

Original Research Article

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Impact of Integrated Nutrient Management on Yield and Yield Attributes of Pea (*Pisum sativum* L.) in Arunachal Pradesh, India

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ABSTRACT

A field experiment was conducted at the Himalayan University Agriculture Field, Jollang, Itanagar, Arunachal Pradesh during the Rabi season of 2025–26 with seven treatments replicated thrice in Randomized Block Design (RBD), to determine the “Integrated Nutrient Management: An Impact on Nutritional Food Security, Growth and Yield of Pea (*Pisum sativum* L.) in Arunachal Pradesh”. The available nutrient status of the experimental field showed high nitrogen (N), low phosphorus (P) and medium potassium (K) levels. The experiment included the following treatments i.e., T₁ – Control, T₂ – 50% NPK + Vermicompost + Rhizobium, T₃ – 75% NPK + Vermicompost + Rhizobium, T₄ – 75% NPK + 25% Vermicompost + Rhizobium, T₅ – 100% NPK + 0% Vermicompost + Rhizobium, T₆ – 125% NPK + Vermicompost + Rhizobium and T₇ – 150% NPK + 150% Vermicompost + Rhizobium. Highest number of pods per plant (29), number of seeds per pod (8.6) and test weight (13.86 g) were recorded with application of T₇ (150% NPK + 150% Vermicompost + Rhizobium). Lowest values for these parameters were recorded under absolute control (T₁). Significantly higher seed yield (11.02 q ha⁻¹), biological yield (25.25 q ha⁻¹) and harvest index (44.60%) were recorded with application of T₇ followed by T₄. Significantly lower seed yield, stover yield, biological yield and harvest index were recorded under absolute control treatment T₁.

Keywords

Integrated Nutrient Management (INM)
Pea
(*Pisum sativum* L.)
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Introduction

Global agriculture is presently facing a major challenge of ensuring food and nutritional security for a rapidly increasing population while combating widespread micronutrient and protein malnutrition, commonly referred to as “hidden hunger.” According to reports of the Food and Agriculture Organization and the United Nations, billions of people worldwide continue to suffer

from deficiencies of essential nutrients such as protein, iron, and zinc, particularly in developing countries where access to animal-based protein sources is limited. Under such circumstances, nutritionally rich plant-based food systems are considered a sustainable and economical solution for improving human nutrition and health. Among plant-based food resources, grain legumes or pulses occupy a significant position due to their high nutritional value and ecological importance. Pulses are

rich sources of protein, carbohydrates, dietary fiber, vitamins, and minerals, and generally contain two to three times more protein than cereal crops such as rice, wheat, and maize. Besides their dietary importance, legumes improve soil fertility through biological nitrogen fixation in association with symbiotic Rhizobium bacteria. This natural process reduces dependence on chemical nitrogen fertilizers and contributes to sustainable agricultural production systems by improving soil health and reducing environmental pollution (Jensen *et al.*, 2020).

Among the pulse crops, pea (*Pisum sativum L.*, 2n = 14) is one of the most important cool-season legumes cultivated throughout temperate, subtropical, and high-altitude tropical regions of the world (Zohary and Hopf, 2000). Pea is widely consumed as a vegetable, pulse, and processed food because of its high nutritive value and palatability. The seeds contain approximately 21–25 percent protein along with appreciable amounts of lysine, dietary fiber, iron, zinc, phosphorus, potassium, and magnesium (Khattab *et al.*, 2009). Since cereals are generally deficient in lysine, pea protein serves as an excellent supplement in cereal-based diets and helps improve overall protein quality (Upadhyaya *et al.*, 2016).

In addition to protein, pea grains are valuable sources of essential micronutrients such as iron and zinc, which are important for human growth, immunity, and metabolic functions. However, the nutritional availability of these minerals may be affected by anti-nutritional compounds such as phytic acid, tannins, and protease inhibitors present in the seeds. Therefore, appropriate agronomic practices capable of improving nutrient uptake and accumulation in the grain are essential for enhancing the nutritional quality of pea (Amarakoon *et al.*, 2012).

