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Profitable Green Manure Crops for Rabi Fallows of Southern Telangana Zone

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ABSTRACT: A research trial conducted to assess the performance of selected legume green manure crops in terms of yield and economics during *rabi* at College of Agriculture, Rajendranagar indicated that the seed and stover yields were highest for cowpea (2128 kg ha^{-1}) and sunhemp (7522 kg ha^{-1}), respectively. The total cost incurred in the cultivation of green manure crops was expressed as cost of cultivation per hectare (₹ ha^{-1}). The price of inputs prevailing at the time of their use was taken into consideration to work out the cost of cultivation. The yields of the green manure crops were converted into the equivalent yield of cowpea based on the price of the produce. The cowpea equivalent yield of different green manure crops pointed out the superiority of cowpea in achieving higher yield (2128 kg ha^{-1}) during *rabi* and its advantage to be used as a seed cum green manure crop that was followed by sunhemp (1880 kg ha^{-1}). The gross returns and net returns of the green manure crops ranged from ₹ 15075-89376 ha^{-1} and ₹ 500–73889 ha^{-1}, respectively with the highest value for cowpea (Gross returns - ₹ 89376 ha^{-1}, Net returns - ₹ 73889 ha^{-1}). The returns per rupee invested was highest for cowpea (5.77) and the least for pillipesara (1.03).

Keywords: *Rabi*, green manure crops, seed yield, stover yield, economics.

INTRODUCTION

Green manures have become popular in the present day as a result of the growing issues in agriculture, such as climate change, extreme weather events, soil deterioration, and land contamination due to the overuse of agricultural chemicals. Growing green manure crops on farmland has shown to be a viable and cost-effective way to ensure the long-term productivity of cultivated areas by preparing the soil for succeeding harvests. The green manure crops are grown and incorporated into the soil in order to restore the land's productivity. Green manures are a gift from nature since they improve the physical, chemical, and biological qualities of the soil while also lowering the nitrogen fertilizer requirements for the following crop.

Unreliability of green manure performance, nonavailability of seeds, and labor intensive operations are the major agronomic constraints (Ramanjaneyulu *et al*., 2021). Socio-economic factors like the cost of land, labor, and mineral N fertilizer are seen to determine the cost-effectiveness and thereby farmers' adoption of sustainable green manure technology (Becker *et al*., 1995).

According to Mishra and Nayak (2004), dhaincha, sunhemp, mung bean and guar grown during *kharif* season as green manure crops contributed 8-21 tons of green matter and 42-95 kg of N ha^{-1}. Similarly, khesari, cowpea and berseem grown during *rabi* season contributed 12-29 tons of green matter and 67-68 kg N ha^{-1}. The green manure crops are generally selected based on the location specific edaphoclimatic conditions, rainfall pattern, irrigation facility and turn-around time (Thimmanna *et al*., 2014).

Further, short duration legume green manure crops can be explored to get some additional income through seed production and then incorporating the green manure crop residues after taking the harvest. This may ensure green manure seed availability for the next season sowing besides enriching the soil through residue incorporation. Seed yield of 4-5 q ha^{-1} under rainfed conditions and 12.5-15.0 q ha^{-1} under limited irrigation conditions (1-3 irrigations depending on soil, climate and crop) is possible (Ramanjaneyulu *et al*., 2021). Most of the green manure crops are fitted into rice-based cropping systems during pre-*kharif* system. In those regions where most of the times the fields are kept fallow following the *kharif* crop, *rabi* legume green manures can be grown to improve the soil quality along with providing seed as well as income. With this concept, the current research was designed to investigate the performance of legume green manure crops during *rabi* for their suitability in the Southern Telangana Zone.

