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RESEARCH ARTICLE

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Residual Effect of Foliar Application of Nano Fertlizers and Organic Source of Nitrogen on the Productivity and Economics of Zero Tilled Green Pea in Rice-green Pea Cropping Sequence

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ABSTRACT

Background: After rice harvest, the majority of farmers in Manipur leave their land fallow without planting anything, despite the fact that it has a great deal of potential for growing a second crop in the *rabi* season with the remaining moisture and nutrients. One of the most crucial options for Manipur's farmers is green pea, which not only boosts their revenue but also makes use of the nutrients and residual moisture in the soil. The current fertilizer application system ignores the carryover effect of the manure or fertilizer applied to the previous crop and instead bases its decisions on the nutritional requirements of the specific crop. Applying organic sources of nutrients to the previous crop greatly benefits the following crop. In light of the aforementioned considerations, an experiment was set up to determine whether the foliar application of nano fertlizers and organic source of nitrogen in the previous *kharif* rice crop had any lasting effects on the productivity of the following green pea crop.

Methods: A field experiment was conducted during the *kharif* and *rabi* season of 2020-21 and 2021-22 at Hiyanglam Mayai Leikai in the Kakching district of Manipur, in order to research the residual effect of foliar application of nano fertlizers and organic source of nitrogen on the productivity and economics of zero tilled green pea in rice- green pea cropping sequence. A factorial randomized block design (FRBD) with three replications was used to set up the experiment.

Result: The pooled data showed that vermicompost @100% RDN had the highest growth and yield characterictics over the vermicompost @ 75% RDN and 50% RDN. The combinations of nano NPK @ 1.5% + 100% RDN through vermicompost resulted in the highest increase growth and yield attributing characters of green pea and lowest was observed in the control + @ 50% RDN treated plot.

Key words: Crop residues, Economics, Nano fertilizers, Nutrient concentration, Vermicompost.

INTRODUCTION

Green pea (*Pisum sativum* L.) is one of the important pulse crop of the Fabaceae family, which ranks fourth in the economic importance of the Fabaceae family and comes in second place after the tomato crop as raw material for canning factories. It is an annual herbaceous plants limited or unlimited growth and adapted to wet climatic conditions. Pea are grown for their fresh green seeds or dry seeds and sugary pods, it is consumed as cooked or canned or frozen food, it is a vegetables rich in protein and carbohydrates and nutrients, on the agricultural side pea production plays an important role in the agricultural cycle as it is a crop that contributes to the stabilization of atmospheric nitrogen and improves soil fertility. After rice harvest, the majority of farmers in Manipur leave their land fallow without planting anything, despite the fact that it has a great deal of potential for growing a second crop in the *rabi* season with the remaining moisture and nutrients. One of the most crucial options for Manipur's farmers is green pea, which not only boosts their revenue but also makes use of the nutrients and residual moisture in the soil. The current fertilizer application system ignores the carryover effect of the manure or fertilizer applied to the previous crop and instead bases its decisions on the nutritional requirements of the specific crop. The development of nanotechnology has made it possible to mass-produce metal nanoparticles that are physiologically important, which can be utilized to improve fertilizer formulations for improved uptake in plant cells and nutrient conservation. Additionally, nano fertilizers can lessen nutrient losses through leaching, enhancing the effectiveness of nutrient use while addressing environmental issues brought on by the extensive use of fertilizer (Raliya *et al*., 2016). Targeted delivery and controlled or slow release mechanisms in nanostructured fertilizers can increase the

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efficiency of nutrient usage. They could precisely release their active substances in response to biological needs and environmental cues. Additionally, through accelerating the rates of photosynthesis, seed germination, seedling growth, carbohydrate and protein synthesis and nitrogen metabolism, nano fertilizers have shown improved crop productivity (Solanki *et al*., 2015). According to Hedge (1998), applying organic sources of nutrients to the previous crop greatly benefits the following crop. In light of the aforementioned considerations, an experiment was set up to determine whether the foliar application of nano fertlizers and organic source of nitrogen in the previous *kharif* rice crop had any lasting effects on the productivity of the following green pea crop.

