RESEARCH ARTICLE Legume Research- An International Journal, Volume 49 Issue 5: 837-843 (May 2026)

Residual impact of Zero Tillage and Conventional Tillage on the Productivity of Field Pea Variety Aman (IPF 5-19) and Prakash (IPFD 1-10) under Rice Fallow System

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10.18805/LR-5577

ABSTRACT

Background: This study evaluates the benefit of zero tillage over conventional tillage for cultivating field pea (*Pisum sativum* L.) varieties in rice fallow system (RFS) during winter season of 2023 at Hengbung, Manipur. The study is conducted to compare the productivity of the two varieties V_1-Aman (IPF 5-19), V_2-Prakash (IPFD 1-10) with tillage practices, W_1-zero tillage and W_2-conventional tillage. Soil analysis after harvest is recorded for studying the residual effect.

Methods: The experimental design adopted is split plot design where the field pea variety, V_1 and V_2 is assigned in subplots and the tillage practices, W_1 and W_2 is assigned in the mainplots. The study involves four treatments (T) which are T1@V_1W_1, T2@V_1W_2, T3@ V_2W_1 and T4@ V_2W_2 in 1hectare experimental farm at FGI, Hengbung in RFS replicated five times. The data for agronomic parameters were recorded and Soil chemical analysis for nitrogen (N), phosphorus (P) and potassium (K) were recorded to study the residual effect.

Result: The recorded agronomic parameters and their residual effect on soil nutrient indicates that zero tillage demonstrated better performance over conventional tillage with both the varieties. There is significant difference between the two varieties and also the nutrient released in soil after harvest where V_1 shows better performance in yield and nutrient release over V_2 and within the same varieties the treatment T1 and T3 shows better performance. The overall findings suggest that zero tillage significantly enhances the crop output of field pea cultivation in RFS.

Key words: Conventional tillage, Field pea, Residual effect, Rice fallow, Soil health, Zero tillage.

INTRODUCTION

Field pea (*Pisum sativum* L.) of the family Leguminosae is a cultivated crop that are grown widely covering an area of 0.64 million hectares and an average yield of 1400 kilogram per hectare (kg/ha) in India (IIPR, 2020-21). It is one of the main source of protein, carbohydrate, fat, vitamins, minerals and amino acids (Dahl *et al.*, 2012., Bhat *et al.*, 2013). The selection of better performing field pea varieties is important to opt for better cultivation (Singh *et al.*, 2018). Breeding of field pea is done in great extend for better varieties (Parihar *et al.*, 2022). Zero-tillage are tillage practices where there is no disturbance in the soil and involves only sowing operations (Baeumer and Bahermans, 1975). The zero tillage system adopted within an area of 1 ha land showed more sustainable approach and reduced the challenges faced in agronomic management and is easily adopted by farmers (Malik *et al.*, 2011; Jat *et al.*, 2012; Bhatt, 2017). The adoption of zero tillage contributes to improvement of overall soil properties but results in increased bulk density which disturbs the soil aggregations. Soil loss can be managed and reduced with minimum tillage therefore lesser manipulation on the soil will improves soil physical properties for field pea cultivation in rice fallow lands (Bhatt and Khera, 2006). It results in soil degradation and also effect environment as compared to Conservation tillage (Haque *et al.*, 2022). RFS improves productivity and sustain

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How to cite this article: Donbiaksiam, T., Jyotsna, N., Zeshmarani, S., Singh, L.B., Telam, R.S., Deori, C., Ningthoujam, J. and Haokip, L. (2026). Residual impact of Zero Tillage and Conventional Tillage on the Productivity of Field Pea Variety Aman (IPF 5-19) and Prakash (IPFD 1-10) under Rice Fallow System. *Legume Research*. **49(5):** 837-843. doi: 10.18805/LR-5577.

Submitted: 22-09-2025 **Accepted:** 03-11-2025 **Online:** 14-11-2025

soil fertility when organic and inorganic nutrient source are utilized (Haque *et al.*, 2019; Garnaik *et al.*, 2024). The planting of rabi crop in rice fallow lands in north east had shown lower emission of greenhouse gas which results in the suitability of RFS (Yadav *et al.*, 2017; Mohapatra *et al.*, 2022). Study have found that there is an increment in productivity of crop and the economic benefit from crop intensification with field pea in RFS (Malik *et al.*, 2017; Ruis *et al.*, 2023). Residual effect of field pea is mainly the huge source of N, as they are fast growing and have the ability to enriched nitrogen in soil and is also utilized as green manures and crops for soil nutrient enrichment (Ahlawat *et al.*, 1998; Devi *et al.*, 2024). It also releases P (Singh *et al.*, 2012) and K (Saha *et al.*, 2021) in adequate amount and studies on its management is studied for better efficiency in nutrient release. Incorporation of green manure during cultivation increases the residual effect of soil nutrients (Marimuthu *et al.*, 2024). With proper management of RFS, the soil environment is fertile, healthy and supports the cultivation of next *rabi* crop after harvest (Choudhary *et al.*, 2023). The study aims at assessing the residual impact of field pea for soil nutrient availability and reveals the importance of selection of a variety for profitable cultivation of field pea in Hengbung in RFS.

