INTERCROPPING OF PULSES AND OILSEEDS WITH SISAL (Agave *sisalana*) IN NORTH COASTAL ZONE OF ANDHRA PRADESH

ABSTRACT

Sisal (*Agave sisalana*) a semi perennial, xerophytic, leaf fibre crop mainly grown in degraded soils for conservation and as live fence, renewed interests in recent times primarily for its quality fibre having great demand in the country. A field experiment was conducted during *rabi 2020 and* 2021 under AINP on Jute and Allied Fibres at Agricultural Research Station, Amadalavalasa – ANGRAU. The experiment was conducted to study the suitability and economic feasibility of short duration pulses and oilseeds as intercrops in between paired row spaces of sisal plantation. Results revealed that, short duration pulses are more feasible than oilseeds as intercrops with increased productivity per unit area. The sisal fibre yield and intercrops yield was higher with pulse intercropping than oilseeds. Sisal fibre equivalent yield of intercrops varied between 1.87 q ha^{-1} in case of sisal + mustard to 5.28 q ha^{-1} in sisal + cowpea. The net returns per rupee invested was highest in sisal + cowpea (3.42) followed by sisal + greengram (3.34), sisal + rajma (3.05) and lowest among pulses was sisal + blackgram (2.83). while, among oilseeds, highest was in sisal + niger (2.90) followed by sisal + mustard (2.80) and sisal + sesame (2.65) compared to lowest in sole sisal (2.49). However, the total system productivity in terms of sisal fibre equivalent yield of cropping system varied between 14.05 q ha^{-1} in case of sole sisal to 21.64 q ha^{-1} in sisal + cowpea. The results inferred that, growing of short duration pulses in between paired row spaces of sisal could be efficiently used by growing short duration pulses like cowpea, greengram, rajma and blackgram for increased cropping system under sisal plantation.

Key words: Sisal, Intercropping, Short duration pulses, Oilseeds, Economics. Yield

INTRODUCTION

Sisal (*Agave sisalana*), a leaf fibre producing plant belongs to Asparagaceae family, commonly known as Agave in India. It is semi perennial, xerophytic and mainly grown in arid and semi-arid regions of Andhra Pradesh, Orissa, Bihar, Karnataka, Maharashtra, and West Bengal (Nayak et al. 2011). In the context of climate change and land degradation neutral, sisal is an excellent CDM (clean development mechanism) crop for biochemical as well as for afforestation in degraded lands besides improvement in soil carbon sequestration (Sarkar and Jha. 2017). Generally, sisal plant

resistant to many pest and diseases consequently reduces pesticide load in the environment, reduces soil erosion through its extensive root system, contributes positively to watershed management. Therefore, designated as "specialty crop" for conservation agriculture (Sarkar et al. 2010; Sarkar et al. 2015; Sarkar and Jha. 2017).

Several species of sisal are indigenous to India largely grown as live fence as well as in wild conditions. Different species 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 in the world. Healthy sisal plant produces 500 -750 leaves in about 10-12 years of its life span. Thus a normal sisal leaf with 600-gram weight produces about 1000 fibres for each leaf (Nayak et al. 2011 and Sarkar et al. 2015). Globally, sisal fibre can be used for multiple purposes and commonly used in shipping industry and several other domestic to industrial uses including high strength requiring long lasting geo-textile and speciality composites.

In this scenario, renewed interests in recent times has been noticed to grow sisal primarily for its quality fibre having great demand in the country (Sarkar et al. 2015). 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. Sisal appears to be a promising alternative in this region, if profitability of this crop could be sustained by introduction of suitable inter crops in sisal for increasing the system productivity.

However, improved production technology of paired row system is usually practiced in north coastal zone for sisal production. But in this system a large amount of land area unutilized in between rows. Therefore, the inter-row space may be utilized with suitable intercrops to improve profitability of the system. But, sufficient and detailed research work on suitable inter crops for sisal plantation in north coastal zone of A.P is truly lacking. Therefore, a field experiment was conducted to identify suitable intercrops for increasing the system productivity as well as profitability of sisal-based cropping system.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* and *Rabi*, 2020 -21 and 2021-22 in sandy clay loam soil at Agricultural Research Station farm, Amadalavalasa,

ANGRAU, Andhra Pradesh under All India Network Project on Jute and Allied Fibres (AINPJAF). 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 experiment was laid out in randomized block design with 9 treatments and three replications. The treatment details are T_1: Sisal + Black gram (GBG-1); T_2: Sisal + Greengram (IPM 2-14); T_3: Sisal + Cowpea (Local variety); T_4: Sisal + Horsegram (Local Black); T_5: Sisal + Sesame (YLM-66); T_6: Sisal + Niger (KGN-2); T_7: Sisal + Mustard (Local variety); T_8: Sisal + Rajma (Amber) and T_9: Sole Sisal. The agro-techniques adopted for the short duration pulses and oilseeds as intercrops in sisal plantation is given in Table 1.

