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Performance of Castor (*Ricinus communis* L.) Based Intercropping Systems in South Gujarat: Growth, Yield and Resource Optimization

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ABSTRACT

A field experiment was conducted at the College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari during Rabi 2023-24 to evaluate the performance of castor (Ricinus communis L.)-based intercropping systems in South Gujarat conditions. The experimental soil was clayey (Vertisols) with low available N (240.42 kg/ha), medium P_2O_5 (39.58 kg/ha) and high K_2O (338.28 kg/ha) with a slightly alkaline pH (7.68). The experiment followed a randomized block design (RBD) with nine treatments: T_1 (sole castor), T_2 (sole green gram), T_3 (sole Indian bean), T_4 (sole sorghum), T_5 (sole sweet corn), T_6 (castor + green gram (1:2)), T_7 (castor + Indian bean (1:2)), T_8 (castor + sorghum (1:2)) and T_9 (castor + sweet corn (1:2)).Results showed that castor plant height was 39.62 cm at 30 DAS, 79.20 cm at 60 DAS and 147.59 cm at harvest. Intercrop heights at harvest were 75.45 cm (green gram), 73.80 cm (Indian bean), 154.20 cm (sorghum) and 152.70 cm (sweet corn). Yield attributes of castor included a main spike length of 49.85 cm, three spikes per plant and 68.2 capsules per spike leading to a seed yield of 1,625 kg/ha and stover yield of 3,004 kg/ha. Green gram yielded 750.23 kg/ha, the highest among intercrops. Oil content (48.67%) was highest in sole castor while T_9 had the highest harvest index (47.81). T_6 (castor + green gram) proved superior optimizing resource use and productivity. However, challenges such as competition for nutrients, moisture and light among intercrops along with pest and disease management complexities being constraints for yield optimization. Additionally, variations in maturity periods created difficulties in synchronized harvesting and to increase resource utilization. Despite these challenges this study made significant contributions by identifying an efficient intercropping system that enhances overall productivity and profitability. The findings revealed the agronomic advantage of castor-green gram intercropping in terms of yield optimization, better land use efficiency and improved soil fertility management. Thus this research provides a sustainable approach for farmers for ensuring the enhanced income and diversified production while maintaining soil health in South Gujarat.

Keywords: *Castor, Growth parameters, Intercrops, Intercrops, Resource optimization, South Gujarat, Stalk yield, Stover yield, Yield attributes.*

Introduction

Castor (*Ricinus communis* L.) is a significant non-edible oilseed crop in India, particularly cultivated in arid and semi-arid regions. It belongs to the Euphorbiaceae family and is native to Ethiopia. Castor is valued for its oil content, which ranges from 45 to 50%, and its industrial importance due to the presence of ricinoleic acid, a unique fatty acid. The oil derived from castor is used in the production of various industrial products like soaps, printing inks, lubricants, and cosmetics, among others. Additionally, castor seed cake is an excellent organic manure, while its stalks are utilized as fuel and in the production of thatching material and paper pulp. The versatility of castor, combined with its oil-rich seeds and multipurpose uses, makes it an essential crop in the Indian agricultural landscape [3].

India is the largest producer and consumer of castor in the world, contributing significantly to global production, particularly in states like Gujarat, Rajasthan, Maharashtra, and Madhya Pradesh.

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The country's dominance in castor production underscores the economic value of this crop. However, the productivity of castor under rainfed conditions is often limited due to factors like low and erratic rainfall, poor soil quality and inadequate adoption of modern agricultural practices. The inclusion of intercropping systems, particularly with crops like pulses, sorghum, and sweet corn, has emerged as a viable solution to mitigate these challenges. Intercropping has the potential to enhance the productivity of castor by utilizing available space more effectively, reducing pest populations and improving soil health [5][12].

Intercropping has long been recognized as a valuable practice in dryland farming, especially in regions with unpredictable rainfall. By introducing compatible intercrops like legumes or fast-growing crops, farmers can improve resource utilization, reduce competition and increase overall yield per unit area. The practice also helps in enhancing soil fertility through nitrogen fixation, while providing additional income from intercrops. Furthermore, intercropping can act as a safeguard against total crop failure, making it a resilient and sustainable practice for farmers in semi-arid regions. The main challenge remains selecting the right intercrops and optimizing planting patterns to reduce competition between the main and intercrop species [5][8].

