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Ningombam Menaka Devi
M.Sc. Scholar, Department of Agronomy, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur India

Kshetrimayum Manishwari Devi
Assistant professor, Department of Agronomy, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur India

Corresponding Author:
Ningombam Menaka Devi
M.Sc. Scholar, Department of Agronomy, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur, Manipur India

Effect of organic and inorganic nitrogenous fertilizers on growth and yield of field pea (*Pisum sativum* L.)

Ningombam Menaka Devi and Kshetrimayum Manishwari Devi

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Abstract
A field experiment was conducted at the Agricultural Experimental Field of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur during the *rabi* season of the year 2022-2023 to study the "Effect of organic and inorganic nitrogenous fertilizers on growth and yield of Field pea (*Pisum sativum* L.)". The experiment was laid out in Randomized Block Design (RBD) comprising seven treatments viz; T_1: Control, T_2: 100% RDN, T_3: 50% RDN + 50% VC (RDN), T_4: 25% RDN +75% VC (RDN), T_5: 100% VC (RDN), T_6: 50% VC (RDN) and T_7: 25% VC (RDN) with three replications. Result revealed that maximum plant height, number of leaves per plant, number of branches, fresh and dry weight of plant, seed yield and its attributing characters like number of pods per plant, number of seeds per pod, pod length, test weight, stover yield as well as harvest index were associated with T3. Available pH, and NPK content of soil was also found to be maximum in T3, however highest soil organic carbon content was found in treatment application of T5. Moreover, T3 recorded maximum gross return (₹/ha 109600), net return (₹/ha 64675) and B: C ratio (1.43). Thus from the present investigation, it can be inferred that application of 50% RDN (urea) + 50% VC (RDN) proved to be more productive and profitable for the cultivation of pea during *rabi* season of Manipur.

Keywords: Pea, Nitrogenous fertilizer, urea, organic, vermicompost

1. Introduction
Pulses are rich source of dietary protein for the majority of the vegetarian population and it also occupy special place in diets of the Indian and the tribal population in the North Eastern Region (NER) of India (Rangappa *et al*., 2024) [22]. Pulses occupy a unique position in agricultural economy by virtue of their ability to fix nitrogen in symbiotic association with Rhizobium, not only meeting the nitrogen requirement for themselves but they also leave nitrogen in the soil which is made available to the next crop and release phosphorus that is bonded to the soil, greatly reducing the requirement for synthetic fertilizers. By lowering reliance on synthetic fertilizers to the soil, pulses can help mitigate the effects of climate change (FAO, 2016) [10]. Nevertheless, pulses are also known to render significant impact on soil health and considered to be key component for sustainable agriculture (Devi *et al*., 2023; Laishram *et al*., 2023) [8, 16]. Among the pulses crops, pea is one of the most adaptable and highest demanding crop. Pea is the third most important pulse crop at global level, after dry bean and chickpea and third most popular *rabi* pulse of India after chick pea and lentil. India occupy fourth position in area (10.53 %) and 5th position in production (6.96 %) (FAOSTAT, 2017) [11].
Pea (*Pisum sativum* L.) a highly nutritive winter vegetable crops of the Fabaceae family, which is commercially grown during *rabi* season in India. Pea is an important and ideal pulse crop with enriched palatable protein having immense potential to enhance farm income as well as increase cropping intensity (Das *et al*., 2016) [6]. They are a cool-season crop which thrive in moist and cool regions; and need frost-free conditions, particularly during their flowering and pod-formation stages. Peas are usually grown for its fresh green pods or dry seeds and sugary pods, which are cooked alone or mixed with other vegetables and is also processed for freezing, canning and dehydration to meet its various nutrients like protein and carbohydrates (Tulbek *et al*., 2017) [29]. In addition to culinary uses, pea can be used as supplement in forage crop mixtures with small grain to feed swine, feeder calf, dairy and poultry rations.

In Manipur Peas have been cultivated for aeons and have continued to grow ever since. Native pea cultivars of Manipur include Makuchabi, Makhyatmubi, and Ningtekpi, etc., (Baite *et al*., 2023) [2] and are primarily cultivated in the winter season. In Manipur, farmers heavily rely on off-season production of vegetables including peas, and suitable soil and climate for these crops in order to obtain greater returns (ICAR, 2024) [15].