MATERIAL AND METHODS

The research trial was conducted during *rabi*, 2020-21 at College farm, College of Agriculture, Rajendranagar, Hyderabad and was laid out in a randomized block design (RBD) and replicated thrice with seven green manure crops *viz*., green gram, black gram, horse gram, cowpea, sunhemp, dhaincha and pillipesara. The clay loam soil of the experimental site was alkaline in reaction with low organic matter and soil available nitrogen and high soil available phosphorous and potassium. All the crops were sown in the second fortnight of November. The mean maximum temperature varied from 26.4°C to 38.1°C and the mean minimum temperature varied from 11.1°C to 18.9°C during the period of crop growth. The relative humidity at morning (RHI) stretched from 75.3 to 95.7 per cent, where it was 22 to 60 per cent in the evening. The bright sunshine hours (BSH) fluctuated between 5.1 to 14.8 hrs. The wind velocity ranged from 2.5 to 4.7 kmph during the growing season. The pan evaporation ranged from 2.4 to 6.8 mm. Recommended dose of fertilizers and seed rate for respective green manure crops are mentioned in the Table 1. The objective of the research was to study the performance of the selected green manure crops in terms of their yield and economics. The data concerning to the yield attributes and yield was recorded at harvest. Plants that were randomly selected in the main plot at the first phase of recording the observations were used to record the yield attributes. The total cost incurred in the cultivation of green manure crops was expressed as cost of cultivation per hectare (₹ ha^{-1}). The price of inputs prevailing at the time of their use was taken into consideration to work out the cost of cultivation. The yields of the green manure crops were converted into the equivalent yield of cowpea based on the price of the produce.

Table 1: Seed rate (kg ha^{-1}) and RDF for the green manure crops.

Green manure crops	N-P_2O_5-K_2O (kg ha^{-1})	Seed rate (kg ha^{-1})
Green gram	20-40-0	30
Black Gram	25-50-0	20
Horse gram	25-40-20	25
Cowpea	25-40-20	25
Sunhemp	12.5–40-0	50
Dhaincha	0–30-0	50
Pillipesara	30-60-0	20

RESULTS AND DISCUSSION

A. Yield performance of green manures during rabi

Yield attributes. Yield attributes are the desirable traits of a crop that are directly related to the yield. The yield parameters of the green manure crops studied in the present investigation are - pods per plant, seeds per pod, and test weight and are presented in Table 2. The number of pods per plant were the highest for sunhemp (50) and the lowest for pillipesara (11) while the number of seeds per pod were the highest for dhaincha (17) and least for horse gram (5). The difference in seed sizes of the green manure crops was reflected in their 100 seed weights. Cowpea with bold seeds weighed 7.34 g per 100 seeds while due to the small seed size, the 100 seed weights of sunhemp, dhaincha, and pillipesara ranged from 1.57 to 1.86 g. The yield attributes reported by the green manure crops during *rabi* were pursuant to their inherent morphological and physiological traits; and their relative adaptability to low-temperature conditions.

Yield. Yield is one of the most important and complex traits in crops. It is both regulated by genes known as quantitative trait loci and influenced by external environmental factors (Wang *et al*., 2012; Zeng *et al*., 2017; Zhang *et al*., 2017). In general, yield in legume crops is determined by indirect traits like plant height, no. of branches, leaf area as well as direct traits like pods per plant, seeds per pod, and 1000-grain-weight (Moldenhauer and Nathan, 2004; Sakamoto and Matsuoka, 2008; Huang *et al*., 2013). The yield obtained by the green manure crops in the present study was an amalgamation of both direct and indirect traits as mentioned above. The cowpea in accordance with the higher pod number, seed size, and seed weight displayed highest grain yield of 2128 kg ha^{-1}. The sunhemp with a yield of 1579 kg ha^{-1} stood next best to cowpea. Conversely, the lowest yield among the green manure crops was reported by pillipesara (201 kg ha^{-1}). The yield obtained by all the green manure crops in the study is far less than their potential yields under favorable conditions. However, the yields of green manure crops presented in this study reflected their adaptability and suitability during *rabi*. The yield of short-statured legumes viz., green gram (483 kg ha^{-1}), black gram (389 kg ha^{-1}), horse gram (305 kg ha^{-1}), and pillipesara (201 kg ha^{-1}) remained very low during *rabi* owing to their poor growth with lesser plant heights, leaf area, and dry matter production.

Stalk yield. Reportedly the stalk yield of the green manure crops varied significantly during *rabi* and is presented in Table 2. The stalk yield of the green manure crops ranged from 670 kg ha^{-1} to 7522 kg ha^{-1}. The best among the green manure crops with the highest stalk yield was sunhemp (7522 kg ha^{-1}). Cowpea stood next best to sunhemp with a stalk yield of 4990 kg ha^{-1}. Apparently, taller stalks with higher biomass might have resulted in exceedingly higher stalk yields of these crops (sunhemp and cowpea) compared to the others The lowest stalk yield, on the other hand, was represented by pillipesara (670 kg ha^{-1}).