In light of these challenges, the present research titled "Performance of Castor (*Ricinus Communis* L.) Based Intercropping System in South Gujarat Condition" aims to explore suitable intercrop combinations for castor and assess their overall system productivity. The investigation will focus on identifying the most effective intercropping systems that can boost castor productivity and provide economic benefits to farmers. This research is essential as it addresses the need for more intensive, resource-efficient farming systems, particularly in rainfed areas where castor is commonly grown. By evaluating the performance of castor-based intercropping systems, the study will contribute valuable insights for improving castor yield, enhancing soil health and optimizing land use for sustainable agricultural practices in Gujarat and similar regions [1][2].

Material and Methods

A field experiment was carried out at College farm, N.M.College of Agriculture, Navsari Agricultural University, Navsari during *Rabi* 2023-24 to study the performance of castor (*Ricinus Communis* L.) based intercropping system in south Gujarat condition. The soil of the experimental plot was clayey (*Vertisols*) with low in available N (240.42 kg/ha), medium in P_2O_5 (39.58 kg/ha) and high in K_2O (338.28 kg/ha). The soil reaction (pH) was slightly alkaline (7.68). The experiment was arranged in a randomized block design (RBD) with nine treatments, which included: T_1 (sole castor), T_2 (sole green gram), T_3 (sole Indianbean), T_4 (sole sorghum), T_5 (sole sweet corn), T_6 (castor + greengram (1:2)), T_7 (castor + Indianbean (1:2)), T_8 (castor + sorghum (1:2)) and T_9 (castor + sweet corn (1:2)). The field preparation included plowing, harrowing and planking to achieve a fine tilth suitable for sowing. The sowing was carried out on 25th August, 2023 with the recommended seed rates for each crop and fertilizers were applied based on the respective treatment requirements. Castor was planted at a spacing of 135 x 90 cm, while intercrops were spaced at 45 x 10 cm. Irrigation was managed according to the critical growth stages of the crops. Observations were recorded at different growth stages including plant population, plant height at 30 and 60 DAS, number of branches per plant, spike length, number of spikes per plant, capsules per spike, and seed yield (kg/ha). The crops were harvested in January and February 2024 and yield attributes such as stalk yield, harvest index and oil content were measured.

Statistical analysis was conducted using the method as described by [10] and the significance of differences was tested using the 'F' test. The data were analyzed using standard ANOVA techniques to assess the performance of different treatments focusing on growth and yield parameters to determine the most effective intercropping system for castor in the region.

Results and Discussion

Growth attributes:

Castor

The plant height of castor was not significantly affected during the early growth stages at 30 and 60 DAS, likely due to minimal competition for space among crops at these stages, which allowed for reduced competition between plants. However, significant differences in plant height were observed at harvest. The tallest plants were recorded in the sole castor treatment (T_1) with a height of 147.59 cm, which was statistically similar to the castor + greengram (1:2) intercropping treatment (T_6) which had a plant height of 143.58 cm. These findings are in agreement with the results of [7], who reported significantly higher plant height in *rabi* castor intercropped with different pulses, suggesting that intercropping with pulses may have minimal impact on the growth of castor during its later stages possibly due to reduced competition for space and nutrients.

Intercrops

Sole green gram (T_2) exhibited significantly higher plant height at 30 DAS (25.7 cm), 60 DAS (53.57 cm) and at harvest (75.45 cm) compared to the intercropping system of castor + greengram (1:2) (T_6). Similarly, sole Indianbean (T_3) had the tallest plants at 30 DAS (24.2 cm), 60 DAS (51.82 cm), and at harvest (73.8 cm) compared to the castor + Indianbean (1:2) treatment (T_7). Sole sorghum (T_4) also recorded higher plant heights at all stages (40.35 cm at 30 DAS, 78.6 cm at 60 DAS and 154.2 cm at harvest) compared to castor + sorghum (1:2) (T_8). Likewise, sole sweet corn (T_5) showed superior growth (39.25 cm at 30 DAS, 78.17 cm at 60 DAS and 151.7 cm at harvest) compared to castor + sweet corn (1:2) (T_9). The greater plant heights in sole cropping systems are attributed to the availability of adequate space and reduced competition among plants.These results align with the findings of [7], who observed similar trends in *rabi* castor intercropped with various pulses suggesting that intercropping may limit the growth of individual crops due to competition for resources.

