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RESEARCH ARTICLE

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Nutrient Uptake and Economics of Summer Greengram as Influenced by Residual Effect of Paddy Residues and Fertility Levels

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ABSTRACT

Background: One of the main reasons for India's decreased food production is the depletion of soil fertility. The primary causes of soil deterioration are lack of awareness among farmers and lack of land use regulations. By limiting the erosion and enhancing the nutrients available to the crops, conservation agriculture increases the organic matter content of the soil and contributes to the improvement of field conditions. But compared to conventional agriculture, the practise of conservation agriculture is less advanced. And also there is a dearth of research on the use of crop residues for the management of soil fertility. So this study was undertaken in order to examine the impacts of crop residue, inorganic fertilizers and cropping system as a component of an integrated crop residues and fertility management system on nutrient uptake and net returns of greengram.

Methods: The experiment consists of strip plot design and was carried out during 2020-21 and 2021-22 under zero till conditions at college farm, Rajendranagar, PJTSAU to study the effect of previous crop residues and fertility levels on succeeding greengram.

Result: According to the data, greengram absorbed more nutrients at various growing stages. The residual effect of incorporation of residues treated with microbial consortia composed of *Trichoderma viridae, Aspergillus awamori and Phanerocheate* spp. along with 300:100:100 kg ha^{-1} of N, P_2O_5 and K_2O (125% RDF) and phosphorous supplied in the form of single super phosphate (SSP) resulted in significantly higher financial returns. In greengram, residue incorporated plots outperformed residue burning, removal and retention plots with 125% RDF in terms of nutrient uptake, as well as monetary returns like gross returns, net returns and B:C ratio. In a similar vein, yield in residue-incorporated plots was higher than it was in residue-removal and *in-situ* burning plots during summer, 2021 and 2022.

Key words: Crop residues, Economics, Greengram, Nutrient uptake, Yield.

INTRODUCTION

The main obstacles preventing the current crop generation's genetic potential from being fully realized are the low and falling productivity of many tropical soils. It is vital to take the necessary steps to stop this decline in soil productivity because if it is not stopped, it will have major consequences for future food demands of an expanding human population. The use of inorganic fertilizers for crop productivity has been constrained by their scarcity and high price (Tanimu *et al.*, 2007). As a consequence, farmer uses the available organic sources. Several nations use the crop wastes that are produced as a result of agricultural activity in various ways. Depending on the final usage, they are used treated or unprocessed. In Indo-gangetic plains (IGP), farmers burn crop residue in open field that leads to not only emission of harmful gases and air pollutants into the atmosphere (Raghavendra *et al.,* 2020), but also causes loss of nutrients. To minimize this problem, recycling of nutrients (Nitrogen, phosphorous and potassium) through crop residue retention is one of the desired options that may lead to effective disposal and help overcome the deficiencies of other nutrients, such as sulphur, zinc and boron deficiencies, which are widespread in the IGP region (Prasad, 2005). In an organic rice-wheat farming system, the potential for plant nutrition in rice and wheat straw is substantial. According to Sharma and Sharma (2004), these crops remove between 35% and 40% of the nitrogen, 10% to 15% of the phosphorous and 80% to 90% of the potassium from the system through the straw. Thus, using straw leads to the recycling of a significant proportion of plant nutrients.

Additionally, fields are kept fallow for 70 to 80 days in the summer following the harvest of the winter crops. In

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these situations, including a legume in crop rotations can be crucial for preserving soil fertility and crop productivity. Legumes are a valuable source of organic nitrogen due to their ability to fix atmospheric nitrogen, their nodulated roots and plant residues left after harvest. Conventional tillage delays the sowing of summer greengram by 7-10 days due to intensive tillage practices followed by farmers for optimum seed bed preparation (Chouhan *et al.,* 2005). Consequently, under such condition resource conserving technologies (RCTs) like zero tillage have emerged over the past 2-3 decades as a means of achieving the optimum yields in intensive cropping systems (Sharma *et al.,* 2012 and Almaz *et al.,* 2017). About 40% of the crop land in India alone is grown using no-till techniques, with the majority of this practise occurring in North India. The soil benefits from this strategy in numerous ways, including erosion prevention, enhanced moisture, cooling effect and carbon supply. Keeping all these things in mind, an attempt has been made to determine the effect of crop residue incorporation on nutrient uptake and economics of summer greengram as influenced by residual effect of paddy residues and fertility levels.

