J. Soils and Crops 30 (1) 35-48, June 2020

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)
NAAS Rating - 4.46
Scientific Journal Impact Factor - 7.375

PERFORMANCE OF RICE AND MAIZE BASED CROPPING SYSTEMS AS INFLUENCED BY ORGANIC NITROGEN, WEED AND PHOSPHORUS MANAGEMENT IN HILL AREAS OF NORTH EAST INDIA

N. Khumdemo Ezung[1], J. K. Choudhary[2], Tiatula Jamir[3] and Moasunep[4]

ABSTRACT

The experiment was carried out at the experiment farm of ICAR, Nagaland Centre, Medziphema during 2015-16 and 2016-17 with the objectives to study the growth, yield and economics of rice and maize based cropping system under organic nutrient and weed management. The experiment was laid out in SPD with three replications. The main plot treatment consisted of four combinations of two cropping systems (C), *viz*, rice-greengram (C_1) and maize-greengram (C_2), two organic nitrogen management (N), *viz*, 75 % RD of N through vermicompost (N_1) and 100 % RD of N through vermicompost (N_2), organic weed management *viz*., no mulching (L_1) and cowpea live mulching (L_2) and the sub-plot treatment consisted of two organic phosphorus management practices (P), *viz*., 75 % RD of P through vermicompost (P_1) and 100 % RD of P through vermicompost (P_2) in greengram. The study revealed that application of 100 % RD of N through vermicompost with cowpea live mulching showed significant effect on growth parameters, *viz*., plant height, dry weight of crops, LAI, CGR, RGR, AGR and yield of rice and maize. It was observed that the sub plot factor showed significant effect on the growth parameters *viz*., plant height, dry weight of crops, LAI, CGR, RGR, AGR and yield parameters of greengram and recorded that the application of 100 % RD of P performed better as compared with the application of 75 % P. Therefore, it can be concluded that for profitable and sustainable farming, maize-greengram cropping sequence can be practiced along with the application of 100 % RD of N through vermicompost in maize with cowpea live mulching and 75 % RD of P through vermicompost in greengram, which not only increased the yield but also enhanced the productivity of the system and maintained the sustainability of the soil.

(Key words: Cropping, growth, nitrogen, mulching, organic, phosphorus, vermicompost, yield)

INTRODUCTION

Cropping system in the NER is also predominantly rice based with little exception in the state of Sikkim where maize is the main food crop. Rice cultivation in the region is under low input low risk and low yield condition. In the lowland mostly, mono-cropping of rice is practiced with the little exception in Tripura, Assam, parts of garo hills etc., where rice-rice system is practiced. The production of food grains in NE region is 5.97 million tonnes and the requirement are 7.6 million tonnes and the requirement would be 15.24 million tonnes by 2021 (Sharma and Datta, 2006). In order to make the region self sufficient in food grain production, the productivity of rice and maize has to be increased from the present level. Rice is also cultivated in *Jhum* under zero input supply and gives very low level of yield (1 to 1.5 t ha^{-1}). The productivity of rice in the state of Tripura (23.57 q ha^{-1}) and Manipur (25.87 q ha^{-1}) are higher than the national average, whereas all other states have lower productivity compared to national average (Das *et al.*, 2011). In case of maize, the state of Manipur (22.00 q ha^{-1}), Mizoram (18.75 q ha^{-1}) and Nagaland (20.00 q ha^{-1}), has comparatively better productivity than national average (Das *et al.*, 2011). Yield can be increased significantly by adopting low cost agro-techniques like improved variety, proper time of sowing, intercultural practices, effective recycling of resources etc.

About 35 % area in the region is plain excepting Assam where plains account for 84.44 % of its total

1. Sr. Scientist and Head, KVK, Kiphire, ICAR Research Complex for NEH Region, Nagaland Centre, Medziphema, Nagaland-797106, India
2. Professor, Deptt. of Agronomy, AAU, Jorhat, Assam-785013, India.
3. Block Technology Manager, Agriculture Technology Management Agency, Wokha, Government of Nagaland, Department of Agriculture, Wokha:797111, Nagaland
4. Agriculture Inspector, Government of Nagaland, Department of Agriculture, Kohima : 797001, Nagaland

geographical area. Net sown area is the highest in Assam (34.12 %) followed by Tripura (23.48 %). Arunachal Pradesh has the lowest net sown area in the region. Cropping intensity is the highest in Tripura (156.5 %) followed by Manipur (152.1 %), Mizoram (136.36 %) and Assam (123.59 %). About 1.6 million hectare area is under shifting cultivation in NE region (Das *et al.*, 2011). Except Sikkim and Tripura, all other NE states are having higher share of area under food grain production compared to national average (65 %). This indicates that there is scope for diversification of food crop based cropping systems.

The importance of highly intensive crop sequence is well recognized to meet the growing demands of ever increasing population. To fulfill the demand of food, oil etc., intensification of cropping sequence is essential depending on the need of the area. Oilseeds and pulses are receiving more attention owing to higher prices due to increased demand. Inclusion of these crops in sequence has been found more beneficial. It is well established that the basic requirement for stabilizing the crop productivity lies in the betterment of soil fertility. But continuous intensive cropping sequence aggravates the problems of weed infestation, reduced soil fertility and infestation of other pests and diseases, which ultimately result in declining the efficiency and productivity of the system. Current generalized recommendations with respect to NPK fertilizers alone are pointing to soil fatigue; proving their decreased efficiency and thus, need upward refinement and proper balance among the required nutrients.

The high input agriculture has led to self sufficiency in food grains but it has posed several new challenges. The need for conversion of intensive agriculture into organic agriculture is now widely felt. Hence, conversion of modern chemically intensive agriculture to a more sustainable form of agriculture like organic farming appears to be a viable option for maintaining the desirable agricultural production in future.

Farming in the north east hill region is regarded as organic by default as the application of fertilizers and pesticides is meagre in this part compared to the other parts of the country. However, with increase in population and lesser production and productivity from traditional system of crop production in this region, there is need to increase the cropping intensity and convert the subsistence agriculture into a sustainable form like organic agriculture.