Table 1: Agro-techniques adopted for pulses and oilseeds as intercrops in between paired rows of sisal

Crop	Variety	Duration (Days)	Spacing (cm)	RDF N:P:K:S (kg ha^{-1})
Pulses				
Vigna mungo (L.) (Blackgram)	GBG-1	70-75	30 × 10	20:50:0
Vigna radiata (L.) (Greengram)	IPM 2-14	60-65	30 × 10	20:50:0
Vigna ungiculata (L.) (Cowpea)	DC-15	75-80	30 × 15	15:50:50
Macrotyloma uniflorum (L.) (Horsegram)	CRHG -22	85-90	30 × 10	10:25:4
Phaseolus vulgaris (Rajmash)	Amber	70-75	30 × 10	90:60:0
Oilseeds				
Sesamum indicum (L.) (Sesame)	YLM-66	80-90	30 × 15	50:20:20
Guizotia abyssinica (L.) (Niger)	KGN-2	95-100	30 × 10	10:0:0
Brassica nigra (Mustard)	Varuna	135-140	30 × 15	60:30:15:20

The sole sisal crop was sown during *kharif* season and in the *rabi* season sisal along with short duration pulses and oilseeds crops were grown. Sisal crop was sown in 4.0 m × 4.0 m paired row and inter crops were sown in line with 4.0 m × 2.4 m spacing in between the lines of sisal. The main crop sisal and inter crops were grown completely under rainfed conditions. agronomic management for growing of inter crops were

followed as per the package of practices as prescribed by ANGRAU. Weeding and thinning operations in inter crops was done after 30 days after sowing and harvested at maturity. Biometrical observations of all the component crops were recorded at regular intervals. The yield and yield attributes were recorded at harvest. The recorded observations for different parameters were statistically analysed using analysis of variance (ANOVA) technique and results are presented at 5 % level of significance (P=0.05).

RESULTS AND DISCUSSION

Effect of intercrops on growth parameters of sisal

Effect of pulses and oilseeds as intercrops on growth parameters of sisal did not vary significantly during the two years of study (Table 2). The pooled data of the two-year study revealed that, highest number of leaves per sisal plant was recorded in pulses as intercrops than oilseeds. Highest number of leaves (31.9 cm) recorded in sisal + horsegram followed by sisal + cowpea (31.8 cm), sisal + rajma (31.7 cm), sisal + greengram (31.3 cm) and lowest was in sisal + blackgram (30.1 cm). while oilseeds as intercrops, highest number of sisal leaves was recorded in sisal + sesame and sisal + niger (29.7 cm) and lowest was in (29.4 cm) as compared to sole sisal (29.2 cm). Whereas, highest leaf length was recorded in Sisal + Greengram (101.0 cm) followed by (sisal + horsegram) (97.9 cm), which was on par with sole sisal. Among oilseeds as intercrops highest leaf length was recorded in sisal + niger (99.5 cm) followed by sisal + sesame (98.7 cm) and lowest was recorded in sisal + mustard (98.4 cm) as compared to sole sisal. similar findings were also reported by Sarkar et al. (2015) in intercropping system with pulses followed in double rowed sisal plantation.

However, similar trend was recorded with respect to leaf width of sisal wherein, highest was in sisal + cowpea (9.6 cm) among pulses, sisal + sesame and sisal + niger (9.6 cm) among oilseeds than sole sisal (9.5 cm). while the green biomass of sisal was obtained with sisal + cowpea (47.25 t/ha) followed by sisal + greengram (47.18 t/ha) in both pulses and oilseeds as intercrops compared to sole sisal (45.97 t/ha). The results are in conformity with Sarkar et al. (2015). All intercrops in the present study successfully established in sisal interspaces as pulses and oilseeds fit well in intercropping system. However, pulses influenced yield attributes of sisal than oilseeds might be due to plant stature of the pulses and provided enough space for the sisal to expand. Besides, intercrops positively influenced the soil fertility.