Despite its high nutritional and agronomic importance, pea productivity often remains below potential levels due to improper and imbalanced nutrient management practices. Modern agriculture has become highly dependent on chemical fertilizers, particularly nitrogenous and phosphatic fertilizers, for obtaining higher crop yields. Although these fertilizers initially improve productivity, continuous and excessive use without adequate organic supplementation has resulted in declining soil fertility, nutrient imbalance, reduction in soil organic carbon, and deterioration of soil biological activity (Hazra *et al.*, 2019). Long-term dependence on inorganic fertilizers may also adversely affect soil structure, microbial diversity, and nutrient-use efficiency.

In leguminous crops such as pea, excessive application of nitrogen fertilizers may suppress biological nitrogen fixation. Under conditions of high soil nitrogen availability, the host plant reduces nodulation and nitrogenase activity because the crop preferentially utilizes readily available mineral nitrogen instead of maintaining symbiotic association with Rhizobium bacteria (Sulieman and Tran, 2014). Similarly, phosphorus applied through chemical fertilizers may become chemically fixed in the soil, especially under acidic or alkaline conditions, thereby reducing its availability to plants and decreasing fertilizer-use efficiency (Bhattacharyya *et al.*, 2015).

To overcome these limitations and maintain long-term soil productivity, Integrated Nutrient Management (INM) has emerged as an important strategy in sustainable agriculture. INM involves the combined and judicious use of inorganic fertilizers, organic manures, and biofertilizers to achieve optimum crop productivity while maintaining soil fertility and environmental sustainability (Subba Rao *et al.*, 2021). Integrated use of different nutrient sources helps synchronize nutrient release with crop demand, reduces nutrient losses through leaching and volatilization, and improves nutrient-use efficiency. Inorganic fertilizers provide readily available nutrients during the early stages of crop growth, whereas organic manures release nutrients gradually through microbial decomposition and improve soil physical, chemical, and biological properties.

Among the organic nutrient sources, vermicompost has gained considerable importance because of its beneficial effects on soil fertility and crop growth. Vermicompost is produced through the decomposition of organic wastes by earthworms and microorganisms, resulting in a nutrient-rich and biologically active organic amendment. It contains readily available nutrients, humic substances, beneficial microorganisms, vitamins, enzymes, and plant growth regulators such as auxins, gibberellins, and cytokinins (Atiyeh *et al.*, 2002). Application of vermicompost improves soil aggregation, water-holding capacity, cation exchange capacity, and microbial activity. Humic and fulvic acids present in vermicompost also stimulate root growth and nutrient absorption by enhancing root surface area and membrane permeability (Pathma and Sakthivel, 2012). Furthermore, vermicompost improves the availability and uptake of micronutrients such as iron and zinc through chelation mechanisms, thereby contributing to enhancement of the nutritional quality of crop produce.

Biofertilizers, particularly *Rhizobium* inoculants, also play a significant role in sustainable pulse production systems. Host-specific *Rhizobium leguminosarum* establishes a symbiotic association with pea roots and forms nodules capable of fixing atmospheric nitrogen into plant-available forms. Within the nodules, specialized bacterial cells synthesize the nitrogenase enzyme complex responsible for nitrogen fixation. Functional nodules contain leghaemoglobin, a pink-colored oxygen-binding protein that maintains a low oxygen environment necessary for nitrogenase activity while supporting bacterial respiration. The biologically fixed nitrogen produced through this symbiosis contributes directly to vegetative growth, protein synthesis, and seed development in pea (Schiltz *et al.*, 2005).

Although several studies have independently examined the effects of chemical fertilizers, organic manures, and biofertilizers on pulse crops, limited information is available regarding the combined influence of NPK fertilizers, vermicompost, and *Rhizobium* inoculation on growth, yield, harvest index, and nutritional quality of pea under integrated nutrient management systems. Since improvement in both crop productivity and nutritional quality is essential for ensuring food and nutritional security, systematic evaluation of integrated nutrient management practices in pea is highly necessary.