MATERIALS AND METHODS

The present investigation was carried out during 2015-2016 and 2016-2017 at the experimental farm of ICAR, Nagaland Centre, Medziphema where the climatic condition of the experimental area is sub-tropical humid. The annual average rainfall varies from 1500 mm to 2000 mm which is mainly received during April to October and from November to March the weather is generally dry. The mean summer temperature ranges between 19°C to 35°C, while in winter it rarely goes below 5°C. The soil was sandy loam in texture with pH 4.84, organic carbon (0.47%), N (147.39 kg ha^{-1}), P_2O_5 (19.04 kg ha^{-1}) and K_2O (170.02 kg ha^{-1}).

The experiment was laid out in split plot design with three replications with a plot size of 5 x 3 m with 0.50 m in between the plots and 1 metre in between the replications. The treatment included cropping system (C), *viz*., rice-greengram (C_1) and maize-greengram (C_2), organic N management (N), *viz*., 75 % RD of N through vermicompost (N_1) and 100 % RD of N through vermicompost (N_2), organic weed management without cowpea live mulching (L_1), with cowpea live mulching (L_2) and organic phosphorus management (P) in the sub plot viz., 75 % RD of P through vermicompost (P_1) and 100 % RD of P through vermicompost (P_2) in greengram. 'Inglongkiri' (upland rice), 'RCM-76' (maize) and 'Pratap' (greengram) were the varieties selected for the study.

According to the treatments, organic N management was done by application of vermicompost at the rate of 75 % and 100 % N as recommended by Assam Agricultural University for rice and maize**.** The recommended dose of N for rice is 40 kg ha^{-1} and maize is 60 kg ha^{-1}**.** Similarly, quantities of vermicompost required to apply P at 75 % and 100 % of the recommendation for greengram by Assam Agricultural University. The recommended dose of P for greengram is 35 kg ha^{-1}. The quantities of vermicompost were calculated based on its N content (1.5 %) and moisture content (40 %) which were determined prior to application**.**

Vermicompost was applied in soil at the time of final land preparation**.**

The CGR, RGR and AGR were calculated taking into account the plant dry weight at 30 DAS and at 60 DAS for all the crops. The formula used are as under,

$$CGR = \frac{W_2 - W_1}{(t_2 - t_1)S}$$

W_2 and W_1 are plant dry weight at time t_1 and t_2
S is land area (m^2) over which dry matter is recorded

$$RGR = \frac{\ln W_2 - \ln W_1}{(t_2 - t_1)S}$$

W_2 and W_1 are plant dry weight at time t_1 and t_2

$$AGR = \frac{W_2 - W_1}{(t_2 - t_1)S}$$

W_2 and W_1 are plant dry weight at time t_1 and t_2

RESULTS AND DISCUSSION

Growth attributing characters of rice and maize

It was observed that the growth parameters such as plant height, dry weight of crops, LAI, CGR, RGR and AGR of rice and maize were significantly higher with application of 100 % RD of N through vermicompost. In both the crops, live mulching (L_2) with cowpea resulted in significantly higher growth performance as compared to no mulching at all stages of crop growth stages during both the years (Table 1-4) which might be due to lesser competition for nutrients and moisture between crop and weeds.

Yield attributing characters and yield of rice and maize

It was observed that the yield and yield attributes of rice and maize was significantly higher with the application of 100 % RD of N as compared to the application of 75 % RD of N through vermicompost (Table 5 & 6). The application of cowpea live mulching also showed significant effect on the yield of both the crops which might be due to suppression of weeds by cowpea resulting in better uptake of nutrients.

The above findings finds conformity with the findings of Thirunavukkarasu and Vinoth (2013), Pradhan and Moharana (2015) in case of rice where they reported that application of vermicompost resulted in significant effect on dry matter accumulation, crop growth rate, relative growth rate, crop yield and productivity of rice and N, P and K uptake. Kmetova and Kovacik (2013) reported that vermicompost application in maize crop had significant effect on thickness of maize stalk, tallest plants, highest thousand kernel weight and in highest grain yield of maize. Mohadeseh et al. (2015) reported that the increase in application of vermicompost, significant corresponding effect was observed on the growth and yield parameters of maize.

Growth attributing characters of greengram

The table 7-10 represents the carry-over effect of the main plot factor *i.e.* cropping system (C) organic N (N) and weed management (L) on the growth attributes of the following greengram which were found to be significant. The data showed that the cropping system C_2 (maize-greengram) performed better as compared to C_1(rice-greengram), where the greengram significantly recorded higher plant height, dry weight, LAI, CGR, RGR and AGR during both the years. Application of 100 % RD of N (N_2) through vermicompost in first *kharif* showed significant carry over effect on the growth attributing characters of greengram over the application of 75 % RD of N (N_1) through vermicompost. It was also observed that application of cowpea live mulching (L_2) in the first *kharif* showed significant effect on the following greengram crop which recorded higher growth attributes as compared to no mulching (L_1).

Effect of organic phosphorus management (P)

The data shown in table 7-10 indicated that the significant effect of P, the sub-plot factor on the growth attributes of greengram. The data revealed that application of 100 % RD of P through vermicompost (P_2) in greengram resulted in significantly higher plant height, dry weight, LAI, CGR, RGR and AGR as compared to the application of 75 % RD of P through vermicompost in greengram.

Interaction effect

Table 7a, 8a, 9b, 10a and 10b reveals the interaction effect of main plot and sub-plot factors, where it was observed that $C_2N_2L_2$ (maize-greengram with 100% RD of nitrogen through vermicompost and cowpea live mulching) interaction recorded significantly higher carry over effect on the growth parameters as compared with the rest of the treatment combinations. The interaction of cropping system (C) and organic weed management (L) was observed in LAI, where it was recorded that C_2L_2 (maize-greengram with cowpea live mulching) was significantly higher as compared to the rest of the treatment combinations (Table 9a).

The present investigation revealed that there was a significant effect of main plot factor as well as the sub-plot factor on growth and yield parameters of greengram. These findings are in conformity with the findings of Romel *et at.* (2014), Jamshidi *et al.*(2013), Rajkhowa *et al.* (2003) and Sitaram *et al.*(2013) where they reported that the increase in application of phosphorus resulted in significant increase in growth parameters of greengram.