Table 2: Effect of pulses and oilseeds grown as intercrops on growth parameters of Sisal

Treatments	No. of Leaves / Plant			Leaf length (cm)			Leaf width (cm)			Green biomass (t/ha)		
	2020	2021	pooled	2020	2021	pooled	2020	2021	pooled	2020	2021	pooled
Sisal + Blackgram	25.4	34.9	30.1	103.5	90.7	97.1	10.6	8.3	9.4	43.34	41.39	42.37
Sisal+ Greengram	26.5	36.2	31.3	102.5	101.0	101.7	10.5	8.5	9.5	45.12	49.24	47.18
Sisal + Cowpea	27.2	36.5	31.8	100.7	95.0	97.8	10.6	8.5	9.6	46.38	48.13	47.25
Sisal + Horsegram	26.9	36.9	31.9	103.4	92.4	97.9	10.7	8.2	9.5	45.89	45.29	45.59
Sisal + Sesame	26.5	32.9	29.7	102.6	94.8	98.7	10.8	8.3	9.6	45.22	38.39	41.80
Sisal + Niger	27.2	32.1	29.7	101.2	97.8	99.5	10.7	8.4	9.6	46.46	43.26	44.86
Sisal + Mustard	26.6	32.3	29.4	102.3	94.5	98.4	10.6	8.3	9.4	45.40	37.33	41.36
Sisal + Rajma	26.4	37.0	31.7	102.5	90.6	96.5	10.7	7.8	9.3	45.10	46.75	45.93
Sole Sisal	25.5	33.0	29.2	102.9	92.8	97.9	10.8	8.1	9.5	43.49	48.46	45.97
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEm ±	0.97	2.71	1.44	0.88	3.98	2.04	0.21	0.29	0.24	1.66	3.53	1.95
CV (%)	6.4	13.5	11.5	1.5	7.3	5.1	3.3	5.9	4.5	6.4	13.8	10.7

EFFECT OF INTERCROPS ON YIELD OF SISAL

The fibre yield of sisal during two years of study did not vary significantly (Table 3). However, pooled data of fibre yield revealed that, effect of intercrops on yield of sisal was higher with pulses than oilseeds. Among pulses, except sisal + black gram which recorded lower yield (14.69 q/ha) and remaining treatments were on par with highest yield in sisal + cowpea (16.35 q/ha). Among, oilseeds highest yield was recorded in sisal + niger (15.57 q/ha) followed by sisal + sesame (14.54 q/ha) and sisal + mustard (14.40 q/ha). However, sole sisal was comparatively higher than oilseeds and recorded 15.88 q/ha of sisal fibre yield. The similar findings were also reported by Rajesh kumar et al. (2017) in intercropping with pulses.

Pooled data of intercrops yield was revealed that, yields among intercrops was on par and highest yield was recorded in sisal + cowpea (11.47 q/ha) and lowest was in sisal + rajma (3.73 q/ha). however, among oilseeds as intercrops highest yield was recorded in sisal + mustard (3.07 q/ha) followed by sisal + sesame (2.47 q/ha) and sisal + niger (2.43 q/ha). Similar trend of results was obtained when intercrops yield was converted to sisal fibre equivalent yield. The results are in conformity with the findings of Sarkar et al. (2013) who reported similar trend of results in pigeonpea and sisal intercropping system.

The benefits of intercropping were always positive in any cropping system. In the present study, fibre yield of sisal, yield of short duration pulses and oilseeds was expressed as sisal fibre equivalent yield of cropping system (q/ha). Pooled results of cropping system as a whole reveal that, effect of short duration pulses as intercrops was significantly higher as

compared to oilseeds. The results are in line with the findings of Sujatha et al. (2011) and Behera et al. (2015).

Similarly, both short duration pulses and oilseeds as intercrops significantly influenced the fibre yield of sisal. Highest sisal fibre equivalent yield of cropping system was obtained in sisal + cowpea (21.64 q/ha) followed by sisal + greengram (21.14 q/ha), sisal + rajma (19.81 q/ha), sisal + blackgram (18.27 q/ha) and lowest among pulses was with sisal + horsegram (17.29 q/ha). Among oilseeds as intercrops highest was obtained in sisal + mustard (17.81 q/ha) followed by sisal + niger (17.64 q/ha) and lowest was in sisal + sesame (16.72 q/ha). However, sole sisal crop recorded lowest equivalent yield (14.05 q/ha) as compared to both short duration pulses and oilseeds as intercrops in the cropping system. The results are in line with the findings of Sarkar et al. (2015) who reported that growing of legume intercrops like pigeonpea, cowpea and blackgram with sisal improved the system productivity. In the present study, pulse crops impacted the Sisal fibre equivalent yield of cropping system (q/ha) than oilseeds. The pulse crops are having positive impact on symbiosis for nitrogen fixation and increase in soil fertility. They have high soil ameliorating properties and ability to thrive better under unfavourable conditions makes the pulses an integral component of agriculture perse as intercrops. This has increased the fibre yield and yield attributes of sisal and increased the system productivity.