MATERIALS AND METHODS

Experimental site

A field study was carried out at the college farm of the Professor Jayashanker Telangana State Agricultural University, Hyderabad during *kharif*, *rabi* and summer seasons of 2020-21 and 2021-22. The site was located at 17°32′22″N latitude and 78°41′11″E longitude and 550 m above mean sea level (MSL). The plot of experiment was characterized by sandy clay loam soil with a pH of 8.33, an EC of 0.37 dS $m^{-1}$and soil organic carbon content of 0.38%. The analysis of soil prior to the commencement of the study revealed that the available nitrogen (N), phosphorus (P) and potassium (K) were 145.0 kg N ha^{-1}, 38 kg P_2O_5 ha^{-1}, 277 kg K_2O ha^{-1}, respectively.

Treatment and experimental design

The field trial was conducted using a strip plot design. The horizontal plot treatments consisted of eight residue management methods *viz.*, R_1: Burning residue before sowing, R_2: Retention of residues, R_3: Removal of residues before sowing, R_4: Incorporation at 15 DAS, R_5: Incorporation at 15 DAS+SSP at equivalent to 'P' dose, R_6: Spraying consortia of decomposers @ 10% of residue weight+surface retention, R_7: Spraying consortia of decomposers @ 10% of residue weight+incorporation at 15 DAS, R_8: Spraying consortia of decomposers @ 10% of residue weight+incorporation at 15 DAS + SSP at equivalent to 'P' dose. The vertical plot treatments involve three fertility management practice *viz.*, F_1: 180:60:60 kg N, P_2O_5 and K_2O ha^{-1} (75% RDF), F_2: 240:80:80 kg N, P_2O_5 and K_2O ha^{-1} (100% RDF) and F_3: 300:100:100 kg N, P_2O_5 and K_2O ha^{-1} (125 % RDF). Rice was sown during *kharif* season of 2020 and 2021, respectively. After harvesting, the residue was

Table 1: Residual effect of paddy residue management and fertilizer levels on yield (kg ha^{-1}) and harvest index of greengram.

Treatment	Seed yield (kg ha^{-1})				Haulm yield (kg ha^{-1})				Harvest index			
	Fertilizer levels (F)											
Residue management (R)	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean
R_1- *In-situ* burning	508	693	843	681	1686	1948	2200	1945	26.20	27.75	27.48	27.14
R_2- Retention	532	688	859	693	1786	1985	2220	1997	26.31	27.61	27.62	27.18
R_3- Removal	491	667	851	670	1650	1917	2184	1917	26.77	27.79	26.90	27.15
R_4- Incorporation	574	760	893	742	1847	2089	2308	2081	26.43	27.78	27.97	27.39
R_5-Incorporation+SSP	744	829	855	809	1972	2307	2390	2223	27.59	28.37	27.23	27.73
R_6-Retention+consortium	543	743	848	711	1841	1989	2192	2007	26.56	28.10	27.75	27.47
R_7-Consortium+incorporation	841	888	915	881	2295	2371	2438	2368	28.21	28.25	28.18	28.21
R_8-Consortium+incorporation+SSP	911	949	1006	955	2431	2508	2583	2507	31.91	26.75	27.08	28.58
Mean	643	777	884		1939	2139	2314		27.50	27.80	27.53	
For comparison the mean of	SE(m)±		CD (P=0.05)		SE(m)±		CD (P=0.05)		SE(m)±		CD (P=0.05)	
Residue management	17		52		35		107		0.22		NS	
Fertilizer levels	14		55		18		72		0.25		NS	
R at levels of F	17		49		26		76		0.47		NS	
F at levels of R	47		135		55		159		1.43		NS	

collected and weighed. Maize was sown during *rabi* seasons of 2020-21 and 2021-22 under zero tilled conditions and rice residue was applied as per the treatments. Recommended dose of fertilizer for rice and maize (120-60-40 and 240:80:80 kg N, P_2O_5 and K_2O ha^{-1}, respectively) was given according to the study. Greengram was sown by dibbling after the harvest of maize under residual conditions. The sowing was done on 9th March and 28th February during summer 2021 and 2022 respectively. The greengram variety used in this investigation was WGG-42 which was released in Telangana in the name of yadadri.

Data collection

Matured pods from the net plot area of 3.0×3.2 m^2 were picked manually and dried in the sun. The weight of cleaned grains obtained from each plot after threshing was recorded. The net plot seed and haulm yield of five plants which were marked for recording post harvest observations were added and the total yield was expressed in kg ha^{-1}. The nitrogen, phosphorous and potassium content of the plant samples were analyzed at harvest stage of the crop. The plant samples were dried in hot air oven at 60^{o}C and the dried samples were grinded in a willey mill. The powdered samples were then used for analysis.

Statistical analysis

Gross returns, net returns and B: C ratio were calculated for each treatment and analyzed statistically. Relationship of seed yield with nutrient uptakes was established by using regression analysis. While doing so, the parameters for which significantly high correlation was noticed were selected for regression studies. Plant seed yield (dependent variable) was assumed as a function of uptake of nutrients (independent variable) and the following straight line model was established by least square technique (Gomez and Gomez, 1984) as follows.

$$Y = a+bx$$

Where:

y= Seed yield (kg ha^{-1}).

a= Y-axis intercept.

b= Regression coefficient.

x = independent variable.