Yield attributing characters and yield of greengram

The table 11 and 12 represents the effect of the main plot factor *i.e.,* cropping system (C), organic N (N) and weed management (L) on the yield attributes of greengram which were found to be significant. The data showed that C_2 (maize-greengram) as compared to C_1 (rice-greengram), greengram produced significantly more number of pods plant^{-1}, seeds pod^{-1}, test weight, seed yield and HI. The application of 100 % RD of N (N_2) recorded significantly higher yield parameters as compared with the application of 75 % RD of N through vermicompost. The application of cowpea live mulching (L_2) also exhibited superior positive effect on the yield parameters by way of suppressing the weeds infestation when compared with no mulching treatment.

Effect of organic phosphorus management (P)

The data shown in table 11 & 12 indicates that the significant effect of P, the sub-plot factor on the yield attributes in greengram. The data revealed that application of 100 % RD of P through vermicompost (P_2) in greengram resulted in significantly more number of pods plant^{-1}, number of seeds pod^{-1}, test weight, seed yield and HI as compared to the application of 75 % RD of P through vermicompost in greengram.

Interaction effect

Table 11a and 12a reveals the interaction effect of main plot and sub-plot treatments, where it was observed that $C_2N_2L_2$ (maize-greengram with 100% RD of nitrogen and cowpea live mulching) interaction recorded significantly higher number of pods plant^{-1}, seeds pod^{-1}, test weight, seed and stover yield.

The efficacy of vermicompost application in increasing the yield of greengram was also reported by Bhatt *et al.* (2012) and Sushil *et al.* (2015). The significant residual effect of vermicompost application on the succeeding greengram and other crops on yield and yield attributes were also reported by Davari *et al.* (2012); Sangeetha *et al.*(2013); Faujdar and Sharma (2013); Dey and Paul (2013); Patel *et al.*(2014); Tushar *et al.*(2014) and Alagappan and Venkitaswamy (2016) where they reported that the increase in application of phosphorus resulted in significant increase in yield and yield parameters of greengram.

Comparative economics of the treatments between the cropping sequence

Table 1. Effect of cropping system, organic N, and weed management on plant height (cm) of rice and maize at 30, 60 days and at harvest

Treatments	30 days		60 days		At harvest	
	2015	2016	2015	2016	2015	2016
$C_1N_1L_1$	22.62	24.85	76.64	88.44	87.72	98.54
$C_1N_1L_2$	31.25	35.74	86.82	95.27	102.79	119.66
$C_1N_2L_1$	30.00	34.62	85.75	92.62	101.69	128.34
$C_1N_2L_2$	33.85	36.59	88.08	98.29	107.10	139.47
$C_2N_1L_1$	45.25	55.65	201.61	215.56	220.09	228.54
$C_2N_1L_2$	60.41	69.81	238.30	243.71	242.62	247.88
$C_2N_2L_1$	59.83	63.74	234.02	239.14	242.47	244.52
$C_2N_2L_2$	80.50	89.74	241.39	248.47	244.71	251.38

Table 2. Effect of cropping system, organic N and weed management on dry weight (g plant^{-1}) of rice and maize at 30, 60 days and at harvest

Treatments	30 days		60 days		At harvest	
	2015	2016	2015	2016	2015	2016
$C_1N_1L_1$	0.60	0.75	10.56	12.56	25.35	45.35
$C_1N_1L_2$	0.80	0.88	13.11	15.11	36.19	56.58
$C_1N_2L_1$	0.73	0.82	12.22	14.22	34.24	50.69
$C_1N_2L_2$	0.86	0.90	14.00	16.24	38.37	58.24
$C_2N_1L_1$	32.00	37.00	75.70	80.89	154.36	178.59
$C_2N_1L_2$	37.88	42.88	84.05	88.45	219.26	278.19
$C_2N_2L_1$	32.78	40.78	77.10	85.26	166.23	236.47
$C_2N_2L_2$	40.48	45.48	98.39	110.24	229.07	298.27

Table 3. Effect of cropping system, organic N and weed management on Leaf Area Index of rice and maize at 30 days, 60 days and at harvest

Treatments	30 days		60 days		At harvest	
	2015	2016	2015	2016	2015	2016
$C_1N_1L_1$	0.34	0.48	1.11	1.15	1.10	1.13
$C_1N_1L_2$	0.50	0.65	1.31	1.47	1.29	1.38
$C_1N_2L_1$	0.43	0.57	1.18	1.29	1.16	1.24
$C_1N_2L_2$	0.68	0.74	1.36	1.48	1.34	1.39
$C_2N_1L_1$	0.42	0.53	1.65	1.76	1.35	1.46
$C_2N_1L_2$	0.65	0.78	2.27	2.48	1.98	2.14
$C_2N_2L_1$	0.59	0.69	1.87	1.99	1.51	1.67
$C_2N_2L_2$	0.75	0.86	3.25	3.88	2.82	2.94

C_1-Rice-greengram, C_2-Maize-greengram, N_1- 75% N as vermi - compost, N_2- 100% N as vermi-compost, L_1-Control (No mulching), L_2-Live mulching with cowpea

Table 4. Effect of cropping system, organic N and weed management on CGR (g/m^2 day^{-1}), RGR (g g^{-1} day^{-1}) and AGR (g plant^{-1}) in first *kharif*

Treatments	CGR		RGR		AGR	
	2015	2016	2015	2016	2015	2016
$C_1N_1L_1$	11.06	13.12	2.37	2.53	0.33	0.39
$C_1N_1L_2$	13.68	15.83	2.58	2.72	0.41	0.47
$C_1N_2L_1$	12.75	14.88	2.51	2.65	0.38	0.44
$C_1N_2L_2$	14.60	17.04	2.64	2.79	0.43	0.51
$C_2N_1L_1$	12.13	12.19	4.21	4.27	1.45	1.46
$C_2N_1L_2$	12.82	12.65	4.31	4.35	1.53	1.51
$C_2N_2L_1$	12.31	12.35	4.22	4.32	1.47	1.48
$C_2N_2L_2$	16.08	17.98	4.46	4.57	1.93	2.15

