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Influence of Drip-irrigation, Manure and Fertilizers on Production of Planting Material in Sisal (*Agave sisalana* Perr. Ex Engelm.)

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A B S T R A C T

Field experiment was conducted during 2006-07 to 2017-18 (12 years) at Sisal Research Station (22.041°N, 84.295°E, 267 m AMSL), Bamra, Odisha, India to study the effect of manure (FYM), drip-irrigation and fertilizers on the number of sucker production in sisal (*Agave sisalana* Perr. Ex Engelm.). It was found that application of manure (FYM @ 5 t/ha), drip-irrigation (with discharge rate of 4 l/hr for 2 hrs at 2 weeks interval during 1st April-15th June), and fertilizers ($N_{60}P_{30}K_{60}$ or $N_{120}P_{30}K_{60}$ kg/ha) produced a total of 142.6 x 10^3 suckers/ha during 7th to 12th crop year. Production of number of suckers diminishes gradually from 7th year to 12th year, after which the sisal crop completes its life cycle by production of flowering stalk and eventual natural dying. The produced 142.6 x 10^3 number of suckers is sufficient for covering 28.5 ha new sisal plantation. The quantum of suckers so produced adds farmers' income by ₹ 5.7 lakh at present price rate of sisal planting material (₹ 4,000 for 1000 suckers).

Introduction

Sisal (*Agave* sp), a xerophytic member of Aaparagaceae family, from which commercial hard fibre is produced from its leaf. Number of species of Agaves namely *A. sisalana*, *A. cantala*, *A. vera-cruz*, *A. amaniensis*, *A. angustifolia*, *A. fourcryodes* and others are cultivated (Sarkar and Jha, 2017). However, among the different species, *A. sisalana* contributes nearly 85% of the total sisal fibre production of the World. In India sisal is cultivated in western Odisha, Jharkhand, Chhattisgarh, and in scattered areas of Maharashtra, Andhra Pradesh and Karnataka (Sarkar, 2015). In Indian condition seed is not produced in sisal might be due to lack of pollinating bat species and therefore, the crop is propagated through vegetative means namely bulbils and suckers. Bulbils are small plantlets with 2-3 small leaves produced on the flowering stalk of mature sisal plant once in 10-12 years or so. Bulbils are so tiny that it require extra care in nurseries for about a year and then it can be used as planting material in the main field of sisal. Whereas, suckers are bigger sized plantlets started producing from the roots of sisal plant after years of active growth and continues up to the end of life span of sisal (say 12 years). Suckers are generally stout enough and are commonly used as propagating material (Sarkar *et al.*,

2010). Earlier it was recorded that planting through bulbils caused 9% or more mortality, whereas, planting through suckers caused minimum mortality of the sisal plantlets (Reddy, 1966). Recent report quantified the number of suckers produced from a healthy sisal plantation for 2 consecutive years only (Sarkar *et al.*, 2017). Virtually there is no information available for influence of manure (FYM), drip-irrigation, and fertilizer application on sucker production capability of sisal for the whole economic life span of sisal. So, it is necessary to generate information about number of sucker production for planting of new sisal plantation. Therefore, a field experiment was conducted to study the effect of manure (FYM), drip-irrigation, and fertilizers on production of number of suckers (planting material) in sisal (*Agave sisalana* Perr. Ex Engelm.).

