Feasibility of castor (*Ricinus communis*) under Sapota-Jatropha based horti-silvi system

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ABSTRACT: *The field experiment entitled "Feasibility of Castor (Ricinus communis L.) under Sapota-Jatropha based Horti-Silvi system" was conducted at the Agronomy Farm (Block-E), Navsari Agricultural University, Navsari, Gujarat, during late Kharif 2015 and 2016. The experiment was comprised of five treatments and four replications laid out in a Randomized Block Design. The experiment site had an eleven years old plantation of Sapota [Manilkara achras (Mill.) Fosberg] plantation spaced at 10 x 10 m and a nine-year-old Jatropha (Jatropha curcas L.) planation at 2.5 x 2.5 m spacing with castor (Ricinus communis L.) grown as an intercrop. Pooled data over two years revealed that the castor crop as sole crop (T_5) recorded significantly higher growth and yield parameters including plant height (123.25 cm), number of branches per plant (8.13), fresh weight of plant (2875.63 g), dry weight of plant (948.75 g), number of spikes per plant (9.88), number of capsules per spike (80.63), yield per plant (272.00 g), yield per plot (9.00 kg), yield per hectare (2525.00 kg), and total biomass (148.47 q/ha) compared to intercropping systems. However, oil content showed no significance variation among treatments. The highest net realization (Rs. 68,343/ha) was obtained in T_2: Castor with 100% pruned Jatropha under Sapota-Jatropha based horti-silvi system while, the highest cost-benefit ratio (1:2.02) was recorded under T_5: Castor sole crop indicating economic feasibility of castor as a sole crop compared to intercropping system.*

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1. INTRODUCTION

Agroforestry is a collective name for land use systems and technologies where woody perennials (trees, shrubs etc.) are deliberately grown on the same piece of land management units as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence (Nair, 1983). Agroforestry systems combine annual and perennial crops, allowing farmers to reap benefits besides alleviating the risk against total crop failure. Agroforestry also generates extra income; improve productivity per unit area, time and inputs due to efficient utilization of resources (Jamnadass *et al*., 2013). It is sustainable land use system which increases the yield and farm income per unit area of the land and also successfully fulfils the needs of farming community for 5Fs *viz.,* food, fruit, fodder, fuel and fibre etc. According to Anonymous (2013) the estimated total tree green cover in the agroforestry system of the country is 1,11,554 sq km which is 3.39 per cent of country's geographical area. The states having maximum agroforestry area is Maharashtra (11,806 sq km), followed by Gujarat (11,591 sq km) and Rajasthan (8,373 sq km).

Castor (*Ricinus communis* L.) is a perennial flowering plant in the spurge family, Euphorbiaceae. It is native to the south eastern Mediterranean Basin, Eastern Africa, and India, but is widespread throughout tropical regions. The seeds contain between 40 % and 60 % oil that is rich in triglycerides, mainly ricinolein and ricin, a water-soluble toxin, which is also present in lower concentrations throughout the plant. Castor oil is used as purgative, laxative, anti-analgesic, anti-inflammatory, hepatoprotective, rheumatic activity, in case of dandruff, hair fall, etc. Castor oil forms a protective surface when used in cosmetic and skin care formulations that acts as a protective barrier for skin.

Keeping in view the adaptation, growing habit, requirement, production potential and economic importance Castor was tested under Sapota-Jatropha based horti-silvi system in South Gujarat condition.