Table 5. Effect of cropping system, organic N and weed management on yield parameters of rice

Treatments	Grains panicle^{-1}		Test weight(g)		Seed yield(t ha^{-1})		Harvest Index (%)	
	2015	2016	2015	2016	2015	2016	2015	2016
$C_1N_1L_1$	115.28	126.35	17.43	19.43	1.51	1.62	33.92	34.59
$C_1N_1L_2$	132.00	144.57	19.98	21.54	1.74	1.88	35.05	35.00
$C_1N_2L_1$	125.59	137.59	19.28	21.14	1.67	1.78	34.56	34.73
$C_1N_2L_2$	148.33	162.54	20.68	22.87	2.04	2.24	36.90	37.62

Table 6. Effect of cropping system, organic N and weed management on yield parameters of maize

Treatments	Grains cob^{-1}		Cob length (cm)		Test weight (g)		Seed yield (t ha^{-1})		Harvest Index (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
$C_2N_1L_1$	410.00	425.63	18.51	20.47	71.34	72.14	3.03	3.12	32.27	32.98
$C_2N_1L_2$	475.96	489.57	20.28	22.51	89.07	90.87	3.94	4.11	35.03	35.09
$C_2N_2L_1$	441.05	452.27	20.07	21.47	75.34	76.44	3.59	3.64	32.58	33.07
$C_2N_2L_2$	507.13	534.24	20.30	23.45	90.49	92.24	4.49	4.55	35.97	36.57

C_1-Rice-greengram, C_2-Maize-greengram, N_1- 75% N as vermi - compost, N_2- 100% N as vermi - compost, L_1-Control (No mulching), L_2-Live mulching with cowpea

Table 7. Effect of cropping system, organic N, weed and P management on plant height (cm) of greengram at 30 days, 60 days and at harvest

Treatments	30 days		60 days		At harvest	
	2015	2016	2015	2016	2015	2016
Cropping system (C)						
C_1-Rice-greengram	34.65	32.83	65.71	61.82	63.90	59.51
C_2-Maize-greengram	38.40	35.63	82.31	76.45	80.26	75.31
Organic N management in 1st *kharif* crop (N)						
N_1- 75% N as vermicompost	35.22	32.54	72.47	67.57	70.52	65.63
N_2-100% N as vermicompost	37.83	34.92	75.54	70.70	73.65	69.19
Organic weed management in 1st *kharif* crop (L)						
L_1- Control (No mulching)	33.47	30.84	68.86	64.29	67.06	62.68
L_2-Live mulching with cowpea	39.59	36.62	79.16	73.98	77.10	72.14
SEd (±)	**0.77**	**0.65**	**1.42**	**1.11**	**1.43**	**1.16**
CD(P=0.05)	**1.64**	**1.39**	**3.05**	**2.39**	**3.07**	**2.49**
Organic P management in 2nd *kharif* crop (P)						
P_1- 75% P as vermicompost	34.67	32.05	71.29	66.34	69.41	64.80
P_2- 100% P as vermicompost	38.38	35.41	76.72	71.92	74.75	70.02
SEd(±)	**0.67**	**0.68**	**1.01**	**0.86**	**1.24**	**1.21**
CD(P=0.05)	**1.44**	**1.46**	**2.17**	**1.84**	**2.63**	**2.59**
Interactions						
CxN, CxL. NxL, CxP, NxP, LxP, CxNxP, CxLxP, CxNxLxP	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CxNxL	*	*	*	*	*	*
CV (%)	**7.30**	**6.71**	**6.68**	**5.60**	**6.90**	**5.99**
	6.40	**7.04**	**4.74**	**4.32**	**5.97**	**6.23**

* Significant, NS- Not significant

Table 7a. Plant height (cm) of greengram at 30 days, 60 days and at harvest as affected by the interaction of cropping system, organic N and weed management during 2015 and 2016

Treatments	30 days				60 days				At harvest			
	2015		2016		2015		2016		2015		2016	
	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2
C_1N_1	30.17	36.08	27.17	33.58	56.99	70.55	54.32	66.06	55.23	68.29	51.90	63.32
C_1N_2	33.25	39.12	30.75	35.81	61.09	74.18	57.26	69.63	59.45	72.64	56.28	66.53
C_2N_1	34.41	40.24	31.91	37.50	77.79	84.54	70.95	78.95	76.21	82.34	69.13	78.16
C_2N_2	36.05	42.91	33.55	39.58	79.56	87.35	74.64	81.26	77.35	85.16	73.41	80.55
	SEd (±)	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**
	1.54	**3.29**	**1.30**	**2.79**	**2.78**	**5.96**	**2.23**	**4.78**	**2.87**	**6.14**	**2.33**	**4.99**

(CD=0.05)

C_1-Rice-greengram, C_2-Maize-greengram, N_1-75% N as vermicompost, N_2-100% N as vermicompost, L_1-Control (No mulching), L_2-Live mulching with cowpea.

Table 8. Effect of cropping system, organic N, weed and P management on dry weight (g plant^{-1}) of greengram at 30 days, 60 days and at harvest