Materials and Methods

A field experiment was conducted during 2006-07 to 2017-18 (12 years) at the Sisal Research Station (located at 22.041°N, 84.295°E, 267 m AMSL) a regional research station of ICAR-CRIJAF), at Bamra, in Sambalpur district of Odisha, India to study the effect of drip-irrigation, manure and different doses of fertilizers on production of sucker (planting material) in sisal (*Agave sisalana* Perr. Ex Engelm.). The experiment soil was acidic in reaction pH (1:2.5 w/v) in water 5.20, low in organic carbon 3.4 g/kg, having available nitrogen of 186 kg/ha, available phosphorus of 31.7 kg/ha and available potassium of 116 kg/ha. The experiment was laid in 3 factor split-split plot design with 2 levels of manure (M_1= no manure, M_2= FYM @ 5t/ha) in main plot, 2 levels of irrigation (I_1= no irrigation; I_2: drip irrigation with discharge rate of 4 l/hr for 2 hours at 2 weeks interval during 1st April to 15th June) in sub plot and 4 levels of fertilizers [N_1= no fertilizer, N_2=$N_0P_{30}K_{60}$, N_3= $N_{60}P_{30}K_{60}$, and N_4= $N_{120}P_{30}K_{60}$] in sub-sub plots with individual plot size of 8 m x 6 m replicated three times. Healthy suckers of sisal were planted in the recommended double row planting system [(1m x 1m) x 3 m] in the month of July, 2006. Other standard recommended agronomic practices were followed to raise the experimental sisal plantation. The suckers produced in the plots were collected for 6 consecutive years starting from 2012-13 and up to 2017-18. So, after 12 years of crop age, the sisal plantation produced flower stalks and started dying which is a common phenomenon in sisal. The 6 years data on numbers of sucker production were processed and analysed by statistical software IBM SPSS Statistics v. 24.

Results and Discussion

Effect of manure on numbers of sucker production in sisal

Application of manure (FYM @ 5 t/ha) showed beneficial effect on number of suckers production in sisal (Table 1). In the first year of sucker collection (2012-13), 22.93 x 10^3 suckers were collected, which reduced gradually in the subsequent years (22.27 x 10^3 in 2013-14; 15.21 x 10^3 in 2014-15 and so on). During this 6 years sucker collection period, a total of 80.65 x 10^3 suckers were produced from the manure applied plots. Application of manure increased sucker production by 52.7% as compared to no manure application.

Effect of drip irrigation on numbers of sucker production

Drip irrigation (with discharge rate of 4 l/hr for 2 hours at 2 weeks interval during 1st April to 15th June) in sisal had significant effect on number of sucker production of sisal (Table 2). Production of suckers decreased over years in both irrigated (20.02 x 10^3 in 2012-13 to 2.61 x 10^3 in 2017-18) and unirrigated

condition (15.55 x 10^3 in 2012-13 to 2.33 x 10^3 in 2017-18). Application of drip irrigation in sisal produced 32.8% more number of suckers as compared to no irrigation.

Effect of nutrients on numbers of sucker production

Production of suckers varied non-significantly with different doses of nutrients, except in 2014-15, when N_{60} P_{30} K_{60} produced the highest number of suckers (23.33 x 10^3). Over a period of 6 years of sucker collection, the highest number of total suckers (103.98 x 10^3) were recorded with N_{120} P_{30} K_{60} (Table 3).

Interaction effect of manure and drip-irrigation on numbers of sucker production

Application of manure and drip irrigation showed positive interaction effect on number of sucker production in sisal (Table 4). In the first year of sucker collection (2012-13), the highest number of suckers produced was 25.33 x 10^3, which was about 72.2% more as compared to no manure and no irrigation (10.57 x 10^3). In the 6 years period of observation, the number of sucker produced with manure and irrigation was 88.86 x 10^3, which was 40.1% more as compared to the no manure and no irrigation treatment.

Interaction effect of manure and nutrients on numbers of sucker production

Application of manure and nutrient in sisal showed significant positive effect on number of sucker production in sisal (Table 5). Application of nutrients ($N_{60}P_{30}K_{60}$ and $N_{120}P_{30}K_{60}$) along with manure (FYM @ 5 t/ha) produced 34.9 x 10^3 and 36.0 x 10^3 suckers in 2012-13. In the subsequent years, the $N_{60}P_{30}K_{60}$ and $N_{120}P_{30}K_{60}$ levels of nutrients along with manure produced the maximum number of suckers. Over the 6 years period, $N_{120}P_{30}K_{60}$ level of nutrient and manuring (FYM @ 5 t/ha) produced the highest number of suckers (126.51 x 10^3).

