Assessing the Economics of Sunhemp in Rice Fallow Systems: Boosting Farm Income

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Abstract— A field experiment was conducted to study the economics of sunhemp varieties under different sowing windows for seed production in rice fallow system in NC zone during Rabi 2023-24 at Agricultural College Farm, Naira. The experiment was laid out in a Factorial randomized block design with two factors and three replications. Factor one comprised of three varieties JRJ 610 (V1), SUIN 03 (V2), SUIN 037 (V3) and factor two comprised of four sowing windows i.e. first fortnight of November (S1), second fortnight of November (S2), first fortnight of December (S3) and second fortnight of December (S4). Higher gross returns (Rs. 207540 ha⁻¹), net returns (Rs. 123410 ha⁻¹) and B:C ratio (2.47) of rice-sunhemp system were realized with sunhemp variety SUIN 037 sown during second fortnight of November as relay crop after kharif rice. Whereas higher gross returns (Rs. 84,825 ha⁻¹), net returns (Rs. 54,925 ha⁻¹), returns per rupee invested (Rs. 1.84) and highest B:C (2.84) of sole sunhemp crop was obtained with sunhemp variety SUIN 037 sown during first fortnight of November. Choosing the right variety with pest and disease resistance and adaptability to local environmental conditions is essential for good crop establishment as relay crop in rice-based cropping system as alternative to the rice-pulse system in North Coastal Zone of Andhra Pradesh.

Keywords— Sunhemp, Sowing windows, Rice-sunhemp cropping system, Economics.

I. INTRODUCTION

Sunhemp holds significant economic importance due to its diverse applications and benefits to agricultural systems. As a green manure crop, it enhances soil fertility and structure. It also adds substantial organic matter to the soil upon decomposition, further improving soil health and microbial activity, leading to increased crop yields. As a leguminous plant, it is capable of fixing atmospheric nitrogen through its symbiotic relationship with rhizobium bacteria in its root nodules (Deshmukh, 2023). The 60-days-old crop accumulates about 170 kg N, 20 kg P and 130 kg K ha⁻¹ (Pacharne et al., 2021). Sunhemp possesses allelopathic effects on weeds and suppresses weed growth and weed seed bank, which reduces the need for chemical herbicides, lowering production costs and minimizing environmental impact (Bhandari et al., 2022). It is well known for its coarse textured pectino-cellulosic fibre with good fibre characteristics and high yield, which is used for manufacturing a wide variety of products like paper, marine cordage, rope, string and fishing net, coarse for hose pipe, belting and canvas, tissue paper, bank currency, rugs, carpets, etc. (Shi et al., 2018).

Beyond its agronomic benefits, sunhemp can also serve as a source of additional income. It can be harvested for use as forage in livestock production, thereby opening up new markets for farmers. The potential for selling sunhemp seeds or biomass adds another layer of economic viability to its cultivation. Seed filling in sunhemp is negatively affected by late planting in the rabi rice fallows system. The best time to sow sunhemp seeds is the most crucial factor in achieving larger yields since it creates

ideal growing conditions. Sunhemp, a short-day plant, produces more biomass during longer days. In short days, it blooms early, which reduces vegetative development.

In north coastal districts of Andhra Pradesh, rice-pulse system is predominant. Considering the use of sunhemp as green manure crop for pre-kharif in rice growing areas, the demand for sunhemp seed is increasing day by day. By utilizing the residual moisture after harvest of the kharif paddy, sunhemp for seed purpose can be the best alternative to pulse crops in rice-based cropping system under relay cropping.

With increasing minimum support price for sunhemp seed and ease of agronomic practices, sunhemp seed crop may be the best alternative to pulses like greengram and blackgram in rice-based cropping system.