Treatments	30 days		60 days		At harvest	
	2015	2016	2015	2016	2015	2016
Cropping system (C)						
C_1-Rice-greengram	2.75	2.57	8.74	8.56	8.58	8.37
C_2-Maize-greengram	3.26	3.12	9.45	9.27	9.10	8.91
Organic N management in 1st *kharif* crop (N)						
N_1- 75% N as vermicompost	2.89	2.71	8.90	8.71	8.67	8.47
N_2-100% N as vermicompost	3.12	2.97	9.29	9.12	9.01	8.82
Organic weed management in 1st *kharif* crop (L)						
L_1- Control (No mulching)	2.49	2.31	8.48	8.28	8.24	8.05
L_2-Live mulching with cowpea	3.52	3.37	9.71	9.55	9.44	9.24
SEd (±)	**0.05**	**0.04**	**0.17**	**0.17**	**0.13**	**0.14**
CD(P=0.05)	**0.12**	**0.10**	**0.37**	**0.38**	**0.28**	**0.31**
Organic P management in 2nd *kharif* crop (P)						
P_1- 75% P as vermicompost	2.78	2.62	8.78	8.58	8.60	8.39
P_2- 100% P as vermicompost	3.23	3.06	9.41	9.25	9.09	8.89
SEd (±)	**0.03**	**0.05**	**0.06**	**0.08**	**0.08**	**0.09**
CD(P=0.05)	**0.07**	**0.10**	**0.14**	**0.17**	**0.17**	**0.19**
Interactions						
CxN, CxL, NxL, CxP, NxP, LxP, CxNxP, CxLxP, CxNxLxP	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CxNxL	*	*	*	*	*	*
CV (%)	**6.68**	**5.68**	**6.67**	**6.91**	**5.23**	**5.92**
	3.95	**6.06**	**2.62**	**3.13**	**3.26**	**3.72**

* Significant, NS- Not significant

Table 8a. Dry weight (g plant^{-1}) of greengram at 30, 60 and at harvest as affected by the interaction of cropping system, organic N and weed management

CD=0.05

Treatments	30 days				60 days				At harvest			
	2015		2016		2015		2016		2015		2016	
	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2
C_1N_1	2.11	3.15	1.96	2.96	7.94	9.16	7.74	8.99	7.73	9.12	7.55	8.90
C_1N_2	2.33	3.40	2.14	3.21	8.37	9.50	8.17	9.36	8.18	9.28	7.98	9.06
C_2N_1	2.61	3.69	2.45	3.49	8.62	9.90	8.42	9.71	8.34	9.49	8.14	9.29
C_2N_2	2.91	3.84	2.71	3.82	8.99	10.29	8.80	10.14	8.73	9.87	8.53	9.71
	SEd (±)	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**
	0.11	**0.24**	**0.09**	**0.20**	**0.35**	**0.75**	**0.35**	**0.76**	**0.26**	**0.57**	**0.29**	**0.63**

C_1-Rice-greengram, C_2-Maize-greengram, N_1-75% N as vermicompost, N_2-100% N as vermicompost, L_1-Control (No mulching), L_2-Live mulching with cowpea.

Table 9. Effect of cropping system, organic N, weed and P management on Leaf Area Index (LAI) of greengram at 30 days, 60 days and at harvest

Treatments	30 days		60 days		At harvest	
	2015	2016	2015	2016	2015	2016
Cropping system (C)						
C_1-Rice-greengram	0.49	0.44	1.62	1.58	1.43	1.37
C_2-Maize-greengram	0.64	0.59	1.91	1.87	1.65	1.57
Organic N management in 1st *kharif* crop (N)						
N_1- 75% N as vermicompost	0.54	0.49	1.67	1.63	1.46	1.39
N_2-100% N as vermicompost	0.59	0.541	1.87	1.82	1.62	1.55
Organic weed Management in 1st *kharif* crop (L)						
L_1- Control (No mulching)	0.48	0.43	1.32	1.28	1.20	1.14
L_2-Live mulching with cowpea	0.66	0.60	2.21	2.17	1.87	1.79
SEd (±)	**0.008**	**0.008**	**0.032**	**0.029**	**0.026**	**0.025**
CD (P=0.05)	**0.018**	**0.016**	**0.068**	**0.063**	**0.055**	**0.054**
Organic P management in 2nd *kharif* crop (P)						
P_1- 75% P as vermicompost	0.53	0.47	1.60	1.55	1.38	1.32
P_2- 100% P as vermicompost	0.61	0.56	1.94	1.89	1.70	1.61
SEd (±)	**0.007**	**0.007**	**0.043**	**0.039**	**0.031**	**0.035**
CD (P=0.05)	**0.015**	**0.016**	**0.093**	**0.083**	**0.066**	**0.076**
Interactions						
CxN, NxL, CxP, NxP, LxP, CxNxP, CxLxP, CxNxLxP	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CxL and CxNxL	*	*	*	*	*	*
CV (%)	**4.97**	**5.06**	**6.17**	**5.86**	**5.72**	**5.88**
	4.29	**4.85**	**8.48**	**7.82**	**6.93**	**8.31**

* Significant, NS- Not significant

Table 9a. Leaf Area Index (LAI) of greengram at 30 days, 60 days and at harvest as affected by the interaction of cropping system and weed management

Treatments	30 days				60 days				At harvest			
	2015		2016		2015		2016		2015		2016	
	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2
C_1	0.42	0.56	0.37	0.51	1.26	1.98	1.21	1.94	1.16	1.71	1.09	1.65
C_2	0.53	0.76	0.48	0.70	1.39	2.44	1.35	2.39	1.25	2.04	1.20	1.94
	SEd (±)	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**	**SEd (±)**	**CD**
	0.012	**0.025**	**0.011**	**0.023**	**0.045**	**0.096**	**0.029**	**0.088**	**0.036**	**0.077**	**0.035**	**0.076**

CD=0.05

C_1-Rice-greengram, C_2-Maize-greengram, N_1-75% N as vermicompost, N_2-100% N as vermicompost, L_1-Control (No mulching), L_2-Live mulching with cowpea

Table 9b. Leaf Area Index (LAI) of greengram at 30 days, 60 days and at harvest as affected by the interaction of cropping system, organic N and weed management

Treatments	30 days				60 days				At harvest			
	2015		2016		2015		2016		2015		2016	
	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2
C_1N_1	0.40	0.54	0.35	0.49	1.23	1.83	1.18	1.78	1.10	1.58	1.05	1.53
C_1N_2	0.44	0.57	0.39	0.52	1.28	2.13	1.23	2.11	1.21	1.84	1.13	1.77
C_2N_1	0.49	0.73	0.44	0.68	1.27	2.33	1.23	2.31	1.19	1.95	1.13	1.85
C_2N_2	0.57	0.79	0.52	0.72	1.51	2.55	1.46	2.47	1.32	2.13	1.26	2.02
	SEd (±)	CD	SEd (±)	CD	SEd (±)	CD	SEd (±)	CD	SEd (±)	CD	SEd (±)	CD
	0.016	0.035	0.015	0.032	0.063	0.135	0.058	0.125	0.051	0.109	0.050	0.107