Table.1 Main effect of manure (M) on number of suckers production/ha (’000) in sisal

Manure levels	Number of suckers produced/ha (’000)						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Total
No manure	12.64	14.28	11.57	6.45	5.62	2.24	52.80
Manure (5t/ha)	22.93	22.27	15.21	11.19	6.33	2.70	80.65
SEm±	0.491	0.820	0.367	0.445	0.132	0.065	1.158
LSD (0.05)	1.700	2.839	1.269	1.541	0.458	0.224	4.008

Table.2 Main effect of irrigation (I) on number of suckers production/ha (’000) in sisal

Irrigation levels	Number of suckers produced/ha (’000)						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Total
No irrigation	15.55	15.74	11.34	7.69	4.65	2.33	57.31
Drip irrigation	20.02	20.81	15.44	9.95	7.30	2.61	76.14
SEm±	0.491	0.820	0.367	0.445	0.132	0.065	1.158
LSD (0.05)	1.700	2.839	1.269	1.541	0.458	0.224	4.008

Table.3 Main effect of nutrients (N) on number of suckers production/ha (’000) in sisal

Nutrient levels	Number of suckers produced/ha (’000)						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Total
N_0 P_0 K_0	6.33	6.59	5.55	4.06	3.63	1.98	28.14
N_0 P_{30} K_{60}	10.65	12.02	7.17	5.67	4.41	2.21	42.14
N_{60} P_{30} K_{60}	26.10	21.08	23.33	11.70	7.31	3.12	92.65
N_{120} P_{30} K_{60}	28.06	33.43	17.51	13.86	8.55	2.57	103.98
SEm±	0.795	1.459	0.529	1.008	0.469	0.173	1.829
LSD (0.05)	NS	NS	1.545	NS	NS	NS	NS

Table.4 Interaction effect of manure (M) and irrigation (I) on number of Sucker production in sisal

Levels of Manure (M)/ Irrigation (I)	Number of suckers produced per ha (’000)													
	2012-13		2013-14		2014-15		2015-16		2016-17		2017-18		Total	
	I_1	I_2	I_1	I_2	I_1	I_2	I_1	I_2	I_1	I_2	I_1	I_2	I_1	I_2
M_1 (No manure)	10.57	14.71	12.18	16.39	7.51	15.63	5.39	7.51	4.35	6.88	2.20	2.29	42.19	63.41
M_2 (FYM @ 5t/ha)	20.53	25.33	19.31	25.23	15.18	15.25	10.00	12.39	4.94	7.72	2.47	2.92	72.43	88.86
SEm±	0.695		1.375		0.519		0.630		0.187		0.092		1.638	
LSD (0.05)	2.404		4.015		1.795		2.179		0.647		0.317		5.669	

Table.5 Interaction effect of manure (M) and nutrients (N) on number of suckers production/ha (’000) in sisal

Year	Treatments	Number of suckers produced/ha (’000)			
		N_0 P_0 K_0	N_0 P_{30} K_{60}	N_{60} P_{30} K_{60}	N_{120} P_{30} K_{60}
2012-13	M_1 (No manure)	5.61	7.53	17.29	20.12
	M_2 (FYM @ 5t/ha)	7.06	13.76	34.90	36.00
	SEm±	0.562			
	LSD (0.05)	1.641			
2013-14	M_1 (No manure)	6.16	11.76	17.29	21.92
	M_2 (FYM @ 5t/ha)	7.02	12.27	24.86	44.94
	SEm±	1.032			
	LSD (0.05)	3.012			
2014-15	M_1 (No manure)	4.94	6.35	17.21	17.76
	M_2 (FYM @ 5t/ha)	6.16	8.00	29.45	17.25
	SEm±	0.748			
	LSD (0.05)	2.185			
2015-16	M_1 (No manure)	3.37	4.24	7.57	10.62
	M_2 (FYM @ 5t/ha)	4.74	7.10	15.84	17.10
	SEm±	0.713			
	LSD (0.05)	2.081			
2016-17	M_1 (No manure)	3.37	4.23	6.24	8.62
	M_2 (FYM @ 5t/ha)	3.88	4.59	8.39	8.47
	SEm±	0.332			
	LSD (0.05)	0.970			
2017-18	M_1 (No manure)	2.00	2.19	2.39	2.39
	M_2 (FYM @ 5t/ha)	1.96	2.23	3.84	2.74
	SEm±	0.119			
	LSD (0.05)	0.348			
Total	M_1 (No manure)	25.45	36.31	68.00	81.45
	M_2 (FYM @ 5t/ha)	30.82	47.96	117.29	126.51
	SEm±	1.294			
	LSD (0.05)	3.777			