MATERIALS AND METHODS

To investigate the long-term effects of organic materials, crop residues and vermicompost applied to the cropping system on the performance of succeeding green pea crops, a field experiment was carried out during the *kharif* and *rabi* season of 2020-21 and 2021-22 at Hiyanglam Mayai Leikai in the Kakching district of Manipur, which is about at 24.48°N and 93.98°E in terms of latitude and longitude and is situated at an altitude of approximately 2545 meters above mean sea level. The soil was clay, had a soil pH of 5.36, high levels of organic carbon (1.35%), medium availability of nitrogen (313.64 kg/ha), phosphorus (36.8 kg/ha) and potassium (240.53 kg/ha). A factorial randomized block design (FRBD) with three replications was used to set up the experiment. The treatments given in the preceding *kharif* rice comprised of four levels of foliar application of nano NPK (19:19:19) were control (F_1), nano NPK (19:19:19) @ 0.5% (F_2), nano NPK (19:19:19) @ 1% (F_3) and nano NPK (19:19:19) @ 1.5% (F_4) and three levels of organic source of nitrogen N_1- vermicompost @ 100% RDN, N_2- Vermicompost @75% RDN and N_3- Vermicompost @ 50% RDN. A foliar spray was used during active tillering (25 DAS) and panicle initiation stage (75 DAS). N:P:K @ 60:40:30 kg/ha of fertilizer was recommended for rice. Vermicompost was used as a per treatment together with full doses of single super phosphate (SSP) and muriate of potash (MOP) and incorporated with the last land preparation. Green pea seeds were sown in lines with 20 cm row to row distance between the rows of stubbles left by previous rice crop with a plant to plant distance of 10 cm. Sowing was done in the second week of November. Growth parameters were recorded at 30 days interval and yield was recorded at the time of harvest.

RESULTS AND DISCUSSION

Growth parameter

The pooled data in Table 1 showed that the different foliar applications of nano fertilizers and organic nitrogen sources utilized in the previous *kharif* rice had a residual effect on the green pea's growth characteristics. The application of nano NPK (19:19:19) @ 1.5% resulted in the highest plant height (40.50 cm), which was statistically higher than all other treated plots. This was followed by the application of nano NPK @ 1% (34.30 cm) and nano NPK @ 0.5% (31.44 cm) and lowest was observed in control plot (19.34 89 cm). It might be due to reducing nutrient leaching and improving nutrient use efficiency, which releases nutrients gradually over a longer period of time. This can help conserve nutrients in the soil for succeeding crops. This finding was similar to (Raliya *et al*., 2016).

With regard to organic source of nitrogen, green pea plots receiving a combination of nano NPK fertilizers and organic sources of nutrients, such as vermicompost, showed the highest development features (Table 1). The application of vermicompost @ 100% RDN recorded a 95 vermicompost @ 50% RDN (29.47 cm). It might be due the application of vermicompost provided the highest availability of N, P, K and organic carbon in soils on soil sampling (after harvesting rice), helping to provide the best direct and residual effect on the availability of soil nutrients, plant nutrient uptake and soil enrichment of the rhizosphere with micro and macronutrients. A similar trend was found in (Nurhidayati *et al*., 2018).

The subsequent green pea crop's plant height was significantly influenced by the interactions between nano NPK and organic source of nitrogen used in *kharif* rice. The interaction between several NPK and organic source of nitrogen used in the prior *kharif* rice crop, on the other hand, had a substantial influenced on the crop growth rate of green pea (Table 1). The interaction between foliar application of nano NKP @ 1.5% + vermicompost @ 100% RDN, (N_1F_4) with a value of (42.59 cm) recorded the highest plant height among the various treatment combinations The lowest plant height was recorded in control + vermicompost @ 50% RDN (17.45 cm). The accumulation of more nutrient residues that were made available to the succeeding crop may have led to better crop growth characteristics of green pea. This may have occurred through the mineralization of organic manures *i.e* vermicompost or the solubilization of nutrients from native sources during the process of decomposition.