Table10. Effect of cropping system, organic N, weed and P management on CGR (g/m^2 day^{-1}), RGR (g g^{-1} day^{-1}) and AGR (g plant^{-1}) of greengram

Treatments	CGR (g m^2 day^{-1})		RGR (g^{-1}g day^{-1})		AGR (g plant^{-1})	
	2015	2016	2015	2016	2015	2016
Cropping system (C)						
C_1-Rice-greengram	3.32	3.33	2.13	2.11	0.20	0.20
C_2-Maize-greengram	3.43	3.41	2.20	2.18	0.20	0.20
Organic N management in 1st *kharif* crop (N)						
N_1- 75% N as vermicompost	3.34	3.33	2.14	2.12	0.20	0.20
N_2-100% N as vermicompost	3.42	3.41	2.18	2.17	0.20	0.20
Organic weed management in 1st *kharif* crop (L)						
L_1- Control (No mulching)	3.32	3.31	2.10	2.08	0.20	0.19
L_2-Live mulching with cowpea	3.43	3.43	2.22	2.21	0.20	0.20
SEd (±)	**0.103**	**0.104**	**0.019**	**0.020**	**0.006**	**0.006**
CD(P=0.05)	**NS**	**NS**	**0.014**	**0.043**	**0.013**	**0.013**
Organic P management in 2nd *kharif* crop (P)						
P_1- 75% P as vermicompost	3.33	3.30	2.13	2.11	0.20	0.19
P_2- 100% P as vermicompost	3.43	3.44	2.19	2.18	0.20	0.20
SEd (±)	**0.042**	**0.046**	**0.008**	**0.009**	**0.003**	**0.003**
CD(P=0.05)	**0.090**	**0.098**	**0.016**	**0.019**	**0.006**	**0.006**
Interactions						
CxN, CxL, NxL, CxP, NxP, LxP, CxNxP, CxLxP, CxNxLxP	**NS**	**NS**	**NS**	**NS**	NS	NS
CxNxL	**NS**	**NS**	*	*	*	*
CV (%)	**10.55**	**10.63**	**3.07**	**3.20**	**10.58.00**	**10.63**
	4.33	**4.69**	**1.20**	**1.43**	**4.33**	**4.69**

* Significant, NS- Not significant

Table 10a. RGR (g g^{-1} day^{-1}) of greengram as affected by the interaction of cropping system, organic N and weed management

Treatments	2015		2016	
	L_1	L_2	L_1	L_2
C_1N_1	2.04	2.17	2.02	2.16
C_1N_2	2.09	2.21	2.07	2.19
C_2N_1	2.11	2.24	2.09	2.22
C_2N_2	2.15	2.28	2.13	2.27
	SEd(±)	**CD(P=0.05)**	**SEd(±)**	**CD(P=0.05)**
	0.039	**0.082**	**0.040**	**0.085**

Table 10b. AGR (g $plant^{-1}$) of greengram as affected by the interaction of cropping system, organic N and weed management

Treatments	2015		2016	
	L_1	L_2	L_1	L_2
C_1N_1	0.194	0.200	0.193	0.201
C_1N_2	0.201	0.203	0.201	0.205
C_2N_1	0.200	0.207	0.199	0.207
C_2N_2	0.203	0.215	0.203	0.211
	SEd(±)	**CD(P=0.05)**	**SEd(±)**	**CD(P=0.05)**
	0.012	**0.026**	**0.012**	**0.027**

C_1-Rice-greengram, C_2-Maize-greengram, N_1-75 % N as vermicompost, N_2-100 % N as vermicompost, L_1-Control (No mulching), L_2-Live mulching with cowpea

Table 11. Effect of cropping system, organic N, weed and P management on yield parameters of greengram

Treatments	Number of pods plant^{-1}		Number of seeds pod^{-1}		Test weight (g)	
Cropping System	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
C_1-Rice-greengram	28.70	23.03	9.84	7.55	34.39	31.37
C_2-Maize-greengram	31.33	26.78	10.16	8.32	35.76	32.76
Organic N management in 1st *kharif* crop (N)						
N_1- 75% N as vermicompost	28.74	23.88	9.78	7.71	34.21	31.19
N_2-100% N as vermicompost	31.28	25.92	10.22	8.13	35.94	32.93
Organic weed management in 1st *kharif* crop (L)						
L_1- Control (No mulching)	25.89	21.27	9.43	7.38	33.30	30.29
L_2-Live mulching with cowpea	34.13	28.53	10.57	8.46	36.85	33.84
SEd (±)	**0.76**	**0.60**	**0.14**	**0.13**	**0.51**	**0.51**
CD(P=0.05)	**1.63**	**1.28**	**0.30**	**0.29**	**1.09**	**1.10**
Organic P management in 2nd *kharif* crop (P)						
P_1- 75% P as vermicompost	27.72	22.89	9.67	7.61	33.85	30.83
P_2- 100% P as vermicompost	32.30	26.92	10.33	8.23	36.30	33.29
SEd (±)	**0.41**	**0.52**	**0.19**	**0.12**	**0.39**	**0.43**
CD(P=0.05)	**0.87**	**1.12**	**0.41**	**0.27**	**0.83**	**0.93**
Interactions						
CxN, CxL, NxL, CxP, NxP, LxP, CxNxP,	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CxLxP, CxNxLxP, CxNxL	*	*	*	*	*	*
CV (%)	**8.81**	**8.37**	**5.00**	**6.07**	**5.05**	**5.57**
	4.75	**7.32**	**6.81**	**5.56**	**3.90**	**4.73**

* Significant, NS- Not significant

Table 11a. Interaction effect of cropping system, organic N and weed management on yield parameters of greengram