Table 3: Yield of sisal fibre, intercrops and fibre equivalent yield of intercrops and cropping system

Treatments	Sisal Fibre yield (q/ha)			Intercrops yield (q/ha)			Sisal fibre equivalent yield of intercrops (q/ha)			Sisal fibre equivalent yield of cropping system (q/ha)		
	2020	2021	pooled	2020	2021	pooled	2020	2021	pooled	2020	2021	pooled
Sisal + Blackgram	15.79	13.60	14.69	4.55	4.74	4.64	3.41	3.73	3.57	19.20	17.33	18.27
Sisal+ Greengram	16.43	16.18	16.31	5.07	5.61	5.34	4.56	5.10	4.83	20.99	21.28	21.14
Sisal + Cowpea	16.89	15.82	16.35	14.50	8.45	11.47	6.34	4.22	5.28	23.24	20.04	21.64
Sisal + Horsegram	16.71	14.88	15.80	3.98	3.96	3.97	1.49	1.48	1.49	18.21	16.36	17.29
Sisal + Sesame	16.47	12.62	14.54	2.64	2.30	2.47	2.27	2.10	2.18	18.73	14.72	16.72
Sisal + Niger	16.92	14.21	15.57	2.34	2.53	2.43	1.96	2.19	2.07	18.88	16.41	17.64
Sisal + Mustard	16.53	15.36	14.40	2.95	3.19	3.07	1.71	2.02	1.87	18.25	17.38	17.81
Sisal + Rajma	16.43	15.92	15.89	4.58	2.88	3.73	4.58	2.70	3.64	21.00	18.63	19.81
Sole Sisal	15.84	12.27	15.88	0.00	0.00	0.00	0.00	0.00	0.00	15.84	12.27	14.05
CD (P=0.05)	NS	NS	NS	-	-	-	-	-	-	1.69	3.41	1.83
SEm±	0.61	1.16	0.65	-	-	-	-	-	-	0.56	1.14	0.64
CV (%)	6.4	13.8	10.3	-	-	-	-	-	-	5.1	11.5	8.5

ECONOMICS OF SISAL BASED INTERCROPPING SYSTEM

The economics of sole sisal crop and intercropping with short duration pulses and oilseeds was worked out by considering the variable cost of fertilizers, labours, seeds and price of each crop yield. Calculated the gross returns, net returns and benefit cost ratio of the sole sisal, intercropping with pulses and oilseeds and sisal based cropping system (Table 4). The results revealed that, inter cropping with short duration pulses positively contributed to economic feasibility and sustainability of the system by ensuring higher economic income to farmers in sisal based cropping system.

Sisal intercropped with cowpea treatment among different treatments ensures highest profit to resource poor farmers as it was reflected in gross, net profit and highest B:C ratio (3.42) compared to other treatments and lowest B:C ratio was recorded in sole sisal (2.49). Intercropping with sisal + cowpea ensured highest B:C ratio followed by sisal + greengram (3.34), sisal + rajma (3.05), sisal + niger (2.90), sisal + horsegram (2.90), sisal + blackgram (2.83), sisal + mustard (2.80) and sisal + sesame (2.65). In the present study, intercropping with short duration pulses contributed higher than oilseeds for cropping system productivity. The results are in conformity with the findings of Padhi et al. 2010 and Sarkar et al. 2015.

Even though sole crop of sisal was grown as live fence and also as an erosion control measure in degraded soils. However, in the present study, inclusion of short duration pulses as intercrops in the system enhanced the productivity of the cropping system. This is due to positive impact of pulses and oilseeds on sisal fibre yield and in improving the system productivity. Similar findings were reported by Sarkar et al. 2015 wherein, they reported that, sisal equivalent yield from the system was highest with pigeonpea followed by cowpea and blackgram as intercrops along with sisal. In addition, the cropping system including pulses ensures food and nutritional security of farm family (FAO, 2016).

Table 4: Economics of Sisal based inter cropping system (pooled data of 2020 and 2021)

Treatment	Gross Returns of cropping system (Rs./ha)	Cost of Cultivation of cropping system (Rs./ha)	Net Returns of cropping system (Rs./ha)	BC Ratio
Sisal + Blackgram	146160	51600	94560	2.83
Sisal+ Greengram	169120	50640	118480	3.34
Sisal + Cowpea	173120	50580	122540	3.42
Sisal + Horsegram	138320	47634	90686	2.90
Sisal + Sesame	133760	50436	83324	2.65
Sisal + Niger	141120	48740	92380	2.90

Sisal + Mustard	139760	49980	89780	2.80
Sisal + Rajma	156160	51130	105030	3.05
Sole Sisal	112400	45184	67216	2.49

CONCLUSION

Sole sisal is generally grown in poor fertile soils, sloppy lands or in degraded soils as live fence, as erosion control measure and for its fibre in various diversified uses. The vacant space in between the paired rows of sisal plantation may be effectively utilized by growing short duration pulses, as they are relatively hardy, adoptable and fit into various cropping systems compared to oilseeds. Thus, cultivation of short duration pulses in paired row sisal plantation effectively utilizes space available, protects soil and makes cropping system more remunerative by ensuring nutritional support and higher farm income to resource poor farm family than traditional sole sisal.

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