LR-5457
[1-7]

RESEARCH ARTICLE

Legume Research- An International Journal

Residual Effect of Different Establishment Methods and Organic Manures Imposed on Rice on Growth, Yield, Nutrient Uptake and Economics of Succeeding Green Gram

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10.18805/LR-5457

ABSTRACT

Background: Cereal-cereal cropping sequence is one of the major crop sequences followed on the same land over the years that has led to decreased soil fertility and increased concern for sustainability. It significantly causes the depletion of available soil nutrients leading to decreased crop productivity. Therefore, it is vital to make efforts to include leguminous crops after rice for maintaining soil fertility and sustainability. Mungbean (*Vigna radiata* L.) is an option that can be included in different rice-based cropping systems for enhancing soil productivity.

Methods: The experiment was conducted over two consecutive seasons, 2021-22 and 2022-23 on clay loam soils at S.V. Agricultural College, Tirupati campus of Acharya N G Ranga Agricultural University, Andhra Pradesh. The test varieties used in the present field experiment were NLR-34449 for rice and LGG-460 for green gram. The rice experiment included three establishment methods as main plot treatments and seven organic nutrient management as sub-plot treatments. Following the rice cultivation, green gram was sown to assess the residual effects of the treatments.

Result: The results revealed that the growth and yield parameters as well as economics of green gram were significantly higher in dry direct seeded rice compared to transplanted and wet seeded rice. Among different organic manures, application of 100% recommended dose of nitrogen (RDN) through poultry manure (PM) to rice resulted in significantly higher growth and yield parameters of green gram followed by application of 50 % RDN through FYM + 50% RDN through PM. The interaction effect between different establishment methods and organic manures could not exert any significant influence on any of the parameters studied in the present investigation.

Key words: Dry direct seeded rice, Farmyard manure, Mungbean, Poultry manure, Sustainability.

INTRODUCTION

Continuous use of inorganic fertilizers deteriorates the chemical, physical and biological properties of soil, ultimately affecting soil health. The negative impacts of chemical fertilizers, combined with their rising costs, have increased interest in organic manures. Organic farming relies on natural biodiversity and locally adapted methods for sustainable crop production. Organic sources such as farmyard manure, vermicompost, poultry manure, green manure, neem cake and biofertilizers play a crucial role in nutrient supply, maintaining soil health and achieving good crop yields with optimal input levels. In regions with continuous rice cropping, often with two to three crops per year, the demand for nitrogen fertilizers is high, but yields tend to stagnate. The judicious use of organic sources like FYM, vermicompost, poultry manure and green manure can enhance crop yields in such areas. Organic fertilizers improve nutrient use efficiency, soil biological health and soil quality. They help conserve soil health by maintaining a balance between soil microflora and organic matter, which enhances soil properties. They also aid in enhancing soil structure, aeration and water retention capacity (Rambuatsaiha *et al.*, 2017).

The application of organic manures regulates soil microbial biomass, aids in the mineralization of soil organic carbon and increases nitrogen availability to crops. Organic manures release various native nutrients, reduce soil salinity and promote soil microbial activity, as soil salinity is influenced by microbial communities and their activity (Mitran *et al.*, 2017). For sustainable crop production, a balanced use of mineral nutrients, organic and biological sources is essential.

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How to cite this article: Vineela, K., Subramanyam, D., Sagar, G.K., Sudhakar, P. and Madhuri, K.V.N. (2025). Residual Effect of Different Establishment Methods and Organic Manures Imposed on Rice on Growth, Yield, Nutrient Uptake and Economics of Succeeding Green Gram. Legume Research. 1-7. doi: 10.18805/LR-5457.

Submitted: 09-12-2024 **Accepted:** 05-06-2025 **Online:** 04-07-2025

The residual effects of organic manures can benefit subsequent crops, lasting up to the third crop sequence.

