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Study on economics of cropping systems as influenced by organic nutrient management under hill areas of North Eastern Region of India

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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 economics of cropping systems under organic nutrient management. The experiment was in SPD with three replications. The main plot treatment consisted of four combinations of two cropping systems (C), *viz.* rice-greengram-toria and maize-greengram-toria and two organic nitrogen management (N)., *viz.* 75% RD through vermicompost and 100 % RD through vermicompost and the sub-plot treatment consisted of two organic phosphorus management practices (P)., *viz.* 75% RD through vermicompost and 100 % RD through vermicompost in greengram. Inglongkiri (upland rice), RCM-76 (maize), Pratap (greengram) and TS-36 (toria) were used as the crop varieties under study. The study revealed that application of 100 % N through vermicompost showed significant effect on yield and yield attributes both in rice and maize which showed significant carry over influence on the following greengram and toria crops. It was observed that the sub plot factor showed significant effect with the application of 100% P as compared with the application of 75% P in greengram. The economic analysis of the first kharif crops revealed that the highest economic return was obtained from maize crop with application of 100% N through vermicompost. The highest gross return was obtained in greengram following maize with 100% N through vermicompost and 100% P through vermicompost in greengram. However, the system economic analysis revealed that maize-greengram-toria system gave the highest economic returns as compared with the rice-greengram-toria system with a B:C ratio of 1.81 and 1.61 during 2015 and 2016, respectively.

1. Introduction

The agricultural production system NEH region is predominantly rainfed and mono-cropped at subsistence level. Slash and burn agriculture is still practiced in almost all states on steep slopes with reduced cycle of 2-3 years against 10-15 years in the past. Thus, in the north-eastern region which is mostly consisted of hills, crop production is subjected to adverse and harsh geo-physical and agro-climatic conditions.

Agriculture in NEH region is not profit oriented due to high weed infestation and labour cost for undertaking weeding operation. The low productivity is mainly due to heavy crop-weed competition. The yield losses caused by weeds in this type of rice culture may reduce grain yield by 5-100% (Singh *et al.,* 2002). The weed flora in upland rice is diverse and consists of grasses, broad-leaved weeds and sedges. Early emergence of weeds along with crop seedlings due to favourable soil conditions and their rapid growth result in severe competition for nutrients, space, light, *etc.* Further, the weed flora emerges in several flushes during the crop growth period.

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Because of such constraints, the area under upland rice is gradually declining in the state. The key to success in direct seeded rice is the availability of efficient weed control techniques (Pandey and Velasco, 2002). Farmers mostly follow manual weeding which is costly, time consuming, back breaking and also limited by availability of labour during the critical period resulting in yield loss and income.

Oilseeds and pulses are receiving more attention owing to higher prices due to increased demand. To fulfill the demand of cereal, pulses, and oilseeds of ever-increasing population, inclusion of oilseeds and pulses in cropping sequence was found more beneficial than cereal alone (Kumar *et al.,* 2008). The short duration pulse crop could very well be introduced in rice and maize-based cropping sequence during summer for maximizing the net return and restoring the soil fertility. Because, inclusion of legume crop during summer in the system increases the organic carbon and available N, P and K in the soil (Sharma *et al.,* 2004). An intensive cropping system which is not only highly productivity and profitable but also stable over time and maintains soil fertility, is of great importance in present scenario.

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 (Modgal *et al.,* 1995).

Thus, the present investigation was undertaken to assess the economics between rice and maize based cropping system with an efficient organic nutrient and weed management practices so as to obtain maximum income.

2. 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 19o C to 35^{o}C, while in winter it rarely goes below 5^{o}C.

The experiment was laid out in split plot design with three replications. The treatment included cropping system (C), viz. rice-greengram (C1) and maize-greengram (C2), organic N management (N), viz. 75% RD through vermicompost (N1) and 100% RD through vermicompost (N2) and organic phosphorus management (P) in the sub plot viz. 75% RD through vermicompost (P1) and 100% RD through vermicompost (P2) in greengram.

3. Results and Discussion

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 application of 100 % RD of N as compared with the application of 75 % RD of N through vermicompost (Table 1(i) to (iv)).