Harvest index. Globally, the harvest index of grain legumes is variable, while in cereals, it is generally considered to be relatively stable (McKenzie, 1987).

Legumes may have more variable harvest indexes than cereals for a number of reasons. Wet and dry seasons (Hernandez, 1986), N application, sowing date, shade, irrigation (Verghis, 1996; Anwar *et al*., 1999), and lodging (McKenzie *et al*., 1985) may all be reasons for harvest index variability. The harvest index of the green manure crops in the study ranged from as low as 17.4 in sunhemp to 34.1 in green gram. Cowpea with a harvest index of 29.9 followed green gram. More biomass can give increased pod bearing structures, and result in more seed yield and a high harvest index (Ayaz, 2001). However, the results from the present study indicated poor translocation of photosynthates to achieve higher yields and therefore, lower harvest index values. This can be confirmed from the yields of green manure crops in this study which are exceptionally lower than their potential yields. The extended period of vegetative growth causing a period of ineffective flowering in the cool winter environment might have reduced the harvest index in sunhemp (Saxena, 1984).

Cowpea equivalent yield of green manure crops. The yield comparison of the green manure crops in the study was done by converting the yields of individual green manure crops to the cowpea equivalent yields (Table 2). The cowpea equivalent yield of different green manure crops indicated the superiority of cowpea in achieving higher yield (2128 kg ha^{-1}) during *rabi* and its advantage to be used as a grain cum green manure crop. This was followed by sunhemp (1880 kg ha^{-1}). The lowest cowpea equivalent yield on the other side was noted with pillipesara (359 kg ha^{-1}).

Table 2: Yield attributes and yield of different green manure crops during *rabi*, 2020-21.

Treatment	Pods plant^{-1}	Seeds pod^{-1}	Grain yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest Index (%)	Test weight (g)	Cowpea equivalent yield of green manure crops (kg ha^{-1})
M_1: Green gram	12	11	483	934	34.1	2.12	828
M_2: Black gram	13	6	389	917	29.8	2.63	556
M_3: Horse gram	18	5	305	992	23.5	2.01	436
M_4: Cowpea	15	10	2128	4990	29.9	7.34	2128
M_5: Sunhemp	50	10	1579	7522	17.4	1.86	1880
M_6: Dhaincha	15	17	716	2775	20.5	1.68	989
M_7: Pillipesara	11	9	201	670	23.0	1.57	359
SEm±	-	-	-	-	-	-	**22.3**
CD (P=0.05)	-	-	-	-	-	-	**68.7**

Economics. Economic profitability is the prime force that drives any scientific technology from research field to the actual area of concern i.e., farmers' field. Hence, the scientific practice that is ecologically promising and economically appealing would be sustainable in long-run (Sudhanshu Sudhakar, 2013).

Cost of Cultivation. The cost of cultivation of green manure crops did not vary much (Table 3). It ranged from ₹ 14237 and ₹ 15487 ha^{-1}. The cost of cultivation incurred was maximum with cowpea (₹ 15487 ha^{-1}). While sunhemp with cost of cultivation of ₹ 14925 ha^{-1} followed cowpea. The difference in cost of cultivation of green manure crops was majorly due to the cost incurred on seed rate, which varied with the seed size of the crops. The different fertilization schedules for these crops also caused changes in the cost of cultivation of the green manure crops.