In India, farmers practice various rice cultivation systems, including transplanting, wet direct-seeded rice and dry direct-seeded rice etc. The traditional method of transplanting of rice in puddled soil is labour-intensive and requires significant water for nursery raising and field preparation. To enhance the crop and water productivity, alternative establishment methods should be promoted (Farooq *et al.*, 2009). Dry direct-seeded rice (D-DSR) is a viable alternative that does not involve puddling the soil. This method is simpler as it eliminates the need for nursery raising, conserves water, reduces production costs and maintains good soil physical conditions. Using a drum seeder for sowing wet sprouted seeds on puddled soil in wet DSR is another effective practice to avoid nursery raising and transplanting.

Pulses play a significant role to recharge soil fertility, hold a unique position in cropping systems, especially in dryland agriculture (Mitra and Mandal, 2012). Rotating leguminous crops after cereals not only fixes nitrogen but also enhances the nutrient availability, reduces disease incidence, improves soil structure and promotes mycorrhiza populations (Singh *et al.*, 2011). Mungbean (*Vigna radiata* L.) is a viable option for inclusion in various rice-based cropping systems to enhance soil productivity. It can withstand environmental stresses such as drought and low soil fertility, in addition to contributing biological nitrogen fixation (Bourgault *et al.*, 2010). Inclusion of a legume into the crop sequence not only supplies substantial biomass but also adds nitrogen to the soil and thereby improving soil fertility and productivity on a sustainable basis. Keeping the above points in view, this experiment aimed to evaluate different establishment methods and organic manures, along with their residual effect in rice on subsequent green gram crop in the Southern Agro-climatic Zone of Andhra Pradesh.

MATERIALS AND METHODS

A field experiment was conducted during the *kharif* and *rabi* seasons of 2021-22 and 2022-23 at the S.V. Agricultural College Farm, Tirupati. The soil at the experimental site was sandy clay loam with a bulk density of 1.43 g cc^{-1}, a pH of 7.85 and an EC of 0.44 dS m^{-1}. It was low in organic carbon (0.38%) and available nitrogen (187 kg ha^{-1}), medium in available phosphorus (25.5 kg ha^{-1}) and potassium (218 kg ha^{-1}). The rice variety NLR-34449 and the green gram variety LGG-460 were used as test crops. The field experiments were planned in a split-plot design with systems of rice cultivation as the main plots and organic nitrogen management practices as sub-plots, with three replications. The main plots consisted of three different rice cultivation systems: Normal Transplanted Rice (N-TPR), Wet Direct Seeded Rice (W-DSR) and Dry Direct Seeded Rice (D-DSR). The sub-plots included seven organic nitrogen management treatments: 100% recommended dose of nitrogen (RDN) through farmyard manure (FYM), 100% RDN through vermicompost (VC), 100% RDN through poultry manure (PM), 50% RDN through FYM + 50% RDN through VC, 50% RDN through FYM + 50% RDN through PM, 50% RDN through VC + 50% RDN through PM and 100% RDN through inorganic fertilizers. The recommended Dose of Fertilizers (RDF) for rice in the Southern Agro-Climatic Zone of Andhra Pradesh was 120:60:40 NPK ha^{-1}.

Healthy grains of the test varieties were selected. The recommended seed rate for N-TPR (75 kg ha^{-1}), W-DSR (37.5 kg ha^{-1}) and D-DSR (37.5 kg ha^{-1}) was used for direct sowing or nursery raising on the same day. Twenty-four-day-old seedlings were manually transplanted into a well-puddled field for N-TPR. In W-DSR, seeds were soaked in water for 24 hours, wrapped in jute gunny bags and kept in the dark for another 24 hours to induce sprouting. These sprouted seeds were sown at a spacing of 20 $\times$ 10 cm using a drum seeder. In D-DSR, the recommended seed rate was sown manually at a spacing of 20 $\times$ 10 cm.