Yield attributing characters and yield of green gram

The Table 2 (i) and Table 2 (ii) represents the effect of the main plot factor i.e. cropping system (C) and organic N management (N) on the yield attributes which were found to be significant. The data showed that in C2 as compared to C1, greengram produced significantly more number of pods/plant, seeds/pod, test weight, seed and stover yield and HI. And, N2 was observed to significantly improve upon these yield attributes in greengram compared to N1.

Effect of organic phosphorus management (P)

The data shown in Table 2(i) and Table 2 (ii) indicated that the significant effect of P, the sub-plot factor on the mentioned yield attributes in greengram. The data revealed that application of 100% P through vermicompost (P2) in greengram resulted in significantly more number of pods/plant, number of seeds/pod, test weight, seed and stover yield and HI as compared with the application of 75% P through vermicompost in greengram.

Residual effect on yield and yield attributes of toria

Data in Table 3(i) and 3(ii) shows the residual effect of the main plot and sub-plot factor on the toria crop which shows that significantly higher residual effect on yield and yield attributes were obtained from application of 100% N through vermicompost (N2) and 100% P through vermicompost (P2) in first kharif and greengram respectively. However, it was found that the response of toria following greengram and maize showed better performance in terms of yield as compared with toria following greengram and rice.

Economics of the treatments

During first kharif crops (rice and maize)

The Table 4(i) and Table 4(ii) show the comparative economics of the treatments in first kharif crops (rice and maize) during 2015 and 2016. It was observed that the highest gross return (Rs. 224600.00 ha-1and Rs.227883.33 ha-1 during 2015 and 2016, respectively) and net return (Rs.165100.00 ha-1and Rs. 168383.33 ha^{-1} during 2015 and 2016, respectively) were obtained with C2N2. Similarly, under rice crop, the highest gross return (Rs.92160 ha-1and Rs.101100 ha^{-1} during 2015 and 2016, respectively) and net return (Rs.46390 ha-1and Rs.55330 ha-1 during 2015 and 2016, respectively) were obtained with C2N2. However, the highest benefit-cost ratio was achieved from C1N1 (1.07 and 1.24 during 2015 and 2016, respectively) and C2N1 (2.78 and 3.33 during 2015 and 2016, respectively) under rice and maize crop respectively. Verma *et al.* 2003; Singh *et al.* 2007 and Kumar *et al.* 2007 also reported similar finding where they found that application of 100% RD through vermicompost was more beneficial in terms of yield and economic return in maize.

During second crop greengram

The Table 5(i) and Table 5(ii) show the comparative economics of the treatments in greengram during 2015 and 2016. It was observed that the highest gross return (Rs.168200 ha-1and Rs.136350 ha-1 during 2015 and 2016, respectively) was obtained from maize crop with the application of 100% P through vermicompost (C2N2P2). However, there was variation in the net return where application of 100% P through vermicompost in greengram obtained the highest net return which recorded an amount of Rs.76420 ha^{-1} during 2015 but during the year 2016, the highest net return of Rs. 46100 ha^{-1} was obtained from the application of 75% P through vermicompost in greengram which was due to reduction in the yield of greengram during the second year. Rs.168383.33 ha^{-1} during 2015 and 2016, respectively, were obtained under maize crop with application of 100 % N through vermicompost with live mulching with cowpea. Narendra *et al.* 2009 and Sitaram *et al.* 2013 also reported similar findings where application of 100% RD through vermicompost was found to be superior to control in terms of yield and economic return.

Similar returns was also observed under rice crop where the highest gross return (Rs.152950 ha^{-1} and Rs.121800 ha^{-1} during 2015 and 2016, respectively) was obtained with the application of 100% P through vermicompost (C1N2P2). However, the net return with the application of 75% P through vermicompost in greengram obtained the highest which recorded an amount of Rs.74450 ha-1and Rs.35900 ha-1 during 2015 and 2016 respectively.

Under maize based cropping, the B:C ratio was observed to be highest with the application of 75 % P through vermicompost which was recorded at 1.03 and 0.62 during 2015 and 2016 respectively (C2N2P1). Similar result was also found under rice based cropping where the highest B:C ratio (1.01 and 0.49 during 2015 and 2016 respectively) was recorded from C1N2P1 which was mainly due to higher cost of vermicompost which increased the cost of cultivation. When we compare the B:C ratio between the rice-greengram and maize-greengram, it was found that that B:C ratio under maize-greengram was the highest during both the years.