Yield attributes

The no. of pods/plant, pod length (cm) and no. of seeds/plant in the following green pea crop significantly increased as a result of various nano NPK fertilizers and organic source of nitrogen (Table 2). The pooled data revealed that application of nano NPK @ 1.5%, recorded maximum no. of pods/plant (3.27), pod length (cm) (9.26cm) and no. of seeds/plant (8.57) which was comparable with the plot receiving nano NPK @ 1% and nano NPK @ 0.5%, respectively but they were significantly higher than control plot. The lowest no. of pods/ plant (1.40), pod length (cm) (6.51) and no. of seeds/plant (4.9) were also observed in control plot.

The pooled data in Table 2 showed that among the various sources of organic nitrogen, the plot receiving vermicompost @ 100% RDN had the statistically highest no. of pods/plant (2.73), pod length (cm) (8.49) and no. of seeds/plant (7.55) while the plot receiving 50% RDN (N_3) had the least residual effect on no. of pods/plant (2.20), length (cm) (7.73) and no. of seeds/plant (6.47). This might be due to the application of vermicompost enhanced the physical, chemical and biological characteristics of the soil, contributed plant development factors and had a favorable impact on the production of dry matter both directly on the first crop and indirectly on the second crop. Application rate and quality both affected the residual effect of vermicompost, so the higher the rate of application, the more residual effect should be on the soil. Hence, it had a positive effect on the vegetative growth of the plants and improved the yield of crops. Similar findings were reported by Jat and Ahlawat (2004) and Atiyeh (1999).

The no. of pods/plant, pod length (cm) and no. of seeds/plant in the following green pea crop were significantly affected by the interaction between nano NPK and organic source of nitrogen (Table 2). The interaction between foliar application of nano NKP @ 1.5% + vermicompost @ 100% RDN, (N_1F_4) recorded the highest no. of pods/plant, pod length (cm) and no. of seeds/plant among the various treatment combinations. The lowest no. of 50% RDN Table 2.

Yield

Table 2 makes it clear that the various foliar applications of nano NKP fertilizers and organic source of nitrogen used in the prior *kharif* rice crop had a considerable lasting residual effect on the production of the following green pea crop. Higher green pod yield was achieved in the plots receiving F_4, or nano NKP @ 1.5% (4131 kg/ha), F_3 *i.e.* nano NKP @ 1% (3612 kg/ha) and they were significantly difference with one another. F_1 or control plot (2030 kg/ha) gave considerably decreased green pod yield across the treatment plots. Application of nano-NPK fertilizers, alternatively, decreased soil pH and EC while increasing soil organic matter and N, P, K, Fe, Mn and Zn concentrations. The findings unmistakably show that the green pea's pod yield and nutritional value were boosted by the nano-fertilizer. As a result, our study has demonstrated that nano fertilizers release nutrients gradually, increasing soil fertility and improving green pod yield. Similar finding was also reported by El-Sayed *et al.* (2020).

Table 1: Plant height (cm) for green pea in relation to the residual effect of nano fertilizers and organic sources of nitrogen.