The recommended dose of nitrogen through organic sources *viz.*, farmyard manure, vermicompost and poultry manure were applied as per the treatments on N-equivalent basis 15 days before the sowing/transplanting. Nutrient and moisture content (%) was presented in the Table 1 and 2. The recommended dose of 120-60-40 kg of N, P_2O_5 and K_2O ha^{-1} were applied in inorganic treatment in the form of urea, single super phosphate and muriate of potash, respectively during both the years of investigation. Recommended dose of N was divided into three splits, 1/3rd as basal, 1/3rd at panicle initiation and 1/3rd at the time of flowering whereas entire phosphorous and potassium were applied as basal at the time of last puddling.

Irrigation was given as per package of practices developed by Acharya N.G. Ranga Agricultural University to the N-TPR. In W-DSR, from sowing to booting stage the field was maintained under wet condition, but not the land submergence. The excess water was drained through drainage channels for active growth of roots. One pre-sowing irrigation for better establishment followed by irrigation at weekly intervals up to physiological maturity were given to the D-DSR, whenever the crop requires.

After harvesting the rice, green gram was sown with the

Table 1: Nutrient content (%) in organic manures.

	2021			2022		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
FYM	0.61	0.22	0.57	0.59	0.24	0.63
VC	1.9	0.65	1.12	1.88	0.67	1.21
PM	2.25	1.26	1.05	2.24	1.28	1.10

Table 2: Moisture content (%).

	2021	2022
FYM	59.4%,	60.1%
VC	42.5%.	41.3%
PM	66.4%,	65.2%

help of manual labour in the undisturbed layout to study the residual effects of different rice cultivation systems and organic manures. The recommended seed rate for green gram (25 kg ha^{-1}) was used for sowing at a spacing of 30 × 10 cm. The data pertaining to green gram is furnished below.

RESULTS AND DISCUSSION

Among the different systems of cultivation practiced in rice, growth parameters of succeeding green gram *viz.*, plant height, leaf area index and dry matter production were significantly higher with D-DSR (M_3) followed by N-TPR (M_1) and W-DSR (M_2) and the latter two treatments were comparable with each other during both years of study as well as in pooled mean. In D-DSR (M_3) plots, optimum supply of oxygen to root zone creates favourable environment for root growth and development of green gram that favoured faster cell division and elongation which have ultimately resulted in increased growth attributes of green gram. These results are in conformity with the findings of Vijaykumar (2009) and Rekha *et al.* (2015). Puddling condition in N-TPR and W-DSR created unfavourable conditions resulting in poor growth and development of green gram because of increased soil strength and reduced pore space lead to reduced growth attributes of green gram. These findings are in line with Samant *et al.* (2021).

Among different nutrient management practices imposed to preceding rice, growth parameters of succeeding green gram were significantly higher with the application of 100% RDN through PM which was significantly higher than the rest of the nutrient management practices. This might be due to the slow decomposition of organic manures especially with poultry manure that led to steady nitrogen release to meet the requirement of crops at critical stages. Enhanced drymatter accumulation with organic manures were also reported by Kumar *et al.* (2020). Even after the completion of growing period, mineralization of nitrogen could be continued to the soil pool (Bouldin *et al.*, 1988). This might have helped in maintaining the soil available nitrogen, inspite of depletion by the crops which increased the growth parameters of green gram. Similar observations have been earlier made by Amanullah *et al.* (2007).

The lowest values of growth parameters of green gram were recorded with the application of 100% RDN through VC. The data pertaining to growth attributes of green gram was presented in (Table 3). Yield attributes of green gram (Table 4) *viz.*, number of pods $plant^{-1}$, number of seeds pod^{-1} and test weight were significantly higher with D-DSR followed by N-TPR and W-DSR. The latter two were comparable with each other during both years of study as well as in pooled mean. This might be due to reduced soil compaction and increased soil aeration in D-DSR plots that leads to better root growth, increased uptake of nutrients,

Table 3: Plant height (cm), leaf area index and dry matter production (kg ha^{-1}) of green gram at harvest as influenced by different systems of cultivation and organic nutrient management practices imposed to preceding rice.