During third crop toria

The Table 6(i) and Table 6(ii) shows the comparative economics of the treatments during the toria crop. It was observed that the highest gross return of Rs.25528 ha^{-1} and Rs.24028 ha^{-1}, net return of Rs. 13350 ha^{-1} and Rs.11850 ha^{-1} and B:C ratio of 2.64 and 2.45 during 2015 and 2016, respectively, was obtained from maize-greengram-toria system with the application of 100% N through vermicompost in maize crop and 100% P through vermicompost in greengram with live mulching ($C_2N_2P_2$).

This is due to higher crop yield as a result of the residual effect on the succeeding toria crop. A similar return was also observed under rice-greengram-toria system where the highest gross return of Rs.21500 $ha^{-1}$and Rs.20000 ha^{-1}, net return of Rs. 17378 ha^{-1} and Rs.15878 ha^{-1}. The B:C ratio of 2.13 and 1.95 during 2015 and 2016, respectively, was obtained from maize-greengram-toria system with the application of 100% N through vermicompost in maize crop and 100% P through vermicompost in greengram with live mulching ($C_2N_2P_2$). This is due to higher crop yield as a result of the residual effect on the succeeding toria crop.

Comparative economics of the treatments between the cropping sequence

The comparative economics of the treatments in respect of cropping sequence has been presented in Table 7(i) and Table 7(ii). It revealed that higher gross return (Rs.418328 $ha^{-1}$and Rs.388261.33 ha^{-1} in 2015 and 2016, respectively) and net return (Rs.258898 $ha^{-1}$and Rs.228831.33 ha^{-1}) was obtained from maize-greengram-toria sequence due to application of

100% N through vermicompost in the maize and 100 % P through compost in greengram as compared with rice-greengram-toria system. However, the B:C ratio was observed to be the highest with the application of 100% N through vermicompost in maize and 75% P through vermicompost in which recorded at 1.81 and 1.61 during 2015 and 2016, respectively.

4. Conclusion

The system economics revealed that during both the years, C_2 was found better than C_1 under the effects of organic N and P management in rainfed condition with respect to gross, net return, and B:C ratio. Therefore, it may be concluded that the productivity and profitability of maize-greengram-toria cropping system is better than the rice-greengram-toria cropping system under organic nutrient management in rainfed condition of north-east hill region. Under this situation, application of vermicompost on the basis of 100% N as recommended for the first cereal crop followed by application of vermicompost on the basis by 75% P_2O_5 as recommended for the second pulse crop like greengram sustains profitable production of the third oilseed crop toria of the system. An organic cropping system under rainfed situation may also be profitable.

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Table 1 (i): Effect of cropping system, organic n and weed management on yield parameters of rice

Treatment	Tillers per hill		Grains per panicle		Panicle length(cm)		Panicle weight(g)	
	2015	2016	2015	2016	2015	2016	2015	2016
C_1N_1	7.751	8.872	115.282	126.352	26.801	27.882	4.652	5.870
C_1N_1	9.382	10.241	132.003	144.571	28.292	31.273	5.650	7.543
C_1N_2	8.813	9.453	125.591	137.592	27.283	29.481	5.562	6.452
C_1N_2	10.640	11.444	148.334	162.544	30.344	35.284	6.244	8.881

Table 1 (ii) Effect of cropping system, organic n and weed management on yield parameters of rice

Treatment	Test weight(g)		Seed yield(q ha^{-1})		Stover yield (q ha^{-1})		Harvest Index (%)	
	2015	2016	2015	2016		2015	2016	2015
C_1N_1	17.430	19.430	15.170	16.270	29.591	30.272	33.9270	34.5922
C_1N_1	19.982	21.542	17.442	18.872	33.062	35.473	35.0503	35.0080
C_1N_2	19.283	21.142	16.743	17.883	31.033	33.471	34.5662	34.7393
C_1N_2	20.681	22.874	20.481	22.470	35.020	37.244	36.9041	37.6214

Table 1 (iii) Effect of cropping system, organic n and weed management on yield parameters of maize

Treatment	Grains /cob		Plants m^{-2}		Cob length(cm)	
	2015	2016	2015		2015	2016
C_2N_1	410.001	425.630	6.762	C_2N_1	410.001	425.630
C_2N_1	475.962	489.573	7.853	C_2N_1	475.962	489.573
C_2N_2	441.054	452.272	7.141	C_2N_2	441.054	452.272
C_2N_2	507.131	534.241	7.980	C_2N_2	507.131	534.241