RESULTS AND DISCUSSION

Yield

Among all the tested combinations, R_8F_3 (consortia+ incorporation+SSP with 125% RDF) recorded significantly higher seed yield and haulm yield (Table 1) which was comparable with R_8F_2 (consortia+incorporation+SSP with

Table 2: Nitrogen, phosphorous and potassium uptake of greengram as influenced by residual effect of paddy residue management and fertilizer levels during 2021 and 2022.

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Horizontal plots: Paddy residue management options (R)			
R_1- *In-situ* burning	25.28	3.94	29.57
R_2- Retention	25.61	4.21	30.00
R_3- Removal	25.42	4.04	29.22
R_4- Incorporation	27.32	4.64	32.39
R_5-Incorporation+SSP	28.76	5.21	35.06
R_6-Retention+consortium	26.09	4.33	30.60
R_7-Consortium+incorporation	30.58	5.82	39.08
R_8-Consortium+incorporation+SSP	32.15	6.43	41.63
Mean	26.06	4.82	33.44
SE(m)±	0.35	0.16	0.74
CD (P=0.05)	1.08	0.49	2.24
Fertilizer levels (F)			
F_1- 75 % RDF	25.59	3.92	29.20
F_2- 100 % RDF	27.89	4.92	34.62
F_3- 125 % RDF	29.47	5.64	36.50
Mean	26.06	4.82	33.44
SE(m)±	0.28	0.17	0.73
CD (P=0.05)	1.13	0.69	2.88
Interaction			
R at levels of F			
SE(m)±	0.59	0.32	1.52
CD (P=0.05)	NS	NS	NS
F at levels of R			
SE(m)±	1.75	0.98	4.60
CD (P=0.05)	NS	NS	NS

100% RDF) and significantly superior over R_8F_1 (consortia+incorporation+SSP with 75% RDF) treatment combination. On the other hand, the significantly lower seed yield and haulm yield were recorded with the treatment combination of R_3F_1 (removal with 75% RDF) which was statistically comparable with that of R_1F_1 (*in-situ* burning with 75% RDF), R_2F_1 (retention with 75% RDF) and R_6F_1 (retention+consortia with 75% RDF). Paddy residues applied to maize crop released plant nutrients slowly to the greengram over time. Higher growth, greater absorption and better translocation of assimilates from source to sink could have resulted in increased yield as nutrients were available at more frequent intervals from residual sources in consortia + incorporation+SSP treatment. These results are also in consonance with the findings of Davari *et al.* (2012) and Shukla *et al.* (2022) in greengram and maize crops, respectively.

Nutrient uptake

The scrutiny of the data on nitrogen (N), phosphorous (P) and potassium (K) uptake of greengram revealed that in consortium+incorporation+SSP (R_8) plots there is significant increase in nitrogen uptake as compared to *in-situ* burning plots (Table 2). The nutrient uptake variation among the treatments showed the importance of microbial consortium application to hasten up the decomposition of residues at rhizosphere (Bargaz *et al*., 2018 and Singh *et al.*, 2012). Naiyar *et al*. (2016) also found an increase in nitrogen uptake by grain and straw of wheat with incorporation of residues which might be due to better root establishment resulting in better translocation and the movement of nutrient in soil solution and ultimately their greater absorption and utilization by the growing plants.

Among the fertility levels, the increase in the fertility levels from 75% RDF to 125% RDF significantly influenced the NPK uptake. The maximum uptake of nutrients was recorded with 125% RDF and lowest values were recorded with 75% fertilizer application. In general, the overall absorption of a nutrient by a plant is proportional to the nutrient concentration and the amount of dry matter produced. Increased uptake at larger doses might have resulted in early plant vigour and a high photosynthetic rate resulting in greater nutrient uptake throughout the crop growth period. Similar results were reported by Brar *et al*. (2000) that application of 180 kg N ha^{-1} during paddy straw incorporation in addition to recommended nitrogen fertilizer dose (120 kg N ha^{-1}) in two equal splits (at sowing and 3 weeks after sowing) significantly increased the nitrogen and phosphorous uptake by 14.8% and 10% as compared to recommended dose alone.

No significant differences were found among residue management practices and fertility levels with respect to nitrogen, phosphorous and potassium uptake.

Economics

Significantly higher gross returns, net returns and B:C ratio were recorded with R_8F_3 (consortia+incorporation+SSP with

Table 3: Residual effect of paddy residue management and fertilizer levels on gross returns, net returns and B:C ratio of greengram.