2. MATERIAL AND METHODS

The investigation was carried out at Agronomy Farm (Block-E), Navsari Agricultural University, Navsari, Gujarat, during late *Kharif* 2015 and 2016. The experiment was comprised of five treatments *viz.,* T_1- Castor with sole Sapota, T_2 - Castor with 100 % pruned

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Jatropha, T_3- Castor with 50% pruned Jatropha, T_4- Castor with unpruned Jatropha and T_5- Castor as sole with four replications in Randomized Block Design (RBD). The experiment was conducted in eleven years old plantation of Sapota [*Manilkara achras* (Mill.) Fosberg] planted at 10 x 10 m spacing along with nine-year-old plantation of Jatropha (*Jatropha curcas* L.) planted at 2.5 x 2.5 m. Castor was intercropped at a spacing of 110 x 70 cm in the present study. The experimental field was brought to fine tilth by ploughing, clods crushing and harrowing with the tractor. Then experimental field was leveled and plots were prepared as per the details of experiment. In this experiment, Jatropha were pruned at about 3 feet (100 % pruning) and 5 feet (50 % pruning) height from the ground level uniformly one week before sowing of the intercrop only in those plots where intercropping in pruned trees as main plot treatments were laid out in the field. Well decomposed farm yard manure was applied uniformly to the entire experimental plot at the rate of 20 t/ha. Phosphorus was applied at the time of planting in the form of single super phosphate to each plot at the rate of 25 kg/ha. Nitrogen was applied in two splits doses first half dose of nitrogen (60 kg/ha) was applied as basal dose at the time of planting and remaining second half dose of nitrogen (60 kg/ha) was applied in the form of urea after 45 days after sowing. Crop was irrigated immediately after each application of fertilizer. Seeds of castor crops (@ 5 kg/ha) as per experimental details (inter crop and sole) were planted at the spacing 110 x 70 cm. Immediately after planting a light irrigation was given to the crop for better establishment of seeds in the field. Depending upon the soil moisture condition, the irrigation was provided at 10 to 15 days intervals. Weeding and hoeing were done at 15 days intervals to keep plot clean and weed free. Necessary plant protection measures were adopted. No serious pest and diseases were observed on this crop during the cropping period. For analysing the economic performance, yield parameters of tree component *viz.,* fruit yield as well as growth and yield parameters of intercrops *viz*., plant height, number of branches per plant, fresh weight of plant, dry weight of plant, number of spikes per plant, number of capsules per spike, yield per plant, yield per plot, yield per hectare, oil content and total biomass were recorded and analysed as per the procedure described for RBD (Panse and Sukhatme, 1985). For the performance in terms of economics the gross realization in term of rupees per hectare was worked out on the basis of yield of each treatment. The price of castor seed was accounted on

Table –1: Effect of Sapota-Jatropha based horti-silvi system on growth parameters of Castor

Treatments	Plant height (cm)	No. of branches per plant	Fresh weight of plant (g)	Dry weight of plant (g)
T_1- Castor with sole Sapota	104.38	7.38	2644.63	870.00
T_2- Castor with 100% pruned Jatropha	96.38	7.13	2616.50	851.25
T_3- Castor with 50% pruned Jatropha	88.88	6.75	2548.25	818.75
T_4- Castor with unpruned Jatropha	78.38	6.13	2408.75	767.50
T_5- Castor as sole	123.25	8.13	2875.63	948.75
S.Em.+ (T)	2.81	0.24	52.87	19.02
C.D. @ 5 % (T)	8.14	0.70	153.12	55.09
C.V.%	8.71	10.21	6.15	6.81

Table –2: Effect of Sapota-Jatropha based horti-silvi system on yield parameters of Castor

Treatments	No. of spikes per plant	No. of capsules per spike	Oil content (%)	Seed yield (g/plant)	Seed yield (kg/plot)	Seed yield (kg/ ha)	Total biomass (q/ha)
T_1- Castor with sole Sapota	8.13	69.38	41.88	254.75	7.90	1533.75	84.89
T_2- Castor with 100% pruned Jatropha	8.00	67.25	40.63	243.38	6.90	1373.13	81.78
T_3- Castor with 50% pruned Jatropha	7.38	59.13	39.88	230.13	6.39	1293.75	78.39
T_4- Castor with unpruned Jatropha	6.00	54.50	38.38	196.25	5.68	1157.50	72.93
T_5- Castor as sole	9.88	80.63	42.13	272.00	9.00	2525.00	148.47
S.Em.+ (T)	0.24	1.64	1.09	5.42	0.18	37.60	1.95
C.D. @ 5 % (T)	0.69	4.75	NS	15.71	0.53	108.91	5.64
C.V.%	9.16	7.51	8.21	6.42	7.69	7.24	6.36