Table.6 Interaction effect of drip-irrigation (I) and nutrients (N) on number of suckers production/ha ('000) in sisal

Year	Treatments	Number of suckers produced/ha ('000)			
		N_0 P_0 K_0	N_0 P_{30} K_{60}	N_{60} P_{30} K_{60}	N_{120} P_{30} K_{60}
2012-13	I_1 (No irrigation)	5.49	8.98	23.53	24.20
	I_2 (Drip irrigation)	7.18	12.31	28.66	31.92
	SEm±	0.562			
	LSD (0.05)	1.641			
2013-14	I_1 (No irrigation)	6.31	11.21	17.92	27.53
	I_2 (Drip irrigation)	6.86	12.82	24.23	39.33
	SEm±	1.032			
	LSD (0.05)	3.012			
2014-15	I_1 (No irrigation)	5.33	7.02	18.43	14.59
	I_2 (Drip irrigation)	5.76	7.33	28.24	20.43
	SEm±	0.748			
	LSD (0.05)	2.185			
2015-16	I_1 (No irrigation)	3.65	4.47	11.45	11.21
	I_2 (Drip irrigation)	4.47	6.86	11.96	16.51
	SEm±	0.713			
	LSD (0.05)	2.081			
2016-17	I_1 (No irrigation)	3.57	4.00	5.26	5.76
	I_2 (Drip irrigation)	3.68	4.82	9.37	11.33
	SEm±	0.332			
	LSD (0.05)	0.970			
2017-18	I_1 (No irrigation)	1.96	2.20	2.70	2.47
	I_2 (Drip irrigation)	2.00	2.23	3.53	2.66
	SEm±	0.119			
	LSD (0.05)	0.348			
Total	I_1 (No irrigation)	26.31	37.88	79.29	85.76
	I_2 (Drip irrigation)	29.96	46.39	106.00	122.19
	SEm±	1.294			
	LSD (0.05)	3.777			

Table.7 Interaction effects of manure (M), irrigation (I) and nutrients (N) on number of sucker production/ha (’000) in sisal

Year	Manure	Irrigation	Number of sucker produced/ha (’000)			
			Nutrients			
			N_0 P_0 K_0	N_0 P_{30} K_{60}	N_{60} P_{30} K_{60}	N_{120} P_{30} K_{60}
2012-13	M_1 (No manure)	I_1 (No irrigation)	4.32	5.80	13.65	18.51
		I_2 (Drip irrigation)	6.90	9.25	20.94	21.73
	M_2 (FYM @ 5t/ha)	I_1 (No irrigation)	6.67	12.16	33.41	29.88
		I_2 (Drip irrigation)	7.45	15.37	36.39	42.12
	SEm±		0.795			
	LSD (0.05)		2.321			
2013-14	M_1 (No manure)	I_1 (No irrigation)	5.80	10.43	15.29	17.18
		I_2 (Drip irrigation)	6.51	13.10	19.29	26.67
	M_2 (FYM @ 5t/ha)	I_1 (No irrigation)	6.82	12.00	20.55	37.89
		I_2 (Drip irrigation)	7.21	12.55	29.18	52.00
	SEm±		1.459			
	LSD (0.05)		NS			
2014-15	M_1 (No manure)	I_1 (No irrigation)	4.71	6.27	9.88	9.18
		I_2 (Drip irrigation)	5.18	6.43	24.55	26.35
	M_2 (FYM @ 5t/ha)	I_1 (No irrigation)	5.96	7.76	26.98	20.00
		I_2 (Drip irrigation)	6.35	8.24	31.92	14.51
	SEm±		1.059			
	LSD (0.05)		3.090			
2015-16	M_1 (No manure)	I_1 (No irrigation)	2.82	3.84	6.75	8.15
		I_2 (Drip irrigation)	3.92	4.63	8.39	13.10
	M_2 (FYM @ 5t/ha)	I_1 (No irrigation)	4.47	5.10	16.16	14.27
		I_2 (Drip irrigation)	5.02	9.10	15.53	19.92
	SEm±		1.008			
	LSD (0.05)		NS			
2016-17	M_1 (No manure)	I_1 (No irrigation)	3.29	3.76	4.63	5.72
		I_2 (Drip irrigation)	3.45	4.71	7.84	11.53
	M_2 (FYM @ 5t/ha)	I_1 (No irrigation)	3.84	4.24	5.88	5.81
		I_2 (Drip irrigation)	3.92	4.94	10.90	11.14
	SEm±		0.469			
	LSD (0.05)		NS			
2017-18	M_1 (No manure)	I_1 (No irrigation)	1.96	2.20	2.27	2.35
		I_2 (Drip irrigation)	2.04	2.19	2.51	2.43
	M_2 (FYM @ 5t/ha)	I_1 (No irrigation)	1.96	2.20	3.14	2.59
		I_2 (Drip irrigation)	1.96	2.27	4.55	2.90
	SEm±		0.173			
	LSD (0.05)		NS			
Total	M_1 (No manure)	I_1 (No irrigation)	22.90	32.32	52.47	61.10
		I_2 (Drip irrigation)	28.00	40.31	83.53	101.80
	M_2 (FYM @ 5t/ha)	I_1 (No irrigation)	29.73	43.45	106.12	110.43
		I_2 (Drip irrigation)	31.92	52.47	128.47	142.59
	SEm±		1.829			
	LSD (0.05)		NS			