Gross returns. The differences in the grain and stalk yields of the green manure crops had brought about significant variation in the gross returns. The gross returns obtained by the cultivation of green manure crops were presented in Table 3. The gross returns of the green manure crops ranged from ₹ 15075 ha^{-1} to ₹ 89376 ha^{-1}. The highest returns of ₹89376 ha^{-1} were reported by cowpea, while the lowest (₹ 15075 ha^{-1}) was given by pillipesara. The sunhemp with gross returns of ₹78950 ha^{-1} stood next best to cowpea. Though the unit price of cowpea is the least (₹42 kg^{-1}) among the green manure crops, the overall better growth of the crop has resulted in higher grain yield which in turn fetched maximum returns. A comparably higher yield of sunhemp due to equivalent performance as that of cowpea has realized higher gross returns next to cowpea. However, the difference between cowpea and sunhemp remained significant. On the other side, in spite of the higher unit cost of the crops - black gram, horse gram, green gram, and pillipesara ranging from ₹ 60 to 75 ha^{-1}, the gross returns of these crops were low and have ranged from ₹ 15075 ha^{-1} to ₹34776 ha^{-1} due to their lowest yields as observed in Table 2 of this article.

Net returns. Owing to significant differences in the gross returns, the net returns from the green manure crops also varied significantly. The data on the net returns of green manure crops were presented in the Table 3.

The net returns of the green manure crops ranged from ₹ 500 ha^{-1} to ₹ 73889 ha^{-1}. Cowpea fetched the highest net return (₹73889 ha^{-1}), while pillipesara fetched the lowest (₹ 500 ha^{-1}). Maximum gross returns even at a higher cost of cultivation have resulted in higher net returns in cowpea (₹ 73889 ha^{-1}) and sun hemp (₹ 64025 ha^{-1}) compared to the other crops. However, the cowpea and sunhemp remained significantly different with cowpea getting higher net returns than sunhemp.

Returns per rupee investment. The returns per rupee investment also were significantly different among the green manure crops during *rabi*. The data on returns per rupee investment were given in Table 3.

The returns obtained per rupee invested due to green manure crops ranged from ₹1.03 to 5.77. A maximum return of ₹ 5.77 per rupee invested was obtained from cowpea, while the minimum of ₹ 1.03 per rupee invested was obtained from pillipesara. The sunhemp with ₹ 5.30 benefit per rupee invested proved to be the next best to cowpea. Exceedingly higher growth of cowpea and sunhemp during *rabi* than the other green manure crops might have incurred more profit per rupee invested. However, the difference between cowpea and sunhemp was significant with cowpea giving higher benefit per rupee invested than the sunhemp.

Table 3: Cost-return analysis of different green manure crops during *rabi*, 2020-21.

Treatment	Cost of cultivation (₹ ha^{-1})	Cost of output (₹) per kg	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Returns per rupee investment
M_1: Green gram	14283	72	34776	20493	2.43
M_2: Black gram	14586	60	23340	8754	1.60
M_3: Horse gram	14237	60	18300	4063	1.29
M_4: Cowpea	15487	42	89376	73886	5.77
M_5: Sunhemp	14925	50	78950	64025	5.30
M_6: Dhaincha	14275	58	41528	27253	2.90
M_7: Pillipesara	14575	75	15075	500	1.03
SEm±	-	-	**939**	**937**	**0.1**
CD (P=0.05)	-	-	**2886**	**2887**	**0.2**

CONCLUSION

From the above results on yield and economics of the green manure crops during *rabi*, it can be inferred that cowpea and sunhemp are the most suitable crops for *rabi* cultivation in Southern Telangana Zone. Among them, cowpea is most dependable with higher grain, and stalk yields than the other crops. Sunhemp can be used as an alternative to cowpea in those regions where cowpea cultivation is not feasible during *rabi*. The remaining crops owing to their poor plant performance in terms of growth, yield, and hence returns are least dependable during *rabi*.

FUTURE SCOPE

Green manuring is widely regarded as one of the most effective methods of soil improvement in India. Much depends on using the right technique, and thus, while research should be expanded to answer several unanswered questions, the ultimate success or failure of green manuring will be determined by the farmer. The expansion of green manuring will have to be incorporated as an important item into the activities of the newly organised advisory services of the Government. Since green manuring is cost effective, eco-friendly, enriches soil, and enhances plant growth and yield apart from improvements in soil organic matter content and microbial population, it will pave a possible way to achieve sustainability in agriculture which is an urgent need of the hour. Furthermore, research is needed to determine the role of green manuring in N fertiliser savings in rainfed and irrigated dry crops, as well as to explore low-cost non-chemical pest and disease management approaches in green manure crops.

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Conflict of Interest. The author(s) declare(s) that there is no conflict of interest.

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