Table – 3: Economics of Castor under Sapota – Jatropha based horti-silvi system

Treatments	Castor				Sapota				Jatropha				Total Cost of Cultivation (Rs./ha)	Total Gross Realization (Rs./ha)	Total Net Realization (Rs./ha)	BCR
	Yield (kg/ha)	Cost of Cultivation (Rs./ha)	Gross Realization (Rs./ha)	Net Return (Rs./ha)	Yield (kg/ha)	Cost of Cultivation (Rs./ha)	Gross Realization (Rs./ha)	Net Return (Rs./ha)	Yield	Cost of (Rs./ha)	Gross (Rs./ha)	Net (Rs./ha)				
T_1	1534	19893	53690	33797	3500	20200	52500	32300	--	--	--	--	40093	106190	66097	1.65
T_2	1373	19893	48055	28162	3828	20200	57420	37220	313	3299	6260	2961	43392	111735	68343	1.58
T_3	1294	19893	45290	25397	3943	20200	59145	38945	348	3299	6960	3661	43392	111395	68003	1.57
T_4	1158	19893	40530	20637	3834	20200	57510	37310	236	2409	4720	2311	42502	102760	60258	1.42
T_5	2525	29274	88375	59101	--	--	--	--	--	--	--	--	29274	88375	59101	2.02

Note: Selling price of Castor @ Rs.35 /kg, Sapota @ Rs. 15/kg and Jatropha @ Rs.20 /kg

the basis of prevailing market rate. The cost of fertilizers is taken as form the current market price. The cost of cultivation of castor, sapota and jatropha was given separately (Appendix 1, 2 and 3, respectively). The cost benefit ratio (CBR) was calculated by an incremental cost of different treatment and benefit obtain through an increase in production due to the respective treatment. The net returns per hectare were calculated by deducting the cost of cultivation from gross return per hectare. The benefit cost ratio was calculated as per formula in which net realization divided by cost of cultivation.

3. RESULTS AND DISCUSSION

Growth parameters

The data with respect to growth of castor are presented in Table -1. It is evident from data presented in table that plant height (123.25 cm), number of branches per plant (8.13), fresh weight of plant (2875.63 g) and dry weight of plant (948.75 g) were registered significantly higher in T_5: Castor sole crop, followed by T_1: Castor with sole Sapota. Whereas, oil content of castor was found non-significant. The minimum plant height (78.38 cm), number of branches per plant (6.13), fresh weight of plant (2408.75 g) and dry weight of plant (767.50 g) were recorded in T_4: Castor with unpruned Jatropha.

Yield parameters

It is clearly revealed from the data presented in Table -2 that number of spikes per plant (9.88), number of capsules per spike (80.63), yield per plant (272.00 g), yield per plot (9.00 kg), yield per hectare (2525.00 kg) and total biomass (148.47 q/ha) were noted significantly higher in T_5: Castor sole crop, followed by T_1: Castor with sole Sapota. The oil content of castor was found non-significant. Moreover, number of spikes per plant (6.00), number of capsules per spike (54.50), yield per plant (196.25 g), yield per plot (5.68 kg), yield per hectare (1157.50 kg) and total biomass (72.93 q/ha) were observed in T_4: Castor with unpruned Jatropha.

The Castor crop when grown in open condition noted maximum growth and yield parameter as compared to Sapota-Jatropha based horti-silvi system. It might be due to more availability of light in sole cropping system as compared to Sapota-Jatropha based horti-silvi system. The results are in line with Singh *et al.* (1987) in Castor under *Leucaena leucocephala*, Subrahmanyam *et al.* (1996) in Castor under *Dalbegia sissoo*, Sarada Devi *et al.* (2002) in Castor under *Melia azadirach.* Moreover, in case of pruning in Jatropha, the growth and yield parameter of Castor were found maximum in pruned Jatropha as compared to unpruned. The similar results were earlier reported by Osman *et al.* (1998), Govinda Rao (2000), Samsuzzaman *et al.* (2002), Padmavathi Devi (2004) and Mutanal *et al*. (2019).