Nitrogen is one of the vital nutrients of plants which help in plant growth by increasing leaf area production resulting in higher photosynthetic activity. Lack of sufficient nitrogen supply will affect the plant growth as well as photosynthetic activity which affect symbiosis. Supplementing Nitrogen through urea is a cost effective and efficient practice to enhance the crop establishment under various environmental conditions and improve crop growth and yield (Devi *et al*., 2023) [9]. It also helps to increase the protein content of pea. A healthy plant often had 3 to 4 % of nitrogen in their above ground tissues and it is one of the most highly concentrated nutrients compared to other nutrient. It also played various important role in soil fertility process also. Plants contain nitrogen in inorganic forms NH_4+ and NO_3-. Nitrogen helps in increasing of yield as well as food quality. Optimum rate of N increases various functions of plants like photosynthetic processes, leaf area production, leaf area duration and net assimilation rate (Leghari *et al*., 2016) [18]. Nitrogen is one of the important elements for growth of plants and its deficiency is one of the major factors for reducing crop production (Fathi and Zeidali, 2021) [12]. Vermicompost is an organic fertilizer that is rich in nutrients and has a high concentration of humus, nitrogen (2.3%), phosphorus (1.55-2.25%), potassium (1.85-2.25%), micronutrients, and more advantageous soil microorganisms such as "nitrogen-fixing bacteria" and mycorrhizal fungi (Rekha *et al*., 2018) [23]. Scientific research has demonstrated that vermicompost is a miraculous plant growth booster (Chaoui *et al*., 2003) [3].

In agricultural production, choosing the appropriate nutrient management is crucial to achieving optimum yield and quality; otherwise, productivity declines and chemical composition weakens. It is widely known that the haphazard use of chemical fertilizers in the absence of organic manures deteriorates the biological and physico-chemical characteristics of soil. On the other hand, as a result of favourable soil conditions, combined application of inorganic and organic fertilizer improves moisture holding capacity, micronutrient delivery, and major nutrient availability to the plant (Shijagurumayum *et al*., 2022) [24], soil health and enhances ecosystem services (Gogoi *et al*., 2021) [13]. Due to the paucity of information available on these topics, the current study was conducted to study the effect of organic and inorganic nitrogenous fertilizers on growth and yield of field pea under Manipur condition.

2. Material and Methods

The experiment was conducted during the *Rabi* season of 2022-2023 at the Agricultural Experimental Field of Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District, Manipur (Latitude: 24.72°N and Longitude: 93.86°E) with an elevation of 790 m above sea level (Fig. 1). The texture of the experimental soil was clay with pH 4.6, EC 0.4 dS/m and O.C 1.6%. Available N, P and K in the soil were 220 kg/ha, 33.9 kg/ha and 295 kg/ha respectively. The experiment was laid out in Randomized Block Design (RBD) with three replications having seven treatments. The treatments comprise of T1: Control, T2: 100% RDN, T3: 50% RDN + 50% VC (RDN), T4: 25% RDN +75% VC (RDN), T5: 100% VC (RDN), T6: 50% VC (RDN) and T7: 25% VC (RDN).The pea variety *Rachna* was sown in line with spacing 30 × 10 cm and seed rate of 60 kg/ha. Ratio of NPK was 20:60:40 Kg/ha, in which full dose of 60 kg/ha phosphorus and potassium 40 kg/ha in form of SSP and MOP were applied to all the treatments. Urea and vermicompost were used as inorganic and organic source of nitrogen. Biometric parameters namely plant height, number of leaves, number of branches, fresh and dry weight were recorded. Yield attributing parameters like number of pods per plant, number of seeds per pod, pod length and test weight were recorded at harvest. Grain and stover yields were recorded plot wise and then expressed as q/ha. The economics of the pea were calculated as per the yield and cost of cultivation obtained and expressed as ₹/ha. The post-harvest soil pH, OC and available NPK were analysed after harvesting of pea and expressed in kg/ha. To observe the significance of differences between the treatments, data were statistically analysed following Gomez and Gomez (1984) [14]. The statistical differences of the data generated for each character were tested with least significant difference (LSD) at 5% probability level using analysis of variance technique (ANOVA).