Treatments	Plant height			Leaf area index			Dry matter production		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot: Systems of cultivation (3)									
M_1: N-TPR	13.4	12.8	13.1	1.45	1.40	1.42	1898	1675	1787
M_2: W-DSR	13.1	12.4	12.7	1.41	1.35	1.38	1875	1658	1767
M_3: D-DSR	14.5	14.0	14.2	1.61	1.56	1.59	2070	1864	1967
SEm±	0.27	0.28	0.25	0.034	0.028	0.027	39.0	40.0	37.0
CD (P=0.05)	1.0	1.1	1.0	0.13	0.11	0.11	153	157	145
Sub plot: Organic nitrogen management practices (7)									
S_1 : 100% N-FYM	14.2	13.5	13.8	1.53	1.48	1.51	1982	1770	1876
S_2 : 100% N-VC	11.2	10.7	10.9	1.31	1.26	1.29	1799	1569	1684
S_3 : 100% N-PM	16.8	16.3	16.5	1.78	1.73	1.76	2160	1974	2067
S_4 : 50% N-FYM + 50% N-VC	11.7	10.9	11.3	1.32	1.28	1.30	1822	1590	1706
S_5 : 50% N-FYM + 50% N-PM	15.1	14.6	14.8	1.58	1.53	1.56	2028	1825	1927
S_6 : 50% N-VC + 50% N-PM	14.5	13.9	14.2	1.56	1.50	1.53	1996	1794	1895
S_7 : 100% N-RDF	12.0	11.5	11.8	1.34	1.30	1.32	1849	1604	1727
SEm±	0.29	0.39	0.33	0.037	0.027	0.021	45.3	50.2	36.3
CD (P=0.05)	0.9	1.2	1.0	0.11	0.08	0.06	130	144	104
Interaction									
M at S									
SEm±	0.54	0.58	0.52	0.068	0.052	0.043	82.5	89.9	69.0
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
S at M									
SEm±	0.50	0.55	0.49	0.064	0.047	0.036	78.5	86.9	62.9
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

enhanced translocation of assimilates from source to sink leading to increased yield attributes in green gram. Similar results were also reported by Sonboir *et al.* (2020). N-TPR and W-DSR plots registered lower values of yield attributes of succeeding green gram as a result of unfavourable conditions for growth and development because of destruction of soil structure.

Among different nutrient management practices imposed to preceding rice, yield attributes of succeeding green gram were significantly higher with the application of 100% RDN through PM. This might be attributed due to the efficient utilization of mineralized nutrients from organic manures that has increased the availability of nutrients throughout the growth of green gram, which inturn increased the yield attributes of green gram. Similar increase in yield attributes of residual green gram due to application of poultry manure to previous crop has been documented by Gedam *et al.* (2008). The lowest values of yield attributes were registered with the application of 100% RDN through VC.

Significantly higher seed and haulm yield (Fig 1) of succeeding green gram was obtained with D-DSR followed by N-TPR and W-DSR. A yield reduction of 8.56% was realised in green gram sown in N-TPR plots compared to D-DSR plots. Higher seed yield of green gram in D-DSR imposed plots is the result of higher growth and yield attributing characters which might be due to better soil structure that promoted better crop growth. In pudding, soil aggregates are destroyed, capillary pores are blocked thus creates poor soil physical condition which is detrimental to the succeeding green gram. Similar results were also reported by Jyothi *et al.* (2020). Better aeration and lower bulk density with D-DSR increased leaf area index and dry matter production in non-puddled soils might be a reason for higher haulm yield of green gram compared to puddled soils. Similar results were also reported by Subramanyam *et al.* (2008) in rice-green gram cropping system.