Treatments	Number of pods plant^{-1}				Number of seeds pod^{-1}				Test weight (g)			
	2015		2016		2015		2016		2015		2016	
	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2
C_1N_1	24.88	30.27	19.18	24.91	9.25	9.96	6.91	7.73	31.52	35.70	28.51	32.67
C_1N_2	25.90	33.73	20.90	27.12	9.57	10.59	7.09	8.34	34.04	36.29	31.02	33.27
C_2N_1	24.88	34.95	21.58	29.86	9.37	10.55	7.64	8.54	32.80	36.82	29.80	33.80
C_2N_2	27.90	37.58	23.43	32.24	9.53	11.18	7.87	9.23	34.84	38.59	31.82	35.61
	SEd (±)	CD (P=0.05)	SEd (±)	CD (P=0.05)	SEd (±)	CD (P=0.05)	SEd (±)	CD (P=0.05)	SEd (±)	CD (P=0.05)	SEd (±)	CD (P=0.05)
	1.52	**3.26**	**1.20**	**2.576**			**0.27**	**0.59**	**1.02**	**2.18**	**1.03**	**2.20**

Table 12. Effect of cropping system, organic N, weed and P management on yield parameters of greengram

Treatments	Seed yield(t ha^{-1})		Harvest Index(%)	
Cropping system (C)	**2015**	**2016**	**2015**	**2016**
C_1-Rice-greengram	0.92	0.67	29.71	27.73
C_2-Maize-greengram	0.95	0.79	32.28	28.64
Organic N management in 1st *kharif* crop (N)				
N_1- 75% N as vermicompost	0.91	0.68	30.29	27.78
N_2-100% N as vermicompost	0.95	0.74	31.70	28.59
Organic weed management in 1st *kharif* crop (L)				
L_1- Control (No mulching)	0.86	0.64	30.53	27.54
L_2-Live mulching with cowpea	1.00	0.78	31.46	28.82
SEd (±)	**0.012**	**0.014**	**0.42**	**0.36**
CD (P=0.05)	**0.026**	**0.030**	**0.90**	**0.78**
Organic P management in 2nd *kharif* crop (P)				
P_1- 75% P as vermicompost	0.89	0.67	29.62	27.29
P_2- 100% P as vermicompost	0.97	0.75	32.37	29.08
SEd (±)	**0.015**	**0.012**	**0.48**	**0.38**
CD (P=0.05)	**0.032**	**0.026**	**1.02**	**0.82**
Interactions				
CxN, CxL, NxL, CxP, NxP, LxP, CxNxP, CxLxP, CxNxLxP	**NS**	**NS**	**NS**	**NS**
CxNxL	*	*	**NS**	**NS**
CV (%)	**4.58**	**6.96**	**4.71**	**4.48**
	5.52	**5.89**	**5.39**	**4.70**

* Significant, NS- Not significant

Table 12a. Interaction effect of cropping system, organic N and weed management on seed yield of greengram (t ha^{-1})

Treatments	2015		2016	
	L_1	L_2	L_1	L_2
C_1N_1	0.84	0.97	0.57	0.73
C_1N_2	0.87	1.00	0.63	0.77
C_2N_1	0.86	0.98	0.66	0.78
C_2N_2	0.90	1.06	0.70	0.85
	SEd (±)	**CD(P=0.05)**	**SEd (±)**	**CD(P=0.05)**
	0.025	**0.053**	**0.028**	**0.061**

C_1-Rice-greengram, C_2-Maize-greengram, N_1- 75% N as vermicompost, N_2-100% N as vermicompost L_1-Control (No mulching), L_2-Live mulching with cowpea

Table 13. Comparative economics of the cropping system

Treatments	Total cost of production (Rs. ha^{-1})		Gross return (Rs. ha^{-1})		Net return (Rs. ha^{-1})		B:C ratio	
	2015	2016	2015	2016	2015	2016	2015	2016
$C_1N_1L_1P_1$	111700	111700	188015	150965	76315	39265	0.68	0.35
$C_1N_1L_1P_2$	129580	129580	200665	164595	71085	35015	0.55	0.27
$C_1N_1L_2P_1$	111750	111750	218630	187986	106880	76236	0.96	0.68
$C_1N_1L_2P_2$	129630	129630	229530	200973	99900	71343	0.77	0.55
$C_1N_2L_1P_1$	119620	119620	198230	165788	78610	46168	0.66	0.39
$C_1N_2L_1P_2$	137500	137500	213880	181019	76380	43519	0.56	0.32
$C_1N_2L_2P_1$	119670	119670	240510	208562	120840	88892	1.01	0.74
$C_1N_2L_2P_2$	137550	137550	245110	221400	107560	83850	0.78	0.61
$C_2N_1L_1P_1$	121350	121350	276350	247408	155000	126058	1.28	1.04
$C_2N_1L_1P_2$	139230	139230	286850	261907	147620	122677	1.06	0.88
$C_2N_1L_2P_1$	121400	121400	321250	317166	199850	195766	1.65	1.61
$C_2N_1L_2P_2$	139280	139280	334700	328926	195420	189646	1.40	1.36
$C_2N_2L_1P_1$	133350	133350	327991	277892	194641	144542	1.46	1.08
$C_2N_2L_1P_2$	151230	151230	336950	287756	185720	136526	1.23	0.90
$C_2N_2L_2P_1$	133400	133400	374600	344546	241200	211146	**1.81**	**1.58**
$C_2N_2L_2P_2$	151280	151280	392800	360773	241520	209493	1.60	1.38

Cropping system

C_1: Rice-greengram
C_2: Maize-greengram

Organic N management

N_1: 75% N through vermicompost
N_2: 100% N through vermicompost

Organic weed management

L_1: Control (No mulching)
L_2: Live mulching with cowpea

Price (Rs.)

Rice: Rs.45 kg^{-1}
Maize :Rs.50 kg^{-1}

Price (Rs.)

Greengram: Rs.150 kg^{-1}

Organic P management

P_1:75% P through vermicompost
P_2:100% P through vermicompost

The comparative economics of the treatments in respect of cropping sequence has been presented in Table 13. It revealed that higher gross return (Rs.392800 ha^{-1} and Rs.360773 ha^{-1} in 2015 and 2016, respectively) and net return (Rs.241520 ha^{-1} and Rs.209493 ha^{-1}) were obtained from maize-greengram sequence due to application of 100 % N through vermicompost in maize , 100 % P through compost in greengram and with cowpea as live mulching. However, the B:C ratio was observed to be the highest with the application of 100 % RD of N through vermicompost in maize, 75 % RD of P through vermicompost in greengram and with cowpea as live mulching which recorded at 1.81 and 1.58 during 2015 and 2016 respectively.