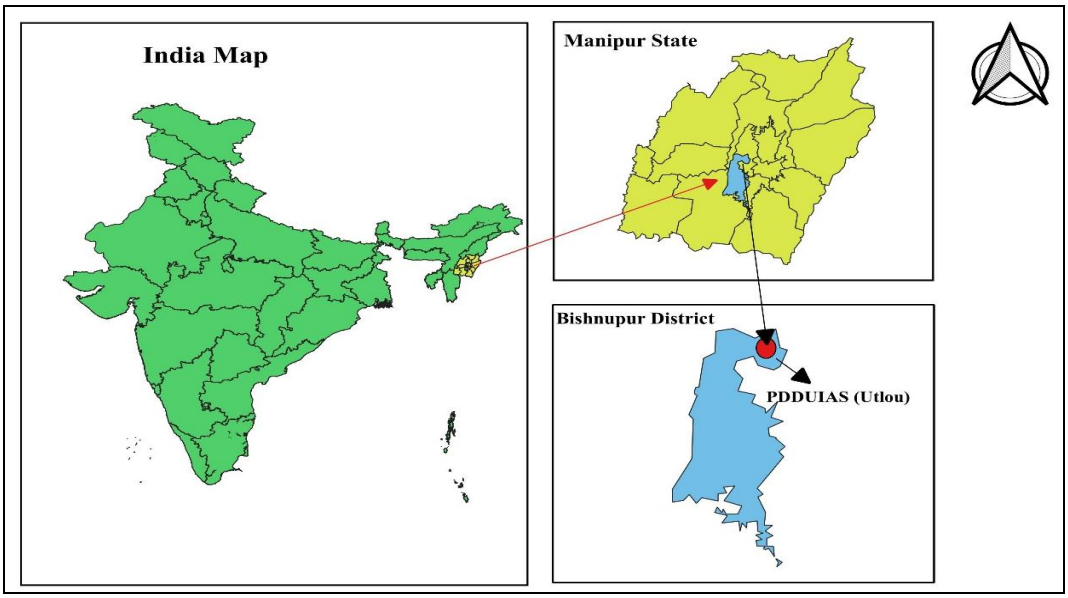

Fig 1: Map of the experimental area, PDDUIAS, Utlou, Bishnupur District, Manipur, India

3. Results and Discussion

3.1 Effect of organic and inorganic nitrogenous fertilizers on growth of pea

The analysed data regarding plant height, number of leaves per plant, number of branches per plant, fresh and dry weight at harvest was highest in T_3: 50% RDN + 50% VC (RDN) while T_1 (control) achieves the lowest growth attributes of pea (Table 1). All the treatment with integrated source of organic and inorganic nitrogen application performed better than sole application of recommended dose of inorganic fertilizer or organic application. This might be due to the increased in balanced supply of nutrient through this specific treatment combination of inorganic and organic sources of nitrogenous fertilizers to plants that have satisfied the required nutrient at different growth stages result in proper establishment of plants. The increased in plant height might be due to the increase in nutrient content as a result of mineralization of inorganic and organic fertilizers thereby increased in sufficient supply of nutrients which led to fast growth of plant. These findings are in consistency to those achieved by Ram *et al.* (2021) [21]. The significant increase in number of leaves per plant and number of branches per plant might be due to sufficient available of nutrient from combined used of organic and inorganic fertilizers which was in accessible form in initial stages of plant growth and concomitantly giving rise to increase in number of leaves. Similar finding was also reported by Baharvand *et al.* (2014) [1] and Tyagi and Singh (2019) [30]. Moreover, highest fresh and dry weight of plant was also found in T_3: 50% RDN + 50% VC (RDN) followed by T_4: 25% RDN + 75% VC (RDN). This might be probably due to better plant height, number of leaves per plant and number of branches per plant. The result corroborated with the finding of Mahto and Yadav (2005) [19].

