) that sisal also needs inorganic source of nutrients for immediate requirement and organic source of nutrients to fulfil the requirement for optimum growth of crop.

The pooled analysis of two years' data pertaining to green leaf and dry fibre yield of two varieties (Bamra local and Leela hybrid) of sisal (Table 4) reveals that, green leaf yield was significantly higher with integrated application of inorganic and organic sources @ 90: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} (T9) compared to other combination of nutrients and control. However, 90 and 60 Kg NPK ha^{-1} along with vermicompost @ 2.5 t ha^{-1} were at par with each other followed by 60:30: 60 kg NPK ha^{-1} + poultry manure @ 4 t ha^{-1} (T10). Sole application of inorganic fertilizers recorded lower green leaf yield and least yield was recorded in the control.

Table 3: Effect of inorganic fertilizers and organic manures on the growth of sisal crop

Treatments	No.of Leaves/plant			Leaf length (cm)			Leaf width (cm)		
	Bamra	Leela	Mean	Bamra	Leela	Mean	Bamra	Leela	Mean
T1	28.5	29.5	29.0	80.3	74.7	77.5	10.4	9.7	10.0
T2	29.2	31.2	30.2	93.1	80.8	87.0	10.7	10.0	10.3
T3	30.7	34.6	32.6	97.1	87.2	92.1	10.7	10.2	10.4
T4	33.2	42.9	38.0	101.1	91.2	96.2	11.1	10.4	10.7
T5	33.0	44.2	38.6	99.6	91.9	95.8	11.3	10.6	11.0
T6	30.2	37.0	33.6	95.6	87.6	91.6	11.0	10.3	10.7
T7	31.8	44.9	38.4	95.9	90.4	93.1	11.5	10.5	11.0
T8	33.8	50.3	42.1	98.7	91.2	95.0	11.8	10.6	11.2
T9	34.8	52.4	43.6	102.7	92.8	97.7	12.0	10.8	11.4
T10	33.2	46.5	39.8	101.3	89.8	95.6	11.2	10.7	10.9
MEAN	31.8	41.3	--	96.5	87.8	--	11.2	10.4	--
	V	**N**	**V x N**	**V**	**N**	**V x N**	**V**	**N**	**V x N**
SE(m)±	**0.76**	**1.69**	**2.39**	**0.79**	**1.77**	**2.51**	**0.08**	**0.18**	**0.25**
CD (5%)	**2.13**	**4.76**	**6.70**	**2.23**	**4.99**	**NS**	**0.22**	**0.50**	**NS**

The similar results were recorded with respect to dry fibre yield of sisal, wherein, 90: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} (T9) recorded higher fibre yield compared to all other combination of treatments and control. However, the treatments T8, T10, T7 and T5 are at par with each other and significantly low yield was recorded with sole application of inorganic fertilizers and control. Among the treatments considered in this experiment the highest green leaf (49.2%) and dry fibre yield (49.4%) was recorded in conjunctive application @ 90: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} over control.

The yield obtained with respect to green leaf and dry fibre yield under integrated nutrient supply attributed to the synergistic effect of NPK and organic manures used in the experiment. Inorganic sources of NPK supply immediate nutrient need by the plant while organic manures supply additional nutrients through mineralization and influenced the physico-chemical as well as fertility status of the soil. The organic manures serve as the nutrient holding site for NPK and hence preventing the nutrient losses from various ways. This might create a favourable nutrient supplying environment for sisal crop to increase the green leaf yield and intern higher dry fibre yield. The results recorded are in line with the findings of (4,7,6). Besides, the integrated nutrient supply sisal leaf waste, vermicompost and poultry manure had considerable amount of plant macronutrients which also might have supported the plant growth and fibre yield (8).

The consistent low yields of the green leaf and dry fibre yield of Bamra local and Leela hybrid with different levels only NPK as compared to integrated nutrient management over two years might be attributed to the application of mineral fertilizer to the semi-arid rainfed soils, which are poor in water holding capacity, low in cation exchange capacity (CEC) and nutrient availability. This could result in leaching losses of applied nutrients due to erratic rainfall. Hence the low performance of sisal might have observed with the only application of NPK fertilizers. The recorded results of the current study are in line with the findings of (9).