Therefore, the present investigation entitled “Impact of Integrated Nutrient Management on Nutritional Food Security, Growth, and Yield Attributes of Pea (*Pisum sativum L.*)” was undertaken with the following objectives:

Materials and Methods

The experiment was conducted during the *Rabi* season of 2025 at Himalayan University in Itanagar. The Crop Research Farm is located in Jollang on the university campus, situated at 27.14 N latitude and 93.62 E longitude, at an altitude of 320 metres above sea level. The site belongs to the Eastern Himalayan Region, and the agro-climatic zone falls under the sub-tropical zone of Arunachal Pradesh. Soil Samples drawn randomly from 0 to 15 cm depth were analysed for physical and chemical properties. The soil was sandy loam and chemical analysis indicate that soil is acidic in reaction, medium in organic carbon, high in nitrogen, low in phosphorus and medium in potassium. The pea variety indigenous the experiment was laid out in randomized

block desing (RBD) with seven treatments and three replications. The plot size was 3 m x 3m with a spacing of 20 cm x 10 cm. the treatment were as follows:

1. T₁: Control
2. T₂: 0% NPK + Vermicompost + *Rhizobium*
3. T₃: 50% NPK + Vermicompost + *Rhizobium*
4. T₄: 75% NPK +25% Vermicompost + *Rhizobium*
5. T₅: 100% NPK + 0% Vermicompost + *Rhizobium*
6. T₆: 100% NPK + 100% Vermicompost + *Rhizobium*
7. T₇: 150% NPK + 150% Vermicompost + *Rhizobium*

Results and Discussion

The data pertaining to yield attributes and yield of pea (*Pisum sativum L.*) were analysed statistically and presented in the following tables. Significant variation was observed among the treatments. The treatment T₇ (150% NPK + Vermicompost + *Rhizobium*) outperformed other treatments, followed by T₅ (100% NPK + Vermicompost) and T₆ (100% NPK + *Rhizobium*). These results reflect the higher efficiency of integrated nutrient management practices in improving yield attributes and productivity of pea crop. Similar findings were reported by Sharma *et al.*, (2020), Kumar and Singh (2021), and Meena *et al.*, (2022), where combined application of inorganic fertilizers, organic manure, and biofertilizer significantly improved yield parameters in legume crops.

The number of pods per plant recorded at harvest is presented in Table 1. The data showed that there was a significant effect of different treatments on the number of pods per plant of pea. Among treatments, significantly higher number of pods per plant (29.6) was observed with T₇ treatment (150% NPK + 150% Vermicompost + *Rhizobium*) which remained on par with T₅ treatment (24) and T₆ treatment (23). Whereas, the significantly lower number of pods per plant (16.3) was recorded under control treatment (T₁).

The increased number of pods per plant observed under T₇ treatment may be attributed to the synergistic effect of inorganic fertilizer, vermicompost, and biofertilizer. Vermicompost improves soil physical properties and microbial activity, while *Rhizobium* enhances biological nitrogen fixation and nutrient availability. The combined effect created a favourable environment for better flowering and pod formation in pea crop. Similar findings were reported by Singh *et al.*, (2019) and Kumar *et al.*, (2021).

The number of seeds per pod recorded at harvest is presented in Table 2. The data indicated that different treatments significantly influenced the number of seeds per pod in pea. Significantly higher number of seeds per pod (8.3) was recorded under T₇ treatment, followed by T₅ (7.2) and T₆ (6.5). The lowest number of seeds per pod (5.18) was recorded under control treatment.

The increase in seeds per pod under integrated nutrient management practices may be due to improved nutrient uptake, enhanced photosynthetic activity, and efficient translocation of assimilates towards reproductive parts. Similar observations were also reported by [Sharma and Verma \(2020\)](#) in pea crop under combined nutrient management practices.