Table 1: Effect of organic and inorganic nitrogenous fertilizers on growth attributes of pea

Treatment	Plant height (cm)	No. of leaves per plant	No. of branches per plant	Fresh weight (g) at harvest	Dry weight (g)at harvest
T_1: Control	36.06	49.57	2.69	39.57	5.60
T_2: 100% RDN	45.06	54.34	3.13	40.64	6.88
T_3: 50% RDN + 50% Vermicompost (RDN)	48.58	58.34	3.64	45.51	8.59
T_4: 25% RDN + 75% vermicompost (RDN)	47.35	56.70	3.39	44.35	8.08
T_5: 100% vermicompost (RDN)	45.61	55.73	3.26	42.41	7.80
T_6: 50% vermicompost (RDN)	44.40	53.20	2.85	39.84	6.65
T_7: 25% vermicompost (RDN)	43.76	51.53	2.73	39.69	6.35
SEm (±)	0.63	0.30	0.03	0.01	0.02
CD (p=0.05)	0.52	0.93	0.11	0.05	0.06

3.2 Effect of organic and inorganic nitrogenous fertilizers on yield and yield attributes of pea

Perusal of data revealed that yield and yield attributes of pea was significantly influenced by application of organic and inorganic nitrogenous fertilizers (Table 2). The treatment T_3: 50% RDN + 50% VC (RDN) recorded the maximum no. of pods per plant, no. of seeds per pod and pod length. The higher number of branches in this treatment influenced higher number of pods per plant. This might be due to balanced supply of nutrient through organic and inorganic sources to plants that promotes better plant growth, flowering and fruiting which resulted in higher number of pods per plant. These findings are in corroboration with those obtained by Chauhan *et al.* (2010) [4]. The maximum no. of seeds per pod and pod length (cm) might be due to the constant and optimum supply of nutrient through this specific treatment that have satisfied the nutrition demand of plant at different growth stages. These results are in accordance with the findings of Shivran *et al.* (2016) [25] and Rajiv and Saurabh (2021) [20]. The test weight did not show significantly different among the treatments, but the highest number of test weight was found in T_3 (250.74 g) and the lowest test weight was found in T_1 (243.80 g). The seed yield, stover yield and harvest index was also found maximum in T_3 and significantly better comparing to other treatments. Higher seed yield in T_3 could be due to the various yield attributing characters like no. of pods per plant and no. of seeds per pod. The higher growth attributes like plant height, no. of leaves, no. of branches also reflected on the stover yield. Moreover, the significant increase in harvest index might be due to the fact that this specific treatment combination has recorded better economic and biological yield. Similar findings were also reported by Chauhan *et al.* (2010) [4], Shivran *et al.* (2016) [25], Tyagi and Singh (2019) [30], Yambem *et al.* (2020) [31] and Singh *et al.* (2022) [27].

Table 2: Effect of organic and inorganic nitrogenous fertilizers on yield attributes

Treatment	No. of pods per plant	Seeds per pod	Pod length (cm)	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
T_1: Control	9.31	3.10	4.20	243.80	7.40	10.43	35.81
T_2: 100% RDN	10.35	5.17	6.91	249.91	9.64	14.47	38.52
T_3: 50% RDN + 50% Vermicompost (RDN)	12.45	7.13	8.16	250.74	13.70	19.68	42.12
T_4: 25% RDN + 75% vermicompost (RDN)	11.53	6.88	7.97	250.73	12.38	18.03	40.70
T_5: 100% vermicompost (RDN)	10.60	5.60	7.25	250.15	12.17	16.41	39.38
T_6: 50% vermicompost (RDN)	10.19	4.65	6.46	249.51	9.26	12.93	37.22
T_7: 25% vermicompost (RDN)	9.95	4.33	5.73	248.01	9.13	11.66	36.46
SEm (±)	0.04	0.06	0.07	1.42	0.03	1.00	0.20
CD (P= 0.05)	0.13	0.14	0.23	N.S	0.09	1.00	0.63