Table 1: Plant height of castor and intercrops as influenced by sole and intercropping systems

Treatments	Plant Height (cm) 30 DAS		Plant Height (cm) 60 DAS		Plant Height (cm) At Harvest	
	Castor	Intercrops	Castor	Intercrops	Castor	Intercrops
T_1: Sole castor	39.62	-	79.20	-	147.59	-
T_2: Sole green gram	-	25.70	-	53.57	-	75.45
T_3: Sole Indianbean	-	24.20	-	51.82	-	73.80
T_4: Sole sorghum	-	40.35	-	78.60	-	154.20
T_5: Sole sweet corn	-	39.25	-	78.17	-	152.70
T_6: Castor + greengram (1:2)	39.60	25.55	77.98	52.25	143.58	73.35
T_7: Castor + Indianbean (1:2)	37.31	23.70	76.07	50.55	134.02	72.05
T_8: Castor + sorghum (1:2)	37.54	40.36	76.62	77.52	134.48	152.11
T_9: Castor + sweet corn (1:2)	39.17	39.15	76.32	78.72	134.79	154.42
S. Em. ±	1.22	-	3.10	-	3.47	-
CD at 5%	N.S.	-	N.S.	-	10.68	-
CV%	6.32	-	8.02	-	4.99	-

Yield attributes and yield

Castor

The seed and stalk yields of castor were significantly influenced by different sole and intercropping treatments. Sole castor (T_1) recorded the highest seed yield of 2250 kg/ha, which was significantly higher than other treatments, although it remained at par with castor + greengram (1:2) (T_6) at 2100 kg/ha. This difference can be attributed to the competition-free environment in sole cropping, where crops did not experience atmospheric stress or nutrient uptake stress, as also reported by [8] in castor with green gram. Similarly, for stalk yield, sole castor (T_1) produced the highest yield of 4977 kg/ha, followed by castor + greengram (1:2) (T_6) with 4802 kg/ha and castor + Indianbean (1:2) (T_7) with 4680 kg/ha. The competition-free environment in sole cropping, coupled with better availability of water, nutrients and optimal uptake, contributed to the higher stalk yield in sole castor. These findings align with [8], who also observed similar trends in castor-based intercropping systems.

Table 2: Length of main spike (cm), number of spike per plant and number of capsule per spike of castor as influenced by sole and intercropping systems

Treatments	Length of Main Spike (cm)	No. of Spike per Plant	No. of Capsule per Plant
T_1: Sole castor	50.65	9.23	60.74
T_2: Sole green gram	-	-	-
T_3: Sole Indianbean	-	-	-
T_4: Sole sorghum	-	-	-
T_5: Sole sweet corn	-	-	-
T_6: Castor + greengram (1:2)	49.68	9.00	54.30
T_7: Castor + Indianbean (1:2)	42.60	6.74	46.53
T_8: Castor + sorghum (1:2)	43.60	6.99	46.94
T_9: Castor + sweet corn (1:2)	49.00	7.95	53.98
S.Em. ±	1.89	0.43	2.27
CD at 5%	5.81	1.31	7.00
CV (%)	8.01	10.67	8.65

Intercrops

Sole cropping systems significantly showed higher yields compared to their intercropping counterparts. Sole green gram (T_2) recorded the highest seed yield of 1250 kg/ha, while sole Indianbean (T_3) gave a maximum seed yield of 1150 kg/ha. Sole sorghum (T_4) produced 2500 kg/ha and sole sweet corn (T_5) yielded 8050 kg/ha. For stover yields, sole green gram (T_2) gave 2800 kg/ha, sole Indianbean (T_3) produced 2650 kg/ha, sole sorghum (T_4) yielded 5280 kg/ha and sole sweet corn (T_5) had a stover yield of 13289 kg/ha. These results demonstrate that sole crops generally outperformed intercropping treatments due to reduced competition for resources, which is consistent with the findings of [8] in castor-based intercropping systems.

