Performance of Green Manure Crops Sunhemp (*Crotalaria juncea* L.) and Dhaincha (*Sesbania aculeata* L.) in Rice Fallow

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Abstract— *In agriculture, green manure is created by leaving uprooted or sown crop parts to wither on a field so that they serve as a mulch and soil amendment. The plants used for green manure are often cover crops grown primarily for this purpose. Green manuring is the easiest and cheapest way to enrich soil fertility besides adding a huge amount of organic carbon to the soil and preventing soil erosion. The non-availability of green manure seed preceding paddy is a major constraint at the farmer level. In rice fallow pulses, yields are declining due to severe incidence of Yellow Mosaic Virus (YMV), and farmers are unable to reap pulses in rice fallow situations. Keeping in view the present scenario, this study on the performance of seed production of green manure crops for seed availability and profitability was taken up in farmers' fields as On Farm Testing. The performance of two crops, Sunhemp (Crotalaria juncea L.) and Dhaincha (Sesbania aculeata L.), was studied for seed yield in a rice fallow situation during Rabi 2021-22 and Rabi 2022-23 under a rainfed ecosystem by the DAATTC, Visakhapatnam District. The results revealed that a higher seed yield was observed in Sunhemp compared to Dhaincha. Seed yield increase was achieved to the tune of 84.00% in Sunhemp (1178 kg ha^{-1}) over Dhaincha (641 kg ha^{-1}). The increase in seed yield could be attributed to the better performance of the Sunhemp crop in terms of growth and yield components. The Sunhemp crop matured a week earlier than the Dhaincha crop.*

Keywords— Sunhemp, Dhaincha, Rice fallow, Seed yield, Economics.

I. INTRODUCTION

India has changed from a region of food scarcity to food sufficiency by increased fertilizer use with subsidized prices, but the use of organic manures, including green manure, has declined substantially. Inorganic fertilizers are becoming more expensive; therefore, the sustainability of soil productivity has become a question. Hence, alternate sources to supplement inorganic fertilizers are needed. Green manuring is a low-cost and effective technology for minimizing the cost of fertilizers, enhancing soil structure, and safeguarding crop productivity. Crops grown for restoring or increasing the organic matter content in the soil are called green manure crops. The use of green manure crops in a cropping system is called 'Green Manuring.'

A green manure crop should possess characteristics such as multipurpose use, short duration, fast growth, high nutrient accumulation ability, tolerance to adverse conditions, wide ecological adaptability, efficiency in water use, high nitrogen accumulation rates, high seed production, and pest and disease resistance. In line with these properties, Sunhemp (Crotalaria juncea L.) and Dhaincha (Sesbania aculeata L.) are suitable species for green manuring with high biomass production of 20-25 t/ha (Tripathi et al., 2013).

The lack of availability of adequate quality seed at an appropriate time and reasonable price for small and marginal farmers is a major constraint in Sunhemp and Dhaincha cultivation. Quality seed production of these crops has received meager importance in spite of huge demand from farmers. Further, the possibility of seed production under rice fallow situations paves the way for identifying suitable crops with high water use efficiency; hence, this study was taken up in farmers' fields.

Objectives:

1. To create awareness among farmers on green manure cultivation in rice fallow situations.
2. To analyze the economics of seed production of green manure crops.

II. MATERIALS AND METHODS

The study was conducted by scientists from the District Agricultural Advisory & Transfer of Technology Centre (DAATTC), Visakhapatnam, in active collaboration with the local Department of Agriculture. The core methodology involved organizing comparative demonstrations in actual farmers' fields, adhering to the principles of On-Farm Testing (OFT) to ensure real-world relevance and farmer engagement.

Site Selection and Crop Establishment: A total of seven locations were selected across the Visakhapatnam district for demonstrations over two consecutive Rabi seasons (2021-22 and 2022-23). The fields chosen were typical of the region's rice-based systems. The key intervention involved broadcast seeding of both Sunhemp and Dhaincha directly into the standing rice crop. This was done 7 to 10 days before the anticipated harvest of paddy. The timing is critical; it allows the seeds to utilize the residual moisture in the "waxy" or saturated soil as the rice field dries out, ensuring good germination without the need for additional irrigation at sowing.

Crop Management and Data Collection: Following rice harvest, the green manure crops were allowed to grow under rainfed conditions, relying on seasonal Rabi rainfall. Standard agronomic practices and need-based plant protection measures were applied uniformly to both crops across all locations to manage pests and diseases. At crop maturity, detailed observations were recorded. In each farmer's plot, five plants were randomly selected for both Sunhemp and Dhaincha to measure key parameters: plant height (in centimeters), number of primary branches per plant, total number of pods per plant, and number of seeds per pod. The days taken from sowing to physiological maturity were also recorded. The entire plot was then harvested to determine the actual seed yield in kilograms per hectare.

Economic and Data Analysis: A simple economic analysis was performed for both crops. The total cost of cultivation was calculated, including costs for seeds, plant protection, labor for harvesting, and threshing. The gross income was derived by multiplying the seed yield by a conservative market price of Rs. 40 per kilogram. Net income and the cost-benefit ratio (C:B ratio) were then computed. For the agronomic data, the results from the seven demonstration sites over two seasons were pooled. The primary analysis focused on calculating the mean (average) performance for each trait for both crops. The percentage difference or improvement of Sunhemp over Dhaincha was calculated to clearly illustrate the comparative advantage.

III. RESULTS AND DISCUSSION

The trials on seed production of Sunhemp and Dhaincha were conducted in 7 locations across the district during the Rabi 2021-22 and Rabi 2022-23 seasons in farmers' fields. Yield attributes and yield are depicted in the following tables. A simple analysis of the mean for various parameters was studied (Table 1 and 2).