3.3 Effect of organic and inorganic nitrogenous fertilizers on post- harvest soil status

Irrespective of the treatments, the pH did not exhibit any significant difference after harvest of the crop. However, highest pH was found in T_3 and T_1 (control) achieved the lowest pH. The highest organic carbon was found in T_5: 100% VC (RDN)

followed by T_4: 25% RDN + 75% VC (RDN) (Table 3). This might be due to the application of higher quantity of vermicompost in soil, which encourages growth of more biomass production as well as shedding of plants leaves and more production of roots biomass contributes more organic carbon after crop harvest. The highest N was estimated in T_3. Investigators indicated that the application of vermicompost played a key role in atmospheric nitrogen fixation as it is high in microbial population and concomitantly influenced by combined application of organic and inorganic nitrogenous fertilizers (Larkra *et al*., 2017) [17]. Application of inorganic and organic sources of nitrogen aids in increased solubilisation of insoluble phosphorous with the help of organic acids like aliphatic acids released from breakdown of organic fertilizers as well as inorganic nitrogenous fertilizers helps in increased the activity of soil microbial population consequently increased in transformation of unavailable potassium into available form. These findings are in consistency to those achieved by Singh *et al*. (2016) [25], Ram *et al*. (2021) [21] and Devi *et al*. (2010) [7].

Table 3: Effect of organic and inorganic nitrogenous fertilizers on post-harvest soil status

Treatment	pH	Organic carbon %	Available NPK (Kg/ha)		
			N	P	K
T_1: Control	4.63	1.63	238.66	33.94	318.67
T_2: 100% RDN	4.67	1.80	245.50	37.33	323.74
T_3: 50% RDN + 50% Vermicompost (RDN)	4.90	2.27	252.67	40.42	328.76
T_4: 25% RDN + 75% vermicompost (RDN)	4.85	2.60	250.47	39.64	326.42
T_5: 100% vermicompost (RDN)	4.77	2.62	248.20	38.15	324.87
T_6: 50% vermicompost (RDN)	4.73	2.11	242.63	35.69	322.67
T_7: 25% vermicompost (RDN)	4.70	2.00	240.32	34.76	320.64
SEm (±)	0.05	0.03	0.42	0.21	0.26
CD (P= 0.05)	N.S	0.09	1.47	0.68	0.83

3.4 Economics

The economic return of field pea cultivation is an important factor since it shows the benefit while implementing a specific treatment. The highest cost of cultivation (₹50899) was obtained from T_5: 100% VC (RDN) (Table 4). This might be due to higher cost of organic source of nitrogenous fertilizer *i.e*. vermicompost. The highest net return was obtained in T_3 (₹64675). Similar finding was also reported by Chongloi and Sharma (2019) [5] from sole pea cultivation with nutrient management of 50% N through vermicompost and 50% N through inorganic fertilizers. The highest B: C ratio was obtained in T_3 (1.43) and lowest return was obtained in T_1 (0.55). The highest gross return was obtained in T_3 (₹109600). Similar finding was also reported by Thaneshwar *et al*. (2017) [28].

Table 4: Effect of organic and inorganic nitrogenous fertilizers on economics

Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
T_1: Control	37999	59200	21201	0.55
T_2: 100% RDN	38951	77120	38169	0.97
T_3: 50% RDN + 50% Vermicompost (RDN)	44925	109600	64675	1.43
T_4: 25% RDN + 75% vermicompost (RDN)	47762	99040	51278	1.07
T_5: 100% vermicompost (RDN)	50899	97360	46461	0.91
T_6: 50% vermicompost (RDN)	44299	74080	29781	0.67
T_7: 25% vermicompost (RDN)	41299	73040	31741	0.76

4. Conclusion

Based on the results from the experiment it can be concluded that application of organic and inorganic nitrogenous fertilizers (T_3: 50 % RDN + 50% VC RDN) significantly increase the growth parameters (plant height, number of leaves per plant, number of branches per plant, fresh and dry weight of plant) and yield attributing factors (number of pods per plant, number of seeds per pod, pod length) over control. Seed yield, stover yield and harvest index were significantly higher with the application of 50% RDN + 50 % VC (RDN) compared to control. The soil post-harvest status organic carbon, nitrogen, phosphorus, potassium content in soil were significant. The economic analysis of the experiment revealed that highest cost of cultivation was observed in 100% VC (RDN). The highest net return, gross return and B:C ratio were obtained in 50% RDN + 50% VC (RDN). Therefore, applying organic fertilizer in addition to inorganic fertilizer at the right amounts of nutrients may be a sustainable way to enhance the Manipur pea's growth, yield, and yield attributing characteristics as well as its economics and soil health.

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