Among different nutrient management practices imposed to preceding rice, higher seed as well as haulm yield of succeeding green gram was recorded with application of 100% RDN through PM. Application of 100% RDN through VC to rice crop resulted in lower seed and haulm yield of residual green gram during both years of study as well as in pooled mean. Organic manures have not been fully utilized by the rice crop in first crop season and notably benefitted the succeeding green gram crop for enhancing its biomass production. The efficient utilization of mineralized nutrients from the poultry manure might have increased the availability of nutrients to green gram and thereby increased the haulm yield and seed yield of residual green gram. Similar findings of enhancing the haulm yield and seed yield due to the residual effect of organics was also reported by Subramani *et al.* (2008).

Among different systems of cultivation practiced in rice, nutrient uptake (Table 5) of green gram *viz*., nitrogen,

Table 4: Yield components of green gram as influenced by different systems of cultivation and organic nutrient management practices imposed to preceding rice.

Treatments	Number of pods plant^{-1}			Number of seeds pod^{-1}			Test weight (g)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot: Systems of cultivation (3)									
M_1 : N-TPR	10.62	10.27	10.45	8.48	8.07	8.27	29.2	28.9	29.0
M_2 : W-DSR	10.48	10.09	10.28	8.21	7.74	7.97	27.8	27.3	27.6
M_3 : D-DSR	11.64	11.35	11.50	9.20	8.77	8.98	33.3	32.8	33.0
SEm±	0.219	0.245	0.195	0.180	0.149	0.139	0.884	0.674	0.683
CD (P=0.05)	0.86	0.96	0.76	0.7	0.58	0.54	3.46	2.64	2.68
Sub plot: Organic nitrogen management practices (7)									
S^1 : 100% N-FYM	11.09	10.82	10.96	8.79	8.35	8.57	30.6	30.2	30.4
S_2 : 100% N-VC	9.85	9.39	9.62	7.94	7.50	7.72	27.0	26.5	26.7
S_3 : 100% N-PM	12.45	11.99	12.22	9.73	9.29	9.51	34.1	33.6	33.9
S_4 : 50% N-FYM + 50% N-VC	10.01	9.55	9.78	7.99	7.55	7.77	27.9	27.5	27.7
S_5 : 50% N-FYM + 50% N-PM	11.54	11.34	11.44	9.01	8.57	8.79	31.8	31.3	31.6
S_6 : 50% N-VC + 50% N-PM	11.25	10.99	11.12	8.86	8.43	8.65	31.1	30.7	30.9
S_7 : 100% N-RDF	10.19	9.92	10.06	8.07	7.63	7.85	28.2	27.8	28.0
SEm±	0.290	0.217	0.255	0.245	0.231	0.176	0.744	0.740	0.561
CD (P=0.05)	0.83	0.62	0.73	0.70	0.66	0.51	2.14	2.12	1.61
Interaction									
M at S									
SEm±	0.514	0.426	0.453	0.433	0.400	0.315	1.48	1.364	1.130
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
S at M									
SEm±	0.502	0.377	0.442	0.425	0.401	0.305	1.29	1.281	0.973
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