The system economic under rice-greengram revealed that higher gross return (Rs. 240510 $ha^{-1}$and Rs. 221400 ha^{-1} in 2015 and 2016, respectively) was recorded with the application of 100 % N through vermicompost in rice, 100 % P through vermin compost in greengram and with cowpea as live mulching. However, it was observed that higher net return (Rs. 120840 ha^{-1} and Rs. 88892 ha^{-1}) and B:C ratio (1.01 and 0.74 during 2015 and 2016 respectively) was obtained with the application of 75 % P through vermicompost in greengram. However, when comparison is made between the two cropping systems, it was found that a higher economic return was obtained under maize-greengram system.

Therefore, it can be concluded that for profitable and sustainable farming, maize-greengram cropping sequence can be practiced along with the application of 100 % RD of N through vermicompost in maize with cowpea live mulching and 75 % RD of P through vermicompost in greengram, which not only increased the yield but also enhanced the productivity of the system and maintained the sustainability of the soil.

REFERENCES

Alagappan, R. Venkitaswamy, 2016. Impact of different sources of organic manures in comparison with TRRI practice, RDF and INM on growth, yield and soil enzymatic activities of rice - greengram cropping system under site - specific organic farming situation. American-Eur. J. Sus. Agri. **10**(2): 1-8.

Bhatt, P. K., B. T. Patel, C. H. Ravel and K. G, Vyas, 2012. Effect of vermicompost and phosphorus levels with PSB on growth and yield of summer greengram (*Vigna radiata* L.) under north Gujarat conditions. Green Farming. **3**(6): 666-669.

Das, A., D. P. Patel, G. C. Munda, P.K. Ghosh, S.V. Ngachan, B.U. Choudhury, G.I. Ramkrushna ,R. Saha, D.J. Rajkhowa, A.S. Pamwar, R. Kumar, M. Kumar and B. Juri, 2011. Conservation agriculture in rice and maize based cropping systems:Principle and practices for NEH Region. Research Bulletin No. 75.

Davari, M. R., H. Ghafari and S.N. Sharma, 2012. Economic feasibility of organic materials in organic farming of rice-based cropping systems. The 1st International and The 4th National Congress on Recycling of Organic Waste in Agriculture. 26 -27 April 2012 in Isfahan, Iran.

Dey, J.K. and S. R. Paul, 2013. Effect of in-situ greengram (*Phaseolus radiatus*) residue and nitrogen levels on toria (*Brassica rapa*) in rice (*Oryza sativa*)-greengram-toria sequence in Ultic Haplustalf. The Ind. J. Agri. Sci. **46**(3) 67-74.

Faujdar, R.S.and M. Sharma, 2013. Effect of FYM, biofertilizers and zinc on yield of maize and their residual effect on wheat. J. Soils and Crops **23**(1): 41-52.

Jamshidi, K., A. R. Yousefi and M. Oveisi, 2013. Effect of cowpea (*Vigna unguiculata*) intercropping on weed biomass and maize (*Zea mays* L.) yield. New Zealand J. Crop and Horti. Sci. **41**(4): 180-188.

Kmetova, M. and P. Kovacik, 2013. The impact of vermicompost application on yield parameters of maize. Mendelnet, **2**: 75-81.

Mohadeseh, V. N. and H. R, Mobasser, H. R. Ganjali, 2015. Effect of different levels of vermicompost on yield and quality of maize varieties. Bio. Forum-An Int. J. **7**(1): 856-860.

Patel, H. K., A. C. Sadhu, Y. C. Lakum and J. V. Suthar, 2014. Response of integrated nutrient management on wheat (*Triticum aestivum* L.) and its residual effect on succeeding crop. Int. J. on Agri. Sci. and Vety. Med. **2**(4): 47-52.

Pradhan, S. and S. Moharana, 2015. Effect of organic nutrient management on growth rate and crop productivity in sustainable rice-rice system. J. Crop and Weed, **11**(2): 28-33.

Rajkhowa, D. J. and M. Saikia, K. M. Rajkhowa, 2003. Effect of vermicompost and levels of fertilizer on greengram. Leg. Res. **26**(1): 63-65.

Romel, B., R. Wasal, M. Haque, M. Sharmin and R. Barua, 2014. Effect of potassium and vermicompost on the growth, yield and nutrient contents of mungbean (BARI Mung 5). Open Sci. J. Biosci. and Bioeng. **1** (3): 33-39.

Sangeetha, S. P., A. Balakrishnan and P. Devasenapathy, 2013. Influence of organic manures on yield and quality of rice (*Oryza sativa* L.) and blackgram (*Vigna mungo* L.) in rice-blackgram cropping sequence. American J. Plant Sci. (4): 1151-1157.

Sharma, U. C. and M. Datta, 2006. Physiography and resources in soils and their management in North East India. ICAR research Complex for NEH Region, Umiam, Meghalaya, 35-62.

Sitaram, T. A. K., S. K. Sharma and M. L. Reage, 2013. Growth attributes and nutrient uptake of green gram as influenced by vermicompost and zinc in arid western Rajasthan. Adv. Res. J. Crop Impv. **4**(1): 65-69.

Sushil, V., E. P. Lal and K. P. Rao, 2015.Studies on integrated nutrient management on seed yield and quality of greengram (*Vigna Radiate* L.). Int. J. Rec. Res. in Life Sci. **2**(2): 42-45.

Tushar, R. M., K. R. Pravat and S. M. Kumar, 2014. Energetics of greengram (*Vigna radiata* L.) production as affected by residual effect of rice establishment methods and nutrient management practices in rice-greengram cropping system. J. Agri. and Vety. Sci. **7**(7): 51-54.

Rec. on 01.12.2019 & Acc. on 15.12.2019