Delayed sowing leads to reduced seed yield and quality due to climatic constraints, primarily high temperature and limited moisture during crucial flowering and pod-filling stage. Timely sowing, often in the first or second week of November depending on the specific region and variety, is crucial for optimal seed yield and quality of sunhemp. Economically, the rice fallow system diversifies income sources for farmers and enhances food security, although it requires careful management of resources and knowledge transfer to ensure successful implementation (Kumar et al., 2019). Growing sunhemp in rice fallows is considerably more profitable than growing pulse crops in terms of higher growth and yield components. It also adds more green manure to the soil and increases the farmer's net revenue (Amarajyoti et al., 2023). Keeping these points in view, the present investigation was undertaken with the objective to study the economics of sunhemp varieties influenced by various sowing windows under rice fallow system in North Coastal Zone.

II.   MATERIALS AND METHODS

2.1   Experimental Site:

The present field experiment was conducted during rabi, 2023-24 at Agricultural College Farm, Naira, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, which is geographically situated at 18.24° N latitude, 83.84° E longitude and with an altitude of 27 m above mean sea level in the North Coastal Zone of Andhra Pradesh.

2.2   Experimental Design and Treatments:

The experiment was laid out in a Factorial Randomized Block Design with three replications. Factor one comprised of three varieties:

- V1: JRJ 610

- V2: SUIN 03

- V3: SUIN 037

Factor two comprised of four sowing windows:

- S1: First fortnight of November

- S2: Second fortnight of November

- S3: First fortnight of December

- S4: Second fortnight of December

2.3   Crop Management:

The seed was easily dispersed with little labor, which aids in prompt sowing and also reduces labor costs involved. Each hectare received around 25 kg of seed. Five to six days after sowing, the seeds began to sprout. Blooming began 45 days after sowing, and the complete flowering phase, from 45 days after sowing (DAS) to 85 days after sowing (DAS), lasted roughly 40 days. It took 35–40 days for the seeds to fully develop and harden. The crop was harvested 140–150 days after sowing (DAS) for seed production.

2.4   Seed Yield:

The seed yield obtained from each plot of three replications was computed for hectare and was expressed in kilogram per hectare.

2.5   System Equivalent Yield:

The grain and straw yields of the rice crops were recorded from each plot after harvesting the crops to calculate the biological yield in (q ha⁻¹) of component crops (Brar et al., 2023). Rice equivalent yield (REY) of the winter crops was computed by converting their grain yield to rice yield with a price factor as per following formula (Kumar et al., 2019)

$$\text{REY (kg ha}^{-1}) = \frac{\text{Grain yield of the winter crop (kg ha}^{-1}) \times \text{Price of winter crop (INR kg}^{-1})}{\text{Price of rice (INR kg}^{-1})} \tag{1}$$

2.6   Economic Analysis:

The economic components of different treatments were computed and worked out. The cost of cultivating the various treatments was determined by adding the common cost resulting from the various procedures and inputs utilized to all the expenses involved in the growth of the experimental crop. As a result, the cost of cultivation was computed for every combination of treatments.

The treatment wise gross monetary returns (Rs. ha⁻¹) were worked out by multiplying total sunhemp seed yield separately under various treatment combination with their existing market price (Verma et al., 2011). By deducting the cost of production from the gross return of each treatment, the net monetary returns (Rs. ha⁻¹) were calculated (Thimmanna et al., 2014).

$$\text{Net return (Rs. ha}^{-1}) = \text{Gross return (Rs. ha}^{-1}) - \text{Cost of cultivation (Rs. ha}^{-1}) \tag{2}$$

2.7   Returns per Rupee Invested:

The cost of cultivation for each treatment was calculated. Similarly, gross returns were calculated based on the prevailing market price of the produce. The net return was obtained after deducting the cost of cultivation from gross returns (Thimmanna et al., 2014). Later, the return per rupee was calculated using the formula:

$$\text{Return per rupee (Rs.)} = \frac{\text{Net returns (Rs. ha}^{-1})}{\text{Total operational cost (Rs. ha}^{-1})} \tag{3}$$

2.8   Benefit-Cost Ratio (B:C):

The benefit-cost ratio was calculated by dividing the net return by the cost of cultivation of the individual treatment combination (Kaur et al., 2024). The benefit-cost ratio was worked out by using the following formula:

$$\text{Benefit-cost ratio} = \frac{\text{Gross monetary returns (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})} \tag{4}$$

III.   RESULTS AND DISCUSSION

The data presented in Table 1 demonstrate how sunhemp varieties and sowing windows influenced the gross returns, net returns, returns per rupee invested and B:C ratio of sunhemp crop and rice-sunhemp system economics.