Interaction effect of drip-irrigation and nutrients on numbers of sucker production

Interaction of drip-irrigation and nutrients exerted significant positive effect on number of sucker production in sisal (Table 6). In 2012-13, the highest number of suckers was produced with $N_{120}P_{30}K_{60}$ and drip-irrigation (31.92 x 10^3). In the subsequent years also $N_{120}P_{30}K_{60}$ (and $N_{60}P_{30}K_{60}$ in 2017-18) nutrients along with drip irrigation produced the maximum number of suckers in sisal. For the 6 years period, a total of 122.19 x 10^3 suckers were produced from $N_{120}P_{30}K_{60}$ nutrients along with drip irrigation.

Interaction effect of manure, drip-irrigation and nutrients on numbers of sucker production

Interaction effect of manure, irrigation and nutrients on number of sucker production in sisal were significant in the first (2012-13) and third year (2014-15) of sucker collection; and in other years, the interaction effects of the 3 factors (manure x irrigation x nutrients) were not significant on the number of sucker production (Table 7). In 2012-13, manuring with drip irrigation and the highest nutrient dose ($N_{120}P_{30}K_{60}$) produced the maximum number of suckers (42.12 x 10^3) which was 15.7% more as compared to next lower nutrient dose ($N_{60}P_{30}K_{60}$). Over the 6 years period, the maximum total sucker production (142.6 x 10^3) was obtained from $N_{120}P_{30}K_{60}$ nutrient along with manuring (FYM @ 5 t/ha) and drip irrigation.

To conclude it may be mentioned that application of manure, drip irrigation and nutrients singly or in combination had significant positive effect on number of sucker production in sisal. For a 6 years period, combined application of manure (FYM @ 5 t/ha), irrigation (discharge rate of 4 l/hr for 2 hours at 2 weeks interval during 1st April to 15th June) and nutrients (N_{60} P_{30} K_{60} or $N_{120}P_{30}K_{60}$) could produce 142.6 x 10^3 suckers, which is at least 5 times more as compared to the sucker production with no manuring, no irrigation and no fertilizer application (22.9 x 10^3). It may be concluded that for obtaining the highest number of suckers in sisal, application of manure (FYM @ 5 t/ha), drip irrigation (discharge rate of 4 l/hr for 2 hours at 2 weeks interval during 1st April to 15th June) along with nutrients @ N_{60} P_{30} K_{60} or $N_{120}P_{30}K_{60}$ are needed. So, for 6 years, the total sucker production will be 142.6 x 10^3 per ha which is sufficient to cover about 28.5 ha (@ 5000 suckers/ha) of new sisal plantation. Moreover, the produced suckers could add sisal planters/ farmer's income by about ₹ 5.7 lakh (@ ₹ 4 per piece of sucker) when it sold as planting material to other sisal farmers/ planters.

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