Table 1(iv) Effect of cropping system, organic n and weed management on yield parameters of maize

Treatment	Test weight(g)		Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Harvest Index (%)	
	2015	2016	2015	2016		2015	2016	2015
C_2N_1	71.342	72.140	30.361	31.272	60.250	63.470	32.2712	32.9892
C_2N_1	89.071	90.872	39.452	41.123	73.583	75.583	35.0360	35.0913
C_2N_2	75.343	76.440	35.922	36.470	71.224	73.781	32.5801	33.0740
C_2N_2	90.490	92.243	44.920	45.581	79.260	81.240	35.9713	36.5774

Table 2(i) Effect of cropping system, organic N and weed management on yield parameters of greengram
C1-Rice-greengram-toria, C2-Maize-greengram-toria, N1- 75% N as vermicompost, N2- 100% N as vermicompost

Treatment	Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Harvest Index (%)	
Cropping system (C)	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
C_1-Rice-greengram	9.218	6.782	19.307	17.010	29.716	27.730
C_2-Maize-greengram	9.542	7.497	22.262	19.376	32.282	28.648
Organic N management in 1st *kharif* crop (N)						
N_1- 75% N as vermicompost	9.164	6.871	20.383	17.770	30.294	27.786
N_2-100% N as vermicompost	9.595	7.408	21.186	18.616	31.704	28.591
SEm (±)	**0.124**	**0.144**	**0.379**	**0.284**	**0.422**	**0.365**
CD (P=0.05)	**0.265**	**0.307**	**0.810**	**0.609**	**0.903**	**0.782**
Organic P management in 2nd *kharif* crop (P)						
P_1- 75% P as vermicompost	8.984	6.719	19.922	17.463	29.626	27.291
P_2- 100% P as vermicompost	9.775	7.560	21.648	18.923	32.372	29.087
SEm (±)	**0.150**	**0.121**	**0.503**	**0.390**	**0.483**	**0.383**
CD (P=0.05)	**0.317**	**0.260**	**1.067**	**0.835**	**1.023**	**0.820**
Interactions	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	**4.581**	**6.967**	**6.304**	**5.416**	**4.718**	**4.488**
	5.523	**5.890**	**8.383**	**7.429**	**5.393**	**4.709**

Table 2 (ii): Effect of cropping system, organic N, weed and P management on yield parameters of greengram NS- Not significant

Treatment	Number of branches/plant		Number of siliqua/plant		Number of seeds/siliqua		Test weight(g)	
Cropping system (C)	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
C_1-Rice-greengram-Toria	4.06	3.51	132.75	127.69	9.91	9.16	2.73	2.52
C_2-Maize-greengram-Toria	4.10	3.59	165.62	164.30	11.69	10.73	2.95	2.75
Organic N management in 1st *kharif* crop (N)								
N_1- 75% N as vermicompost	4.05	3.52	144.21	139.92	10.56	9.60	2.77	2.55
N_2-100% N as vermicompost	4.10	3.58	154.15	152.06	11.04	10.29	2.91	2.72
SEm (±)	**0.01**	**0.005**	**3.03**	**2.16**	**0.18**	**0.02**	**0.02**	**0.008**
CD (P=0.05)	**0.04**	**0.010**	**6.50**	**4.63**	**0.39**	**0.05**	**0.06**	**0.016**
Organic P management in 2nd *kharif* crop (P)								
P_1- 75% P as vermicompost	4.03	3.49	134.77	132.36	9.99	9.24	2.70	2.48
P_2- 100% P as vermicompost	4.13	3.61	163.55	159.63	11.61	10.65	2.98	2.79
SEm (±)	**0.02**	**0.008**	**2.43**	**2.02**	**0.23**	**0.04**	**0.03**	**0.009**
CD (P=0.05)	**0.05**	**0.017**	**5.15**	**4.33**	**0.50**	**0.09**	**0.07**	**0.019**
Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	**1.57**	**2.23**	**7.05**	**5.14**	**5.98**	**4.43**	**3.41**	**4.89**
	2.26	**3.82**	**5.65**	**4.80**	**7.60**	**7.28**	**4.08**	**5.73**