Economics

The net realization of Castor was recorded highest under Sapota-Jatropha based horti-silvi system. However, BCR was noted highest in sole cropping as compared to Sapota-Jatropha based horti-silvi system. The highest net realization (Rs.68,343/ha) was registered in T_2. Castor with 100 % pruned Jatropha whereas BCR was reported in T_5: Castor sole crop (1:2.02). The lowest net realization (Rs. 59,101/ha) was noted in T_5: Castor sole crop whereas BCR was recorded in T_4-Castor with unpruned Jatropha (1:1.42) (Table -3). The probable reason for it might be due to good availability of light in sole cropping system as compared to Sapota-Jatropha based horti-silvi system as well as increase in growth and yield parameters of Castor in sole cropping system as compared to Sapota-Jatropha based horti-silvi system (Table:1 and 2). These results are in line with earlier findings of Joseph *et al.* (1999) in sunflower with *Albizia lebbeck*, Korwar *et al.*

Appendix - 1: Cost of Cultivation (Rs /ha) Castor

Description	Rate	Open Condition	Sapota-Jatropha based horti-silvi System
Fixed Cost			
Preparatory tillage			
Ploughing by tractor with (1time) M.B. plough	@Rs.300/ hr	Rs. 900 for 3 hours	Rs. 600 for 2 hours
Ploughing by tractor with (2 times) cultivator	@ Rs.200/ hr	Rs. 400 for 2 hours	Rs. 200 for 1 hours
Ploughing by tractor with (1 times) Rotavator with planking	@ Rs.600/ hr	Rs. 1,200 for 2 hours	Rs. 600 for 1 hours
Total		**Rs. 2,500**	**Rs. 1,400**
Lay out and Transplanting			
Layout ,Preparation of channel, beds, making furrows, and earthing up	@ Rs.178 /day	Rs. 890/ 5 labour	Rs. 534/ 3 labour
Planting	@ Rs.178/ day	Rs. 1424/ 8 labour	Rs. 1,068/ 6 labour
Gap filling	@ Rs.178/day	Rs. 178 / 1 labour	Rs. 178 / 1 labour
Total		**Rs. 2,492**	**Rs. 1,780**
Seed (5kg/ ha) @175 Rs per kg		**Rs. 875 (5 kg/ ha)**	**Rs. 539 (3.08 kg/ ha)**
Manures and fertilizers (120-25-00 NPK kg/ha)			
FYM 20 t /ha	@ Rs. 470/t	Rs. 9,400/ 20 t/ha	Rs. 5,790.40/ 12.32 t
Urea	@ Rs. 6/kg	Rs. 1,562.40 / 260.40 kg	Rs. 962.40 / 160.40 kg
SSP	@ Rs. 9/kg	Rs. 1,406.25 / 156.25 kg	Rs. 866.25 / 96.25 kg
Expenditure on fertilizer application (5 labours for 1 day)	@ Rs.178/ /labour/day	Rs. 890/ 5 labour	Rs. 534/ 3 labour
Total		**Rs.13,259**	**Rs. 8,153**
Intercultural operations			
Weeding two times	@ Rs.178/day	Rs. 1,780/ 5 labour	Rs. 1,424 / 4 labour
Total		**Rs. 1,780**	**Rs. 1,424**
Irrigation application			
Irrigations - 4	@ Rs. 30 per hour	Rs. 1200/ (@ 10 hr for 1 ha.)	Rs. 960 / (@ 8 hr for 1 ha.)
Labour charges (2 men for 1 irrigation)	@ Rs.178/ /labour/day	Rs. 1424	Rs. 1,424
Total		**Rs. 2,624**	**Rs. 2,384**
Plant protection			
Labour for spraying (2 men per spray)	@ Rs.288 /labour/day	Rs. 1,152	Rs. 1,152
Chlorpyrifos 1 spray	@ 215/lit	Rs. 322.50/ 1.5 lit / ha	Rs.215 /1.00 lit/ ha
Imidacloprid 1 spray	@ 1420/lit	Rs. 1065/ 0.750 lit / ha	Rs. 710 / 0.500 lit / ha
Total		**Rs. 2539.50 *i.e.* 2,540**	**Rs. 2,077**
Harvesting and Marketing			
Harvesting, Threshing and Cleaning	@ Rs.178/day	Rs. 3,204/ 6 labours for 3 day	Rs. 2,136/ 4 labours for 3 day
Total		**Rs. 3,204**	**Rs. 2,136**
Fixed Cost - Grand Total		**Rs. 29,274**	**Rs. 19,893**