Treatment	Gross returns (₹ ha^{-1})				Net returns (₹ ha^{-1})				B:C ratio			
					Fertilizer levels (F)							
Residue management (R)	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean	F_1- 75 % RDF	F_2- 100 % RDF	F_3- 125 % RDF	Mean
R_1- *In-situ* burning	38445	52091	63207	51248	16026	29839	41122	28996	3.35	4.61	4.96	4.14
R_2- Retention	40332	51794	64385	52170	18080	29542	42133	29918	3.51	4.12	4.86	4.17
R_3- Removal	37204	50227	63811	50414	14952	27975	41559	28162	3.24	4.18	4.98	4.13
R_4- Incorporation	43088	57092	67247	55809	21169	34840	44662	33557	3.64	4.33	4.92	4.30
R_5-Incorporation+SSP	55849	62308	64297	60818	33597	40056	42045	38566	4.15	4.61	4.76	4.51
R_6-Retention+consortium	41164	55656	63700	53507	19079	33404	41282	31255	3.56	4.28	4.78	4.21
R_7-Consortium+incorporation	63017	66524	68935	66159	40598	44272	46849	43906	4.53	4.69	4.79	4.67
R_8-Consortium+incorporation+SSP	69357	71150	74363	71623	47105	48898	52111	49371	4.70	4.80	4.98	4.83
Mean	48557	58355	66243		26326	36103	43970		3.84	4.39	4.88	
For comparison the mean of	SE(m)±	CD(P=0.05)			SE(m)±	CD (P=0.05)			SE(m)±	CD(P=0.05)		
Residue management	1287	3905			1289	3910			0.03	0.10		
Fertilizer levels	844	3314			805	3162			0.07	0.28		
R at levels of F	1199	3473			1209	3502			0.07	0.22		
F at levels of R	3085	8936			3091	8955			0.26	0.74		

Table 4: Regression equation between seed yield *vs* NPK uptakes as influenced by residual effect of paddy residue management and fertility levels.

Parameter	DAS	Regression	
		Equation	R^2
N uptake (kg ha^{-1})	15	y = 301.51×-48.22	0.34
	30	y = 56.76×+209.97	0.57
	45	y = 25.74×+ 224.24	0.46
	Harvest	y = 25.82×+103.67	0.52
P uptake (kg ha^{-1})	15	y = 166.99×+619.96	0.50
	30	y =170.73×+604.44	0.53
	45	y = 73.24×+612.24	0.44
	Harvest	y = 69.95×+452.78	0.45
K uptake (kg ha^{-1})	15	y= 238.34×+93.01	0.37
	30	y=30.28×+249.81	0.63
	45	y=23.29×+193.81	0.56
	Harvest	y=15.15×+114.96	0.59

125% RDF) than other combinations but statistically at par with that of R_8F_2 (consortia+incorporation+SSP with 100% RDF) and superior over R_8F_1 (consortia+incorporation+SSP with 75% RDF) treatment combination (Table 3). The treatment combination *viz*; R_7F_3 (consortium+ incorporation at 125 % RDF) also followed similar trend. On the other hand, significantly lower monetary returns were recorded with the treatment combination of R_3F_1 (removal with 75% RDF) and was in equivalence with that of R_1F_1 (*in-situ* burning with 75% RDF), R_2F_1 (retention with 75% RDF) and R_6F_1 (retention + consortia with 75% RDF) (Table 3).

The higher returns observed in consortia+ incorporation+SSP with 125% RDF and 100 % RDF could be due to higher seed and straw yields obtained in these treatment combinations. Badiger *et al.* (2019) also reported that application of 50 percent recommended dose of chemical fertilizers along with microbial consortia reduced the cost of inputs in greengram. Similar findings were reported by Singh *et al*. (2019).

Regression analysis

Regression between nutrient uptake and seed yield

The dependence of seed yield on the NPK uptakes was evident from significant (P=0.01) and positive correlation between yield and N uptake, P uptake and K uptake data (Table 4). Determination coefficient (R^2) was observed to be 0.57 for N uptake, 0.53 for P uptake and 0.63 for K uptake which indicates that there is increase in nutrient uptake as a result of higher yield.

CONCLUSION

It can be concluded that paddy residue management and fertility levels to zero till maize had a significant impact on greengram yield, nutrient uptake and economics. When microbial consortia+SSP+incorporation was combined with 100% RDF, higher seed yield, haulm yield, NPK uptake, gross returns, net returns and B-C ratio were noticed. Therefore, under zero till rice-maize-greengram cropping system, crop residue incorporation at 6.5-7.0 t ha^{-1} and application of microbial consortia in conjunction with fertilizers had a positive residual impact on boosting summer greengram uptake and resulting in higher yield and monetary returns.

Conflicts of interest

We, the authors of the paper undersigned hereby declare that there are no conflicts of interest regarding the publication of the manuscript in Legume Research Journal.

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