The test weight recorded at harvest is presented in Table 3. The data indicated that different treatments significantly influenced the test weight of pea. Among treatments, significantly higher test weight (11.0 g) was recorded under T₇ treatment, followed by T₅ (8.3 g) and T₆ (7.2 g). Whereas, the significantly lower test weight (4.7 g) was recorded under control treatment.

The increased test weight under integrated nutrient management practices may be attributed to improved nutrient availability, enhanced nitrogen fixation, and better translocation of photosynthates towards seed development. Vermicompost improves soil fertility and microbial activity, while Rhizobium enhances nitrogen supply, resulting in bold and healthy seeds. Similar findings were also reported by [Sharma et al., \(2021\)](#).

The seed yield recorded at harvest is presented in Table 4. The data revealed that different treatments had significant influence on seed yield of pea. Significantly higher seed yield (11.0 t ha⁻¹) was observed under T₇ treatment, followed by T₅ (9.1 t ha⁻¹) and T₆ (8.3 t ha⁻¹), while significantly lower seed yield (1.42 t ha⁻¹) was recorded under control treatment.

The increase in seed yield under integrated nutrient management might be attributed to better growth and yield attributes, increased nutrient use efficiency, and enhanced dry matter accumulation. Combined use of NPK, vermicompost, and Rhizobium improved soil fertility and created favourable conditions for higher productivity of pea crop. Similar findings were also reported by [Yadav et al., \(2021\)](#).

The biological yield recorded at harvest is presented in Table 5. The data indicated significant variation among treatments with respect to biological yield. Significantly higher biological yield (25.2 t ha⁻¹) was recorded under T₇ treatment, whereas the lowest biological yield (11.9 t ha⁻¹) was observed under control treatment.

The higher biological yield under integrated nutrient management may be due to increased vegetative growth, improved nutrient availability, and enhanced dry matter production throughout the crop growth period. Similar results were reported by [Patel et al., \(2020\)](#).

The harvest index recorded at harvest is presented in Table 6. Significant differences among treatments were observed for harvest index of pea. Significantly higher harvest index (44.6%) was observed under T₇ treatment, followed by T₅ (44.2%).

The lowest harvest index (37.2%) was recorded under control treatment.

The increase in harvest index under integrated nutrient management may be attributed to efficient partitioning of photosynthates towards economic yield. Combined application of inorganic fertilizers, vermicompost, and Rhizobium improved crop growth and yield efficiency, thereby increasing harvest index in pea crop. Similar findings were reported by [Meena et al., \(2021\)](#).

In conclusion, the present investigation revealed that integrated nutrient management practices significantly influenced the yield attributes and yield of pea (*Pisum sativum* L.). Among all the treatments, T₇ (150% NPK + Vermicompost + Rhizobium) recorded the highest number of pods per plant, number of seeds per pod, test weight, seed yield, biological yield, and harvest index.

The superior performance of this treatment may be attributed to balanced nutrient supply, improved soil health, enhanced microbial activity, and efficient nutrient uptake resulting from the combined application of inorganic fertilizers, organic manure, and biofertilizer.

Therefore, it may be concluded that the integrated use of chemical fertilizers along with vermicompost and Rhizobium inoculation has great potential to improve productivity, profitability, and soil fertility in pea cultivation under the agro-climatic conditions of Arunachal Pradesh.

Table.1 Effect of treatments on number of pods per plant of pea.