Table 3 (i) Yield parameters of toria as influenced by the carry over effect of cropping system, organic N and weed management during the first *kharif* (rice and maize) and organic P management in second crop (greengram) of the sequence

Treatment	Number of branches/plant		Number of siliqua/plant		Number of seeds/siliqua		Test weight(g)	
Cropping system (C)	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
C_1-Rice-greengram-Toria	4.06	3.51	132.75	127.69	9.91	9.16	2.73	2.52
C_2-Maize-greengram-Toria	4.10	3.59	165.62	164.30	11.69	10.73	2.95	2.75
Organic N management in 1st *kharif* crop (N)								
N_1- 75% N as vermicompost	4.05	3.52	144.21	139.92	10.56	9.60	2.77	2.55
N_2-100% N as vermicompost	4.10	3.58	154.15	152.06	11.04	10.29	2.91	2.72
SEm (±)	**0.01**	**0.005**	**3.03**	**2.16**	**0.18**	**0.02**	**0.02**	**0.008**
CD (P=0.05)	**0.04**	**0.010**	**6.50**	**4.63**	**0.39**	**0.05**	**0.06**	**0.016**
Organic P management in 2nd *kharif* crop (P)								
P_1- 75% P as vermicompost	4.03	3.49	134.77	132.36	9.99	9.24	2.70	2.48
P_2- 100% P as vermicompost	4.13	3.61	163.55	159.63	11.61	10.65	2.98	2.79
SEm (±)	**0.02**	**0.008**	**2.43**	**2.02**	**0.23**	**0.04**	**0.03**	**0.009**
CD (P=0.05)	**0.05**	**0.017**	**5.15**	**4.33**	**0.50**	**0.09**	**0.07**	**0.019**
Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	**1.57**	**2.23**	**7.05**	**5.14**	**5.98**	**4.43**	**3.41**	**4.89**
	2.26	**3.82**	**5.65**	**4.80**	**7.60**	**7.28**	**4.08**	**5.73**

Table 3(ii) Yield parameters of toria as influenced by the carry over effect of cropping system, organic N and weed management during the first *kharif* (rice and maize) and organic P management in second crop (greengram) of the sequence NS-Not significant

Treatment	Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Harvest Index (%)	
Cropping system (C)	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
C_1-Rice-greengram-Toria	3.02	2.77	8.75	7.31	25.49	27.33
C_2-Maize-greengram-Toria	3.62	3.37	8.99	7.50	28.56	30.75
Organic N management in 1st *kharif* crop (N)						
N_1- 75% N as vermicompost	3.25	3.00	8.77	7.32	26.61	28.59
N_2-100% N as vermicompost	3.39	3.14	8.97	7.49	27.44	29.49
SEm (±)	**0.06**	**0.06**	**0.08**	**0.01**	**0.38**	**0.40**
CD (P=0.05)	**0.14**	**0.14**	**0.18**	**0.03**	**0.82**	**0.86**
Organic P management in 2nd *kharif* crop (P)						
P_1- 75% P as vermicompost	3.14	2.89	8.70	7.27	26.16	28.05
P_2- 100% P as vermicompost	3.49	3.24	9.04	7.54	27.89	30.03
SEm (±)	**0.04**	**0.04**	**0.11**	**0.01**	**0.30**	**0.34**
CD (P=0.05)	**0.10**	**0.10**	**0.25**	**0.03**	**0.65**	**0.72**
Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	**6.86**	**7.36**	**3.34**	**3.36**	**4.93**	**4.81**
	5.14	**5.35**	**4.63**	**3.59**	**3.89**	**4.06**

Table 4 (i) Comparative economics of the treatments in rice and maize during 2015

Treatment	Total cost of production (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Per day net return (Rs)	B:C ratio
C_1N_1	37800	68265	30465	83.47	0.81
C_1N_1	37850	78480	40630	111.32	1.07
C_1N_2	45720	75330	29610	81.12	0.65
C_1N_2	45770	92160	46390	127.10	1.01
C_2N_1	47450	151800	104350.00	285.89	2.19
C_2N_1	47500	179600	132100.00	410.27	2.78
C_2N_2	59450	197250	137800.00	329.18	2.32
C_2N_2	59500	224600	165100.00	452.33	2.77

Table 4(ii) Comparative economics of the treatments in rice and maize during 2016