Appendix - 2: Cost of cultivation of Sapota (Rs/ha)

Operations	Cost/unit	Total cost (Rs/ha)
Cost of Planting		Rs 4500/-
Planting Material	Rs. 40/-	346.15 ha/Year
Preparation of Pits, Planting	Rs. 5 /-	*i.e.*, Rs. 346 ha/Year
Weeding and pruning (10 labours 2 times per year)	@ Rs 178/labour/day	Rs 3560/-
Expenditure on fertilizer application (5 labours for 1 day)	@ Rs 178/labour/day	Rs 890/-
Fruit harvesting (3 labours 10 times per year)	@ Rs 178/labour/day	Rs. 5340/-
Recommended dose of fertilizers/ plant (100 kg FYM, 1000-500-500 g NPK		
FYM 10 t /ha @ 400	@ Rs. 470/t	Rs. 4700/ 10 t/ha
Urea	@ Rs. 6/kg	Rs. 1302/ 217 kg
SSP	@ Rs. 9/kg	Rs. 2812.5 / 312.5 kg
MOP	@ Rs. 15/kg	Rs. 1249.50/ 83.30 kg
	Total-10064	**Total Rs. 20,200**

Appendix – 3: Cost of cultivation of Jatropha (Rs/ha)

Operations	Cost/unit	Total cost (Rs/ha)
Cost of Planting	Rs.2/-	Rs 3000/-
Planting Material		272.73 ha/Year
Preparation of Pits, Planting		*i.e.*, Rs. 273 ha/Year
Weeding (3 labours 2 times per year)	@ Rs 178/labour/day	Rs 1068/-
Pruning (5 labours 1 times per year)	@ Rs 178/labour/day	Rs 890/-
Fruit harvesting (3 labours 2 times per year)	@ Rs 178/labour/day	Rs. 1068/-
	Total – A With Pruning	**Rs. 3299 /ha/year**
	Total – B Without Pruning	**Rs. 2409 /ha/year**

(2006) in Castor with Amla, Singh (2012) in wheat under agri-horti-silvi system, Solanki *et al.* (2014) in medicinal crops with Sapota-Jatropha and Pandey *et al.* (2016) in Turmeric and Ginger with Sapota-Jatropha.

4. CONCLUSION

Cultivation of castor as a sole crop resulted in a significant increase in growth and yield parameters compared to its cultivation under the Sapota–Jatropha based horti-silvi system. However, the highest net realization was observed in T_2: Castor with 100% pruned Jatropha under the Sapota–Jatropha system, whereas the maximum benefit–cost ratio (BCR) was recorded in T_5: Castor sole cropping. Based on the findings, it is concluded that growing castor as an intercrop during the initial establishment phase of Sapota or within a Sapota–Jatropha based horti-silvi system is economically feasible. This practice not only provides additional income to farmers but also enhances land use efficiency and contributes to overall system productivity, making it a sustainable approach for integrated land management.

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