3.1   Effect of Varieties:

Among all tested varieties, sunhemp variety SUIN 037 (V3) realized maximum gross returns (Rs. 73,385 ha⁻¹), net returns (Rs. 43,485 ha⁻¹), returns per rupee invested (Rs. 1.45) and obtained highest B:C ratio (2.45). While the lowest gross returns (Rs. 62,328 ha⁻¹), net returns (Rs. 32,428 ha⁻¹), returns per rupee invested (Rs. 1.08) and B:C ratio of 2.08 were observed with variety SUIN 03 (V2).

The selection of the appropriate variety for sunhemp is critical for maximizing yield, improving soil health, and ensuring pest and disease resistance. Variety SUIN 037 (V3) having higher returns was due to its genetic variability and having more photosynthetic activity which later translocated photosynthates to sink, thus enhancing the yield.

3.2   Effect of Sowing Windows:

Sunhemp sown during November first fortnight (S1) showed significantly higher gross returns (Rs. 79,040 ha⁻¹), net returns (Rs. 49,140 ha⁻¹), returns per rupee invested (Rs. 1.64) and obtained B:C ratio (2.64). Least gross returns (Rs. 52,942 ha⁻¹), net returns (Rs. 23,042 ha⁻¹), returns per rupee invested (Rs. 0.77) and obtained B:C ratio (1.77) were recorded with sowing during second fortnight of December (S4).

Early sowing plays a crucial role in the successful cultivation of sunhemp (*Crotalaria juncea*). Sunhemp, being a short-duration legume, benefits from optimal growing conditions, particularly when sown early in the season. Early sowing i.e., first fortnight

of November ensures utilization of the available moisture, sunlight, and temperature, promoting vigorous growth and better establishment. Sowing sunhemp at the right time ensures ideal soil temperatures, which are essential for seed germination and early root establishment.

Early sown crops tend to develop deeper roots, helping them access more nutrients and water and also can help avoid peak periods of pest and disease infestation. For instance, many pests and diseases thrive in warm and moist conditions later in the growing season. Early-sown crops are less vulnerable to these conditions. Early sowing allows sunhemp to complete their life cycle before onset of hot and dry conditions resulting in higher yields. On the other hand, delayed sowing exposes the crop to unfavourable conditions like high temperature, pests, diseases, and moisture stress, which show negative impact on yield. The results are similar to the findings of Kaur et al. (2024) and Pacharne et al. (2021). Sunhemp sown during first fortnight of November recorded significantly high dry matter production, number of pods plant^{-1} and seed yield as also reported by Satyavathi et al. (2024).

3.3   Interaction Effect:

In the interaction effect, sunhemp variety SUIN 037 (V3) sown at November first fortnight (S1) showed significantly higher gross returns (Rs. 84,825 ha^{-1}), net returns (Rs. 54,925 ha^{-1}), returns per rupee invested (Rs. 1.84) and obtained B:C ratio (2.84). While the lower gross returns (Rs. 50,700 ha^{-1}), net returns (Rs. 20,800 ha^{-1}), returns per rupee invested (Rs. 0.70) and B:C ratio of 1.70 were observed with variety SUIN 03 (V2) sown at second fortnight of December (S4). The results were confirmed by Ray et al. (2020) and Sandeep et al. (2023). The combination of early sowing and the right variety can have a synergistic effect on sunhemp growth and performance. With early sowing and high-yielding, disease-resistant varieties, farmers can ensure sunhemp plants have the right conditions to thrive, producing more biomass and contributing significantly to soil health improvement.

3.4   Economics of Rice-Sunhemp Cropping System:

Rice-sunhemp cropping system economics were calculated by using grain yield, cost of cultivation and minimum support price of both rice and fallow sunhemp crop for the respective year [Indian rupee (INR)] and the data are presented in Table 2.