Treatment	Total cost of production (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Per day net return (Rs)	B:C ratio
C_1N_1	37800	73215.00	35415.00	97.03	0.94
C_1N_1	37850	84930.00	47080.00	128.99	1.24
C_1N_2	45720	80475.00	34755.00	95.22	0.76
C_1N_2	45770	101100.00	55330.00	151.59	1.21
C_2N_1	47450	156348.34	108898.34	298.35	2.30
C_2N_1	47500	205583.33	158083.33	433.11	3.33
C_2N_2	59450	182350.00	122900.00	336.71	2.07
C_2N_2	59500	227883.33	168383.33	461.32	2.83

Table 5 (i): Comparative economics of the treatments in greengram during 2015

Treatment	Total cost of production (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Per day net return (Rs.)	B:C ratio
$C_1N_1P_1$	73900	119750.00	45850.00	125.62	0.62
$C_1N_1P_2$	91780	132400.00	40620.00	111.29	0.44
$C_1N_1P_1$	73900	140150.00	66250.00	181.51	0.90
$C_1N_1P_2$	91780	151050.00	59270.00	162.38	0.65
$C_1N_2P_1$	73900	122900.00	49000.00	134.25	0.66
$C_1N_2P_2$	91780	138550.00	46770.00	128.14	0.51
$C_1N_2P_1$	73900	148350.00	74450.00	203.97	1.01
$C_1N_2P_2$	91780	152950.00	61170.00	167.59	0.67
$C_2N_1P_1$	73900	124550.00	50650.00	138.77	0.69
$C_2N_1P_2$	91780	135050.00	43270.00	118.55	0.47
$C_2N_1P_1$	73900	141650.00	67750.00	185.62	0.92
$C_2N_1P_2$	91780	155100.00	63320.00	173.48	0.69
$C_2N_2P_1$	73900	130741.67	56841.67	155.73	0.77
$C_2N_2P_2$	91780	139700.00	47920.00	131.29	0.52
$C_2N_2P_1$	73900	150000.00	76100.00	208.49	1.03
C_2N_2P2	91780	168200.00	76420.00	209.37	0.83

Table 5 (ii) Comparative economics of the treatments in greengram during 2016

Treatment	Total cost of production (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Per day net return (Rs.)	B:C ratio
$C_1N_1P_1$	73900	79250.00	5350.00	14.66	0.07
$C_1N_1P_2$	91780	92400.00	620.00	1.70	0.01
$C_1N_1P_1$	73900	103950.00	30050.00	82.33	0.41
$C_1N_1P_2$	91780	116050.00	24270.00	66.49	0.26
$C_1N_2P_1$	73900	87900.00	14000.00	38.36	0.19
$C_1N_2P_2$	91780	102700.00	10920.00	29.92	0.12
$C_1N_2P_1$	73900	109800.00	35900.00	98.36	0.49
$C_1N_2P_2$	91780	121800.00	30020.00	82.25	0.33
$C_2N_1P_1$	73900	93000.00	19100.00	52.33	0.26
$C_2N_1P_2$	91780	105050.00	13270.00	36.36	0.14
$C_2N_1P_1$	73900	111650.00	37750.00	103.42	0.51
$C_2N_1P_2$	91780	123150.00	31370.00	85.95	0.34
$C_2N_2P_1$	73900	100741.67	26841.67	73.54	0.36
$C_2N_2P_2$	91780	109700.00	17920.00	49.10	0.20
$C_2N_2P_1$	73900	120000.00	46100.00	126.30	0.62
C_2N_2P2	91780	136350.00	44570.00	122.11	0.49

Table 6(i) Comparative economics of the treatments in toria during 2015

Treatment	Total cost of production (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Per day net return (Rs)	B:C ratio
$C_1N_1P_1$	8150	16753.33	8603.33	23.57	1.06
$C_1N_1P_2$	8150	17400.00	9250.00	25.34	1.13
$C_1N_1P_1$	8150	18006.67	9856.67	27.00	1.21
$C_1N_1P_2$	8150	18933.33	10783.33	29.54	1.32
$C_1N_2P_1$	8150	16920.00	8770.00	24.03	1.08
$C_1N_2P_2$	8150	17440.00	9290.00	25.45	1.14
$C_1N_2P_1$	8150	18100.00	9950.00	27.26	1.22
$C_1N_2P_2$	8150	21500.00	13350.00	36.58	1.64
$C_2N_1P_1$	8150	17606.67	9456.67	25.91	1.16
$C_2N_1P_2$	8150	20746.67	12596.67	34.51	1.55
$C_2N_1P_1$	8150	22180.00	14030.00	38.44	1.72
$C_2N_1P_2$	8150	24380.00	16230.00	44.47	1.99
$C_2N_2P_1$	8150	18640.00	10490.00	28.74	1.29
$C_2N_2P_2$	8150	21800.00	13650.00	37.40	1.67
$C_2N_2P_1$	8150	22953.33	14803.33	40.56	1.82
$C_2N_2P2_1$	8150	25528.00	17378.00	47.61	2.13