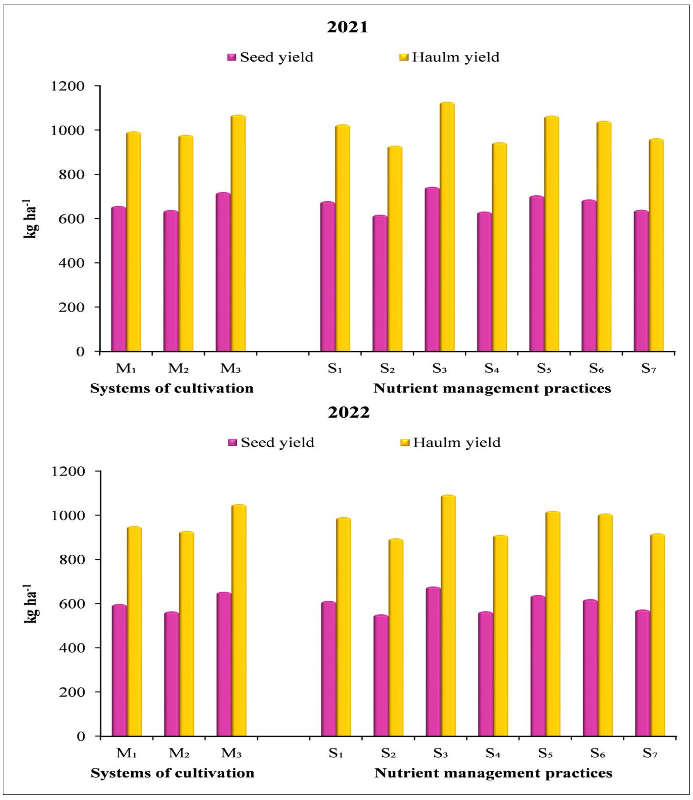

Fig 1: Seed yield and haulm yield (kg ha^{-1}) of green gram as influenced by different systems of cultivation and organic nutrient management practices imposed to preceding rice.

Table 5: Nutrient uptake (kg ha^{-1}) of green gram as influenced by different systems of cultivation and organic nutrient management practices imposed to preceding rice.

Treatments	Nitrogen			Phosphorous			Potassium		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot: Systems of cultivation (3)									
M_1 : N-TPR	44.6	40.7	42.7	10.77	10.45	10.61	47.2	43.5	45.3
M_2 : W-DSR	44.0	39.3	41.6	10.48	10.11	10.30	46.8	42.8	44.8
M_3 : D-DSR	49.3	44.4	46.9	11.91	11.50	11.71	52.0	47.6	49.8
SEm±	1.08	0.88	0.75	0.201	0.226	0.259	1.0	0.92	0.86
CD (P=0.05)	4.2	3.4	7.9	0.79	0.89	1.02	3.9	3.6	3.4
Sub plot: Organic nitrogen management practices (7)									
S_1 : 100% N-FYM	46.9	42.4	44.6	11.23	10.87	11.05	49.4	45.3	47.4
S_2 : 100% N-VC	41.7	37.2	39.4	9.89	9.53	9.71	44.4	40.8	42.6
S_3 : 100% N-PM	51.7	47.2	49.4	12.62	12.26	12.44	54.1	50.0	52.1
S_4 : 50% N-FYM + 50% N-VC	42.5	38.0	40.2	10.19	9.83	10.01	45.1	41.1	43.1
S_5 : 50% N-FYM + 50% N-PM	48.3	43.8	46.1	11.64	11.27	11.46	50.7	46.6	48.6
S_6 : 50% N-VC + 50% N-PM	47.5	43.0	45.3	11.34	10.98	11.16	50.1	45.9	47.9
S_7 : 100% N-RDF	43.3	38.8	41.0	10.46	10.09	10.27	46.8	42.7	44.7
SEm±	1.17	0.87	0.81	0.235	0.250	0.236	0.98	0.70	1.14
CD (P=0.05)	3.3	6.3	2.3	0.67	0.72	0.68	2.8	2.0	3.3
M at S									
SEm±	2.16	1.65	1.50	0.427	0.460	0.458	1.87	1.45	2.02
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
S at M									
SEm±	2.02	1.51	1.40	0.407	0.433	0.408	1.70	1.21	1.97
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