Treatment		30 DAS			60 DAS			90 DAS	
Foliar application	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
F_1	10.05	9.44	9.74	19.79	18.89	19.34	19.79	18.89	19.34
F_2	14.54	17.78	16.16	27.57	35.31	31.44	27.57	35.31	31.44
F_3	15.70	19.07	17.39	31.59	37.02	34.30	31.59	37.02	34.30
F_4	17.14	20.39	18.77	36.65	44.35	40.50	36.65	44.35	40.50
S.E (d) (±)	0.078	0.078	0.055	0.008	0.008	0.006	0.008	0.008	0.006
CD (p=0.05)	0.162	0.161	0.121	0.017	0.016	0.013	0.017	0.016	0.013
Organic nitrogen									
N_1	15.38	17.58	16.48	32.79	34.96	33.88	32.79	34.96	33.88
N_2	14.72	16.55	15.63	27.52	34.16	30.84	27.52	34.16	30.84
N_3	12.97	15.89	14.43	26.39	32.56	29.47	26.39	32.56	29.47
S.E (d) (±)	0.068	0.067	0.048	0.007	0.007	0.005	0.007	0.007	0.005
CD (p-0.05)	0.141	0.140	0.105	0.015	0.014	0.011	0.015	0.014	0.011
Treatment combinations									
N_1F_1	10.58	9.49	10.04	22.51	20.32	21.42	22.51	20.32	21.42
N_1F_2	15.97	18.41	17.19	33.63	36.28	34.95	33.63	36.28	34.95
N_1F_3	16.12	20.08	18.10	35.32	37.77	36.55	35.32	37.77	36.55
N_1F_4	18.86	22.34	20.60	39.71	45.47	42.59	39.71	45.47	42.59
N_2F_1	10.16	9.48	9.82	19.23	19.08	19.16	19.23	19.08	19.16
N_2F_2	15.18	18.40	16.79	25.22	35.03	30.12	25.22	35.03	30.12
N_2F_3	16.17	18.57	17.37	29.82	37.54	33.68	29.82	37.54	33.68
N_2F_4	17.36	19.73	18.54	35.80	44.97	40.39	35.80	44.97	40.39
N_3F_1	9.40	9.35	9.38	17.63	17.26	17.45	17.63	17.26	17.45
N_3F_2	12.46	16.53	14.50	23.87	34.62	29.25	23.87	34.62	29.25
N_3F_3	14.80	18.56	16.68	29.62	35.74	32.68	29.62	35.74	32.68
N_3F_4	15.21	19.11	17.16	34.43	42.62	38.53	34.43	42.62	38.53
S.E (d) (±)	0.136	0.135	0.096	0.014	0.014	0.010	0.014	0.014	0.010
CD (p=0.05)	0.281	0.280	0.210	0.030	0.028	0.022	0.030	0.028	0.022

F_1: Control; F_2: Nano NPK (19:19:19) @ 0.5% at tillering and panicle initiation stage; F_3: Nano NPK (19:19:19) @ 1% at tillering and panicle initiation stage; F_4: Nano NPK (19:19:19) @ 1.5% at tillering and panicle initiation stage; N_1: Vermicompost @100% RDN; N_2: Vermicompost @ 75% RDN; N_3: Vermicompost @ 50% RDN.

The plot receiving N_1, which was application of 100% RDN (3567 kg/ha), had the highest green pod yield among the various organic source of nitrogen and that was followed by N_2, *i.e* application of vermicompost @ 75% RDN (3212 kg/ha). The lowest green pod yield was obtained with 50% RDN application (N_3), which resulted in yields of (2978 kg/ha) (Table 2). This could be owing to the vermicompost's microbial stimulation and the N given through slow mineralization. Hence application of vermicompost significantly improved the soil chemical properties such as pH, electrical conductivity, organic matter and nutrient status and resulted in better plant growth and yield (Senthamizhkumaran *et al.,* 2021 and Nagavallemma *et al*., 2004).

The green pod yield of the succeeding green pea crop was significantly affected by the interactions between the various foliar applications of nano NKP fertilizers and organic source of nitrogen (Table 2). The interaction between foliar application of nano NKP @ 1.5% + vermicompost @ 100% RDN, (N_1F_4) recorded the highest green pod yield among the various treatment combinations, with a total of (4761) kg/ha. The green pod yield with the lowest value (1881 kg/ha) was observed in control + vermicompost @ 50% RDN.