Treatment	Number of pods plant ⁻¹
T₁ – Control	16.3
T₂-0% NPK +Vermicompost +Rhizobium	18.6
T₃-50% NPK + Vermicompost + Rhizobium	21
T₄- 75% NPK +25% Vermicompost + Rhizobium	29
T₅: 100% NPK + 0% Vermicompost + Rhizobium	24
T₆: 100% NPK + 100% Vermicompost + Rhizobium	23
T₇: 150% NPK + 150% Vermicompost + Rhizobium	29.6
F test	S
S.Ed (±)	1.0
CD (P=0.05)	2.1

Table.2 Effect of treatments on number of seeds per pod of pea

Treatment	Number of seeds
T₁ – Control	5
T₂-0% NPK +Vermicompost +Rhizobium	5.6
T₃-50% NPK + Vermicompost + Rhizobium	6.1
T₄- 75% NPK +25% Vermicompost + Rhizobium	8.0
T₅: 100% NPK + 0% Vermicompost + Rhizobium	7.2
T₆: 100% NPK + 100% Vermicompost + Rhizobium	6.5
T₇: 150% NPK + 150% Vermicompost + Rhizobium	8.3
F test	S
S.Ed (±)	0.1
CD (P=0.05)	0.4

Table.3 Effect of treatments on test weight (g) of pea

Treatment	Test weight (g)
T₁ – Control	4.7
T₂-0% NPK +Vermicompost +Rhizobium	5.3
T₃-50% NPK + Vermicompost + Rhizobium	6.5
T₄- 75% NPK +25% Vermicompost + Rhizobium	9.1
T₅: 100% NPK + 0% Vermicompost + Rhizobium	8.3
T₆: 100% NPK + 100% Vermicompost + Rhizobium	7.2
T₇: 150% NPK + 150% Vermicompost + Rhizobium	11.0
F test	S
S.Ed (±)	0.2
CD (P=0.05)	0.6

Table.4 Effect of treatments on seed yield (t ha⁻¹) of pea

Treatment	Seed yield (t-ha ⁻¹)
T ₁ – Control	4.7
T ₂ -0% NPK +Vermicompost +Rhizobium	5.3
T ₃ -50% NPK + Vermicompost + Rhizobium	6.5
T ₄ - 75% NPK +25% Vermicompost + Rhizobium	7.2
T ₅ : 100% NPK + 0% Vermicompost + Rhizobium	9.1
T ₆ : 100% NPK + 100% Vermicompost + Rhizobium	8.3
T ₇ : 150% NPK + 150% Vermicompost + Rhizobium	11.0
F test	S
S.Ed (±)	0.7
CD (P=0.05)	1.5

Table.5 Effect of treatments on biological yield (t ha⁻¹) of pea

Treatment	Biological yield (t ha ⁻¹)
T ₁ – Control	11.9
T ₂ -0% NPK +Vermicompost +Rhizobium	14.5
T ₃ -50% NPK + Vermicompost + Rhizobium	16.6
T ₄ - 75% NPK +25% Vermicompost + Rhizobium	17.9
T ₅ : 100% NPK + 0% Vermicompost + Rhizobium	22.3
T ₆ : 100% NPK + 100% Vermicompost + Rhizobium	20.3
T ₇ : 150% NPK + 150% Vermicompost + Rhizobium	25.2
F test	S
S.Ed (±)	0.2
CD (P=0.05)	0.5

Table.6 Effect of treatments on harvest index (%) of pea

Treatment	Harvest index (%)
T ₁ – Control	37.2
T ₂ -0% NPK +Vermicompost +Rhizobium	39.1
T ₃ -50% NPK + Vermicompost + Rhizobium	40.5
T ₄ - 75% NPK +25% Vermicompost + Rhizobium	41.1
T ₅ : 100% NPK + 0% Vermicompost + Rhizobium	44.2
T ₆ : 100% NPK + 100% Vermicompost + Rhizobium	42.6
T ₇ : 150% NPK + 150% Vermicompost + Rhizobium	44.6
F test	S
S.Ed (±)	0.5
CD (P=0.05)	1.1

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Author Contributions

Taj Cander Tok: Investigation, formal analysis, writing—original draft. Raja Husain: Validation, methodology, writing—reviewing. Lipi Rina:—Formal analysis, writing—review and editing. Sonbeer Chack: Investigation, writing—reviewing. Kasinam Doruk: Resources, investigation writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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