Table 3: Seed yield and Stalk yield (kg ha^{-1}) of castor and intercrops as influenced by sole and intercropping systems

Treatments	Seed Yield (kg/ha)		Stalk Yield (kg/ha)	
	Castor	Intercrops	Castor	Intercrops
T_1: Sole castor	2250.10	-	4977.21	-
T_2: Sole green gram	-	1250.60	-	2800
T_3: Sole Indianbean	-	1150.00	-	2650
T_4: Sole sorghum	-	2500.12	-	5280
T_5: Sole sweet corn	-	8050.23	-	13289
T_6: Castor + greengram (1:2)	2100.00	750.23	4802.40	1600
T_7: Castor + Indianbean (1:2)	2050.00	688.43	4680.36	1410
T_8: Castor + sorghum (1:2)	1750.11	1400.32	3650.00	2980
T_9: Castor + sweet corn (1:2)	1580.01	4880.12	3300.01	9998

Quality Parameters

The results on the harvest index of castor showed no significant influence from different sole and intercropping systems. This non-significant result aligns with the findings of [8], who also observed similar trends for castor when intercropped with greengram. Regarding the oil content of castor, the data indicated that different intercropping systems did not have a significant effect on oil content percentage. These findings are in agreement with those of [10], who reported no significant impact on oil content when castor was intercropped with groundnut and greengram. The lack of significant differences in both harvest index and oil content could be attributed to the minimal interference from intercropping systems, which did not substantially affect these parameters.

Table 4: Harvest index and oil content (%) of castor as influenced by sole and intercropping Systems

Treatments	Harvest Index	Oil Content (%)
T_1: Sole castor	45.15	48.67
T_2: Sole green gram	-	-
T_3: Sole Indianbean	-	-
T_4: Sole sorghum	-	-
T_5: Sole sweet corn	-	-
T_6: Castor + greengram (1:2)	43.63	48.38
T_7: Castor + Indianbean (1:2)	43.73	48.21
T_8: Castor + sorghum (1:2)	47.61	47.61
T_9: Castor + sweet corn (1:2)	47.81	48.13
S.Em. ±	1.37	1.16
CD at 5%	N.S.	N.S.
CV (%)	6.02	4.81

Conclusion

Based on the one-year field experiment conducted to evaluate the performance of a castor (*Ricinus communis* L.) based intercropping system in South Gujarat, it can be concluded that sole castor (T_1) exhibited the highest plant height, seed yield and stalk yield, with significantly higher seed yield (2250 kg/ha) and stalk yield (4977 kg/ha) compared to the intercropping treatments. Intercropping with greengram (T_6) resulted in a notable yield reduction, though it remained at par with sole castor in seed yield (2100 kg/ha) and stalk yield (4802 kg/ha) demonstrating the potential of castor + greengram for improved yield. Similar trends were observed for other intercrops, where sole treatments (greengram, Indianbean, sorghum, sweet corn) outperformed the respective intercropping treatments in both seed and stover yields. However, it is important to note that intercropping while showing a slight reduction in certain yields due to competition, does not significantly affect castor's harvest index or oil content. These findings align with previous studies[8][10]. Intercropping is not necessarily harmful to the crops and although the sole crop treatments showed higher yields for certain parameters the calculation of economic returns and equivalent yields may show that intercropping systems can still be superior by maximizing land use efficiency and improving overall productivity. Therefore, while intercropping may reduce specific yields it could be more beneficial from an economic standpoint offering a sustainable and potentially more profitable farming practice in South Gujarat conditions.

Future Scope of the Study

Future research on castor-based intercropping systems can focus on sustainable resource utilization as it can enhance productivity. Economic analysis and mechanization-friendly approaches will aid in large-scale adoption. There is a need to study the effect of intercropping on weed suppression, as it may help reduce weed competition and minimize herbicide dependence. Studies on climate resilience, genotypic evaluation, and carbon sequestration can contribute to environmental sustainability. On-farm trials will help validate findings and promote widespread adoption of intercropping in South Gujarat and similar agro-climatic regions.

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Conflict of interest

The authors declare that they have no conflict of interest.

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