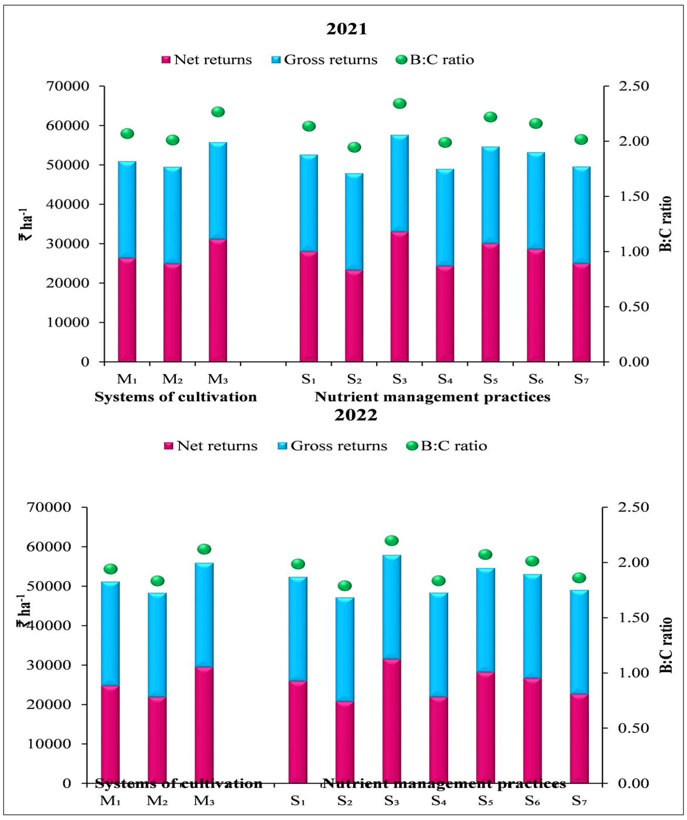

Fig 2: Economics of green gram as influenced by different systems of cultivation and organic nutrient management practices imposed to preceding rice.

phosphorus and potassium were significantly higher with D-DSR. N-TPR and W-DSR were next best systems of rice cultivation which were at par with each other. This might be due to lesser nutrient uptake in puddled situation because of considerable wastage of water and plant nutrients through deep percolation and leaching losses below the root zone and set a chain of undesirable hazards such as poor soil aeration, water logging and imbalanced nutrient supply. In case of aerobic situation, nutrient uptake in succeeding crop is more due to better root activity as indicated by increased root volume and root weight under D-DSR conditions. Similar observations were also recorded with Pushpa *et al.* (2014).

The highest nutrient uptake of succeeding green gram was noticed with the application of 100% RDN through PM which was significantly higher than rest of the nutrient management practices. The positive carry over effect of organic sources probably owed to the decomposition and release of nutrients for a long time leading to increased nutrient supply as reported by Raju *et al.* (1993). Application of 100% RDN through VC resulted in the lowest uptake of nutrients by green gram.

Significantly higher gross and net returns as well as benefit-cost ratio (Fig 2) of green gram were recorded with D-DSR system of cultivation which was followed by N-TPR and W-DSR with significant disparity during both years of study as well as in pooled mean. This could be due to improvement in yield attributes *viz.*, number of pods plant^{-1}, number of seeds pod^{-1} and test weight which helped to increase the seed yield of green gram that inturn increased the gross and net returns as well as benefit-cost ratio of succeeding green gram. Similar results are supported by Rao *et al.* (2016) and Jyothi *et al.* (2020).

Across different nutrient management practices imposed to rice, application of 100% RDN through PM recorded significantly higher gross and net returns as well as benefit-cost ratio of succeeding green gram. This might be due to slow and steady release of nutrients from organic manures especially from poultry manure that increased the yield attributes and seed yield of green gram. These results are in conformity with the findings of Rao *et al.* (2022). Significantly lower gross and net returns as well as benefit-cost ratio of succeeding green gram were realised with the application of 100 % RDN through VC which was comparable with 50% RDN through FYM + 50% RDN through VC and 100% RDN through inorganic fertilizers applied to preceding rice during both years of study as well as in pooled mean.

CONCLUSION

Overall, the present investigation revealed that the highest values of growth parameters, yield parameters, yield, benefit-cost ratio and nutrient uptake of succeeding green gram were obtained with D-DSR sown plots and application of

100% RDN through PM to preceding rice crop on sandy clay loam soils of Southern Agro-climatic Zone of Andhra Pradesh.

ACKNOWLEDGEMENT

As a part of Ph.D. research programme, the entire work was supported by Acharya N G Ranga Agriculture University, Lam, Guntur, Andhra Pradesh, India.

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Conflict of interest

The all authors declared that they have no conflict of interest.

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