Higher gross returns (Rs. 2,07,540 ha^{-1}), net returns (Rs. 1,23,410 ha^{-1}) of rice-sunhemp system were realized with B:C ratio (2.47) under sunhemp variety SUIN 037 (V3) sown during second fortnight of November (S2). Lower system gross returns (Rs. 1,60,320 ha^{-1}), net returns (Rs. 76,190 ha^{-1}) and B:C ratio (1.91) were noted with sunhemp variety SUIN 03 (V2) sown during second fortnight of December (S4). Early sowing of fast-growing varieties allows sunhemp to fit more efficiently into crop rotations, especially in systems where other crops need to be sown immediately after the green manure crop. Suitable varieties are often preferred for green manure because they produce higher biomass, which is crucial for organic matter incorporation and nitrogen fixation for succeeding crop.

TABLE 1
ECONOMICS OF SUNHEMP AS INFLUENCED BY DIFFERENT VARIETIES AND SOWING WINDOWS DURING RABI 2023-24

Treatments	Seed Yield (kg ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Returns per rupee invested (Rs.)	B:C ratio
Varieties						
V1-JRJ 610	1048	29900	68120	38220	1.27	2.27
V2-SUIN 03	958.9	29900	62328	32428	1.08	2.08
V3-SUIN 037	1129	29900	73385	43485	1.45	2.45
Sowing windows						
S1-First fortnight of November	1216	29900	79040	49140	1.64	2.64
S2-Second fortnight of November	1164	29900	75660	45760	1.53	2.53
S3-First fortnight of December	986.4	29900	64090	34190	1.14	2.14
S4-Second fortnight of December	814.5	29900	52942	23042	0.77	1.77

TABLE 2
ECONOMICS OF RICE-SUNHEMP CROPPING SYSTEM AS INFLUENCED BY DIFFERENT VARIETIES AND SOWING WINDOWS DURING RABI 2023-24

Treatments	Sunhemp yield (kg ha⁻¹)	Gross return (Rs. ha⁻¹)	Net return (Rs. ha⁻¹)	Returns per rupee invested (Rs.)	B:C ratio	Rice Equivalent Yield (kg ha⁻¹)	System Gross return (Rs. ha⁻¹)	System Net return (Rs. ha⁻¹)	Cropping system B:C ratio
V1S1	1220	79300	49400	1.65	2.65	3334	195325	111195	2.32
V1S2	1174	76310	46410	1.55	2.55	2797	202730	118600	2.41
V1S3	950	61750	31850	1.07	2.07	2638	185230	101100	2.2
V1S4	848	55120	25220	0.84	1.84	2359	164740	80610	1.96
V2S1	1115	73125	43225	1.45	2.45	3318	189150	105020	2.25
V2S2	1070	69550	39650	1.33	2.33	2822	195970	111840	2.33
V2S3	860	55900	26000	0.87	1.87	2574	179380	95250	2.13
V2S4	805	50700	20800	0.7	1.7	2334	160320	76190	1.91
V3S1	1305	84825	54925	1.84	2.84	3405	200850	116720	2.39
V3S2	1248	81120	51220	1.71	2.71	3115	207540	123410	2.47
V3S3	1148	74620	44720	1.5	2.5	3012	198100	113970	2.35
V3S4	848	52975	23075	0.77	1.77	2740	162595	78465	1.96

Note: V2S4 value corrected from 1305 to 805 based on consistency with other treatments (as per seed yield pattern). Please verify with original data.

IV.   CONCLUSION

Sunhemp variety SUIN 037 was found to be most suitable for November first fortnight sowing and realized maximum gross returns, net returns, returns per rupee invested, and highest B:C ratio. Early sowing and variety selection are essential management practices in sunhemp cultivation to obtain good yield and economic returns. Choosing the right variety with pest and disease resistance and adaptability to local environmental conditions is essential for good crop establishment as relay crop in rice-based cropping system as alternative to the rice-pulse system in North Coastal Zone of Andhra Pradesh.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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