Table 6(ii) Comparative economics of the treatments in toria during 2016

Treatment	Total cost of production (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Per day net return (Rs)	B:C ratio
$C_1N_1P_1$	119850	204768.33	84918.33	232.65	0.71
$C_1N_1P_2$	137730	218065.00	80335.00	220.10	0.58
$C_1N_1P_1$	119900	236636.67	116736.67	319.83	0.97
$C_1N_1P_2$	137780	248463.33	110683.33	303.24	0.80
$C_1N_2P_1$	127770	215150.00	87380.00	239.40	0.68
$C_1N_2P_2$	145650	231320.00	85670.00	234.71	0.59
$C_1N_2P_1$	127820	258610.00	130790.00	358.33	1.02
$C_1N_2P_2$	145700	266610.00	120910.00	331.26	0.83
$C_2N_1P_1$	129500	293956.67	164456.67	450.57	1.27
$C_2N_1P_2$	147380	307596.67	160216.67	438.95	1.09
$C_2N_1P_1$	129550	343430.00	213880.00	585.97	1.65
$C_2N_1P_2$	147430	359080.00	211650.00	579.86	1.44
$C_2N_2P_1$	141500	346631.67	205131.67	562.00	1.45
$C_2N_2P_2$	159380	358750.00	199370.00	546.22	1.25
$C_2N_2P_1$	141550	397553.33	256003.33	701.38	1.81
$C_2N_2P_2$	159430	418328.00	258898.00	709.31	1.62

Cropping system

C_1: Rice-greengram-toria
C_2: Maize-greengram-toria

Organic N management

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

Organic P management

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

Price (Rs.)
Rice: Rs.45/kg
Maize :Rs.50/kg

Price (Rs.)
Greengram: Rs.150/kg

Price (Rs.)
Toria: Rs.60/kg

Table 7(i) Comparative economics of the treatments in Rice & maize-greengram-toria sequence during 2015

Treatment	Total cost of production (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Per day net return (Rs)	B:C ratio
$C_1N_1P_1$	119850	167718.33	47868.33	131.15	0.40
$C_1N_1P_2$	137730	181515.00	43785.00	119.96	0.32
$C_1N_1P_1$	119900	205386.67	85486.67	234.21	0.71
$C_1N_1P_2$	137780	218413.33	80633.33	220.91	0.59
$C_1N_2P_1$	127770	183795.00	56025.00	153.49	0.44
$C_1N_2P_2$	145650	199115.00	53465.00	146.48	0.37
$C_1N_2P_1$	127820	227495.33	99675.33	273.08	0.78
$C_1N_2P_2$	145700	242900.00	97200.00	266.30	0.67
$C_2N_1P_1$	129500	265455.01	135955.01	372.48	1.05
$C_2N_1P_2$	147380	280645.01	133265.01	365.11	0.90
$C_2N_1P_1$	129550	337913.33	208363.33	570.86	1.61
$C_2N_1P_2$	147430	351613.33	204183.33	559.41	1.38
$C_2N_2P_1$	141500	300231.67	158731.67	434.88	1.12
$C_2N_2P_2$	159380	312350.00	152970.00	419.10	0.96
$C_2N_2P_1$	141550	369336.67	227786.67	624.07	1.61
$C_2N_2P_2$	159430	388261.33	228831.33	626.94	1.44

Cropping system

C_1: Rice-greengram-toria
C_2: Maize-greengram-toria

Price (Rs.)
Rice: Rs.45/kg
Maize :Rs.50/kg

Organic N management

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

Price (Rs.)
Greengram: Rs.150/kg

Organic P management

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

Price (Rs.)
Toria: Rs.60/kg