Economics

The pooled data in Table 3 revealed that the foliar application of nano NKP @ 1.5% + vermicompost @ 100%RDN (N_1F_4), gave the highest gross returns (Rs.238073), net returns (Rs. 213373) and B:C ratio (8.6), respectively followed by the treatment combination of N_2F_4 *i.e* nano NKP @ 1.5% + vermicompost @ 75% RDN (Rs. 199535), (Rs. 174835) and (7.1) and N_1F_3 *i.e* nano NKP @ 1% + vermicompost @ 100% RDN (Rs.185025), (Rs. 160325) and B:C ratio of (6.5). The N_3F_1 plot, which was given 50% RDN through vermicompost + control, produced the lowest gross returns (Rs. 94082), net

Table 2: Yield and yield attributing parameters for green pea in relation to the residual effect of nano fertilizers and organic sources of nitrogen.

Treatment	No. of pods/plant			Pod length (cm)			No. of seeds /pod			Green pod yield kg/ha		
Foliar application	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
F_1	1.40	1.40	1.40	6.57	6.45	6.51	5.20	4.80	4.9	2100	1961	2030
F_2	2.33	2.47	2.40	8.02	8.26	8.14	7.07	7.27	7.17	2962	3512	3237
F_3	2.60	2.80	2.70	8.38	8.85	8.62	7.47	7.67	7.57	3404	3819	3612
F_4	3.20	3.33	3.27	8.89	9.64	9.26	8.40	8.73	8.57	3910	4353	4131
S.E (d) (±)	0.007	0.008	0.005	0.006	0.006	0.004	0.005	0.004	0.003	1.40	1.16	0.91
CD (p=0.05)	0.014	0.016	0.011	0.012	0.013	0.009	0.010	0.009	0.007	2.90	2.41	2
Organic nitrogen												
N_1	2.65	2.80	2.73	8.34	8.65	8.49	7.50	7.60	7.55	3451	3684	3567
N_2	2.35	2.45	2.40	8.09	8.25	8.17	7.15	7.25	7.20	2953	3471	3212
N_3	2.15	2.25	2.20	7.46	7.99	7.73	6.45	6.50	6.47	2879	3078	2978
S.E (d) (±)	0.006	0.007	0.004	0.005	0.006	0.004	0.004	0.004	0.003	1.21	1	0.79
CD (p-0.05)	0.012	0.014	0.010	0.010	0.012	0.008	0.009	0.008	0.006	2.51	2.08	1.73
Treatment combinations												
N_1F_1	1.60	1.60	1.60	6.96	6.81	5.20	6.89	5.00	5.20	2293	2130	2212
N_1F_2	2.60	2.80	2.70	8.48	8.60	7.70	8.54	7.80	7.70	3347	3843	3595
N_1F_3	2.80	3.00	2.90	8.55	8.97	7.90	8.76	8.00	7.90	3521	3880	3700
N_1F_4	3.60	3.80	3.70	9.38	10.21	9.40	9.79	9.60	9.40	4642	4881	4761
N_2F_1	1.40	1.40	1.40	6.40	6.30	5.00	6.35	4.80	5.00	2033	1963	1998
N_2F_2	2.20	2.40	2.30	8.42	8.50	7.50	8.46	7.60	7.50	2696	3813	3254
N_2F_3	2.60	2.80	2.70	8.50	8.81	7.70	8.65	7.80	7.70	3364	3846	3605
N_2F_4	3.20	3.20	3.20	9.04	9.40	8.60	9.22	8.80	8.60	3718	4264	3990
N_3F_1	1.20	1.20	1.20	6.33	6.23	4.80	6.28	4.60	4.80	1974	1789	1881
N_3F_2	2.20	2.20	2.20	7.17	7.67	6.30	7.42	6.40	6.30	2843	2879	2861
N_3F_3	2.40	2.60	2.50	8.10	8.76	7.10	8.43	7.20	7.10	3327	3732	3530
N_3F_4	2.80	3.00	2.90	8.24	9.31	7.70	8.78	7.80	7.70	3370	3913	3642
S.E (d) (±)	0.011	0.013	0.009	0.010	0.011	0.007	0.008	0.008	0.006	2.42	2.01	1.57
CD (p=0.05)	0.024	0.027	0.019	0.020	0.023	0.016	0.017	0.016	0.013	5.02	4.17	3.46