TABLE 1

YIELD AND YIELD ATTRIBUTES OF GREEN MANURE CROPS FOR SEED PRODUCTION IN RICE FALLOW DURING RABI 2021-22 AND 2022-23.

Sl. No.	Season & Year	Plant Height (cm)		No. of Branches		Days to Maturity		No. of Pods		No. of Seeds/Pod		Seed Yield (kg/ha)		% Yield Increase of Sunhemp over Dhaincha
		Sun.	Dhai.	Sun.	Dhai.	Sun.	Dhai.	Sun.	Dhai.	Sun.	Dhai.	Sun.	Dhai.	
1	Rabi, 2021-22	124	81	7	3	116	124	140	25	11	8	1251	611	105%
2	Rabi, 2021-22	116	77	8	3	122	121	156	37	10	7	1053	672	57%
3	Rabi, 2021-22	117	63	7	5	119	121	162	33	10	6	1152	593	94%
4	Rabi, 2022-23	122	69	8	4	114	124	123	29	12	8	1151	620	86%
5	Rabi, 2022-23	118	74	7	4	121	122	139	32	12	6	1052	670	57%
6	Rabi, 2022-23	121	93	6	3	119	122	147	36	11	8	1251	681	84%
7	Rabi, 2022-23	116	86	8	4	118	122	151	37	11	6	1350	641	111%
Average		**119.1**	**77.6**	**7.3**	**3.7**	**118.4**	**122.3**	**145.4**	**32.7**	**11**	**7**	**1179.9**	**641.1**	**84.30%**
% Improvement (Sun. over Dhai.)			**53.50%**		**97.30%**		**-3.2%** (Fewer Days)		**344.60%**		**57.10%**		**84.10%**	

TABLE 2
ECONOMICS OF GREEN MANURE CROPS SEED PRODUCTION IN RICE FALLOW SITUATION (AVERAGE OF RABI 2021-22 AND 2022-23 SEASONS).

Sl. No.	Particulars	Sunhemp (Rs./ha)	Dhaincha (Rs./ha)	Difference (Rs./ha)
1	Grain Yield (kg/ha)	1180	641	539
2	Grain Value (@ Rs. 40/kg)	47200	25640	21560
3	Cost of Cultivation	15100	13600	1500
4	Net Income (Rs./ha)	32100	12040	20060
5	C:B Ratio	2.13	1.15	0.98

Plant height (cm): In Sunhemp, plant height varied from 116 to 124 cm with a mean of 118 ± 3.3 cm. In Dhaincha, plant height varied from 63 to 95 cm with a mean of 77 ± 10.5 cm. Sunhemp was 52.6% taller than Dhaincha.

Number of branches per plant: The number of branches varied from 6 to 9 in Sunhemp (mean 7.3 ± 0.8). In Dhaincha, fewer branches per plant were observed (mean 3.7 ± 0.8). More branches per plant may give more biomass, a desirable trait for a green manure crop. The number of branches was 75.0% higher in Sunhemp.

Days to maturity: Maturity duration ranged from 114 to 122 days with a mean of 117 ± 2.6 days in Sunhemp. The mean number of days to maturity for Dhaincha was 121 ± 1.5 days, with a range of 119 to 124 days. Sunhemp matured approximately four days earlier than Dhaincha.

Number of pods per plant: In Sunhemp, the number of pods ranged from 123 to 162 with a mean of 145 ± 12.8. Increased vegetative growth and branch number in Sunhemp contributed to a higher pod count. In Dhaincha, the number of pods varied from 25 to 37 with a mean of 33 ± 4.9. Sunhemp produced 355.3% more pods than Dhaincha.

Number of seeds per pod: The average number of seeds per pod in Sunhemp was 11 ± 0.8 (range 10-13). In Dhaincha, the average was 7 ± 0.8 (range 6-8). Sunhemp produced 71.4% more seeds per pod.

Seed yield (Kg ha^{-1}): A substantial yield increase of 84.0% was achieved in Sunhemp (1178 ± 108 kg ha^{-1}) over Dhaincha (641 ± 39 kg ha^{-1}). The higher yield in Sunhemp can be attributed to more pods supported by profuse plant growth and more branches.

Economics: The cost analysis revealed an additional grain yield of 537 kg ha^{-1} from Sunhemp compared to Dhaincha (Table 2). This resulted in an additional net income of Rs. 22,710 ha^{-1} from Sunhemp, despite a slightly higher cost of cultivation (mainly due to more harvesting charges). The cost-benefit ratio was higher for Sunhemp (2.58) compared to Dhaincha (1.15).

IV. CONCLUSIONS

This two-year, on-farm evaluation conclusively demonstrates that Sunhemp (*Crotalaria juncea* L.) is significantly better suited than Dhaincha (*Sesbania aculeata* L.) for seed production in rice fallow systems of the Visakhapatnam region, and likely in similar agro-ecologies. Sunhemp outperformed Dhaincha in every critical aspect: it showed more vigorous growth, matured earlier, and delivered dramatically higher seed yields due to superior pod and seed formation. Crucially, this agronomic superiority translated into strong economic profitability, with a cost-benefit ratio more than double that of Dhaincha.

Therefore, it is recommended that extension agencies and farmers actively promote Sunhemp as the green manure crop of choice for rice fallow seed production. This strategy achieves a dual purpose: it provides farmers with a lucrative supplemental income during the fallow period, and it simultaneously solves the critical problem of green manure seed unavailability at the farm gate. The seed produced locally can then be used by the same farmers or their community for green manuring in the subsequent pre-Kharif season, creating a self-sustaining cycle that enhances soil fertility, reduces dependency on chemical fertilizers, and improves the overall sustainability of the rice-based cropping system. This practice represents a simple, low-cost, and high-impact technology for resilient agriculture.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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