Table 4: Effect of integrated nutrient management on green leaf and fibre yield of sisal

Treatments	Green leaf yield (t/ha)			Fibre yield (q/ha)		
	Bamra	Leela	Mean	Bamra	Leela	Mean
T1	42.47	35.76	39.11	13.96	11.95	12.96
T2	43.47	37.73	40.60	14.28	12.61	13.45
T3	45.46	41.86	43.66	14.94	13.99	14.47
T4	49.24	51.70	50.47	16.18	17.28	16.73
T5	49.15	53.92	51.53	16.15	18.02	17.08
T6	45.31	44.85	45.08	14.89	14.99	14.94
T7	47.63	54.95	51.29	15.65	18.36	17.01
T8	50.89	62.53	56.71	16.72	20.90	18.81
T9	51.84	64.87	58.35	17.04	21.68	19.36
T10	49.12	55.95	52.54	16.14	18.70	17.42
Mean	47.46	50.41	--	15.6	16.8	--
	V	N	V x N	V	N	V x N
SE(m)±	0.94	2.11	2.99	0.31	0.70	0.99
CD (5%)	2.66	5.95	8.42	0.88	1.98	2.79

3.2 Effect of INM on soil fertility status

The pooled data on post-harvest soil fertility status indicated the improvement in soil fertility due to various treatments. The available nitrogen content of the soil was increased positively with the integrated application of NPK and organic manures over only NPK and control. Higher available N was recorded in 60: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} and lowest among sole NPK recorded in 30: 30: 60 kg NPK ha^{-1} and least in control.

While with respect to available phosphorus, highest was recorded in 60: 30: 60 kg NPK ha^{-1} + poultry manure @ 4 t ha^{-1}, lowest among sole NPK fertilizer application was recorded in 30: 30: 60 kg NPK ha^{-1} and the least in control. Whereas, the potassium status in soil indicated highest content in 60: 30: 60 and 90: 30: 60 kg NPK ha^{-1} + vermicompost @ 2.5 t ha^{-1} and lowest recorded among sole NPK in 30: 30: 60 kg NPK ha^{-1} and least in control. However, the increase in soil fertility status with respect to nitrogen and phosphorus over control and only NPK treatments was non-significant but significant with respect to potassium content in soil.

However, the interaction effect between varieties and different nitrogen levels was significant with green leaf yield and dry fibre yield.

The increase in available nitrogen status under integrated application of nutrients might be attributed to mineralization of nitrogen from organic manures, greater multiplication of soil microbes and stimulation of soil enzymes. As a result of which organically bound nitrogen converted to mineralizable form of nitrogen. The findings of the present experiment are in line with the results of (7, 10).

While the available phosphorus content was increased due to organic matter might be the protective cover on sesquioxides and thus reduced the phosphate fixation and increased its available forms in soil. Besides this the release of non-exchangeable forms of K from the soil also might have enriched the available potassium content in soil. As a result of released K and applied K, sisal crop not only met its requirements but also enriched the fertility of soil. The present work results are in confirmation with the findings of (11,7).

Table 5: Effect of integrated nutrient management on post-harvest soil fertility status

Treatments	Aval. N (kg/ha)			Aval. P_2O_5 (kg/ha)			Aval. K_2O (kg/ha)		
	Bamra	Leela	Mean	Bamra	Leela	Mean	Bamra	Leela	Mean
T1	155	160	158	19.6	20.4	20.0	155	171	163
T2	158	159	159	20.4	19.8	20.1	168	173	170
T3	159	163	161	20.8	19.7	20.3	166	176	171
T4	163	158	161	21.4	20.8	21.1	170	176	173
T5	164	159	162	20.8	20.4	20.6	171	176	174
T6	163	163	163	21.7	20.8	21.3	171	182	177
T7	163	159	161	20.3	21.2	20.8	174	179	177
T8	166	165	166	21.2	22.4	21.8	175	180	178
T9	165	165	165	21.6	19.8	20.7	184	176	180
T10	163	163	163	22.3	21.5	21.9	170	189	180
Mean	162	161	--	21.0	20.7		171	178	--
	V	N	V x N	V	N	V x N	V	N	V x N
SE(m)±	0.53	1.19	1.68	0.15	0.33	0.46	0.65	1.44	2.04
CD (5%)	NS	3.4	NS	NS	0.94	NS	1.9	4.2	5.9

4. CONCLUSION

The conjunctive application of inorganic and organic source of nutrients proved to be highly rewarding in marginal, nutrient depleted and degraded soils for remediation and continuous nutrient supply particularly for semi-perennial crops like sisal. Comparative advantage of organic manure on soil physical-chemical properties over sole NPK fertilizer was reflected in the form of crop growth and fibre yield. Sisal is suitable for marginally waste lands, suitable for climate resilience, puts low pesticide load to environment through its cultivation process.

Being, semi-perennial and low agronomic activity in its cultivation conserves the soil. The integrated nutrient management practiced in the current study with organic sources like sisal waste, vermicompost and poultry manure improved the fertility status of soil, crop growth and fibre yield. Therefore, combined application of organic and inorganic sources of nutrients could be the suitable option for soil health and green leaf and fibre yield sustenance of sisal under rainfed in north coastal zone of Andhra Pradesh.

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