F_1: Control; F_2: Nano NPK (19:19:19) @ 0.5% at tillering and panicle initiation stage; F_3: Nano NPK (19:19:19) @ 1% at tillering and panicle initiation stage; F_4: Nano NPK (19:19:19) @ 1.5% at tillering and panicle initiation stage; N_1: Vermicompost @100% RDN; N_2: Vermicompost @ 75% RDN; N_3: Vermicompost @ 50% RDN.

Table 3: Economics for green pea in relation to the residual effect of nano fertilizers and organic sources of nitrogen.

Treatment combinations	Total cost of cultivation	Gross return			Net return			B:C ratio		
		2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
N_1F_1	24700	114666	106517	110591	89966	81817	85891	3.6	3.3	3.5
N_1F_2	24700	167334	192167	179750	142634	167467	155050	5.8	6.8	6.3
N_1F_3	24700	176050	194000	185025	151350	169300	160325	6.1	6.9	6.5
N_1F_4	24700	232080	244067	238073	207380	219367	213373	8.4	8.9	8.6
N_2F_1	24700	101667	98127	99897	76967	73427	75197	3.1	3.0	3.0
N_2F_2	24700	134800	190633	162717	110100	165933	138017	4.5	6.7	5.6
N_2F_3	24700	168220	192317	180269	143520	167617	155569	5.8	6.8	6.3
N_2F_4	24700	185884	213186	199535	161184	188486	174835	6.5	7.6	7.1
N_3F_1	24700	98713	89452	94082	74013	64752	69382	3.0	2.6	2.8
N_3F_2	24700	142168	143933	143050	117468	119233	118350	4.8	4.8	4.8
N_3F_3	24700	166371	186600	176486	141671	161900	151786	5.7	6.6	6.1
N_3F_4	24700	168483	195667	182075	143783	170967	157375	5.8	6.9	6.4

F_1: Control; F_2: Nano NPK (19:19:19) @ 0.5% at tillering and panicle initiation stage; F_3: Nano NPK (19:19:19) @ 1% at tillering and panicle initiation stage; F_4: Nano NPK (19:19:19) @ 1.5% at tillering and panicle initiation stage; N_1: Vermicompost @100% RDN; N_2: Vermicompost @ 75% RDN; N_3: Vermicompost @ 50% RDN.

return (Rs. 69382) and a B:C ratio of (2.8). Higher net returns and a better B:C ratio might have been caused by the production of more yield in combination with a higher market price for greenpea seeds. The outcome of Ajithkumar *et al.* (2021) is consistent with the outcomes of this study.

CONCLUSION

The use of nanotechnology in agriculture is still in its infancy. However, it has the ability to completely transform agricultural systems, particularly when it comes to concerns about the use of fertilizer. Application of nanofertilizers encouraged green pea growth, development and has the potential to enhance crop productivity and plant nutrition. On the other hand, applying organic sources of nutrients to the previous crop greatly benefits the following crop by improving the availability of N, P, K and organic carbon in soils, helping to provide the best direct and residual effect on the availability of soil nutrients, plant nutrient uptake and soil enrichment of the rhizosphere with micro and macronutrients, so the higher the rate of application, the more residual effect should be on the soil. The results of this study will be useful for future investigations into the use of vermicompost and nanotechnology in agriculture.

Conflict of Interest

The authors declare that there are no conflicts of interest within them.

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