MATERIALS AND METHODS

The experiment was carried out in the month of september where a field trial is superintended during 2023 at FEEDS group of Institution, College of Agricultural Sciences, Hengbung (Fig 1), Manipur, where the soil texture is silty clay with percentage of clay (48.80), silt (40.10) and sand (11.10) respectively. The average temperature is 2°C to 22°C during winter season and located between 31° 30′N latitude to 33°30′E longitude with an altitude of 2011m above mean sea level (MSL). The experimental design adopted is split-plot design and replicated five times with four treatments (T) under RFS. The two field pea varieties- V_1 and V_2 are sown in the field without tillage, W_1 and with tillage, W_2 where the variety, V_1 - Aman (IPF 5-19) and V_2 - Prakash (IPFD 1-10) are grown in the subplot and the mainplot consist of tillage method with W_1- Zero tillage (without tillage) and W_2- Conventional tillage (with tillage). The characteristics of the field pea varieties (V_1 and V_2) were recorded in Table 1 (Ministry of Agriculture and Farmer Welfare, 2024). The treatments consist of T1@V_1W_1, T2@ V_1W_2, T3@ V_2W_1 and T4@ V_2W_2. Each plot size is 5 m × 3 m (15m^2) in an area of one hectare under RFS. No chemical fertilizers were added and FYM is placed @20 tonnes/hectare (t/ha) in the furrows under zero tillage for T1 and T3 whereas FYM is incorporated into the soil during final ploughing under conventional tillage for T2 and T4. Agronomic parameters *viz.*, growth and development at 50% flowering, height of field pea plant (cm), number of pods per field pea, pod length (cm), number of seeds per pod, growth and development at 80% maturity, seed weight per plot (g) and seed yield (kg/ha) were recorded (Table 2). Yield data in tonnes per hectare (t/ha) were assessed to study and record the effect of W_1 and W_2 on field pea productivity of the two varieties after 130 days after sowing the field pea. The initial soil sample were collected and also after harvest at 15cm depth for soil nutrient analysis. Alkaline permanganate method is used for determining the available N by Subbiah and Asija, 1956, P by Bray and Kurtz-1 extractants (Bray and Kurtz, 1945) and K is analyzed using neutral ammonium acetate method (Chapman, 1965). Analysis of variance is used in soil nutrient analysis as given by Gomez and Gomez (1984) at 0.05 significance.

RESULTS AND DISCUSSION

Agronomic parameters of the two field pea variety with different tillage practices

Among the treatments, T3@ V_2W_1 (Prakash with zero tillage) takes least days (65) to reach 50% flowering and maximum days (129) to reach 80% maturity whereas T2@ V_1W_2 (Aman with conventional tillage) takes longest day (71) for 50%

Fig 1: Field pea cultivation in Hengbung.

flowering and shortest days (122) to reach 80% maturity showing Prakash (V_2) shows early flowering but longer duration to mature (Table 3). The maximum field pea crop height was recorded in T1@ V_1W_1 (130.11) and lowest in T4@ V_2W_2 (88.83). The treatment T1@V_1W_1 shows maximum outcome in pod length (5.58 cm), number of pods per plant (15.38), number of seeds per pod (6.44), seed weight per plot (566 g) and seed yield per hectare (1597 kg/ha) and the observed record indicates that field pea variety Aman (V_1) is more suitable and efficient than Prakash (V_2) in Hengbung region (Table 3). Similar results are obtained from previous findings by kumar *et al*. (2013), Das *et al*. (2014); Dixit *et al*. (2014); Praharaj (2015) and Singh *et al*. (2018). The yield of the field pea V_1 and V_2 is higher in zero tillage system and similar findings is reported by Brandt,(1989); Mahli and Nyborg, (1990); McAndrew *et al*. (1994); Das *et al*. (2019).

Residual management of soil nutrient of field pea Aman (IPF-5-19) and Prakash (IPFD 1-10)

In Table 3, the data on nitrogen mineralization of field pea variety V_1 and V_2 with tillage method W_1 and W_2 showed that T_1@V_1W_1 (162.65 kg/ha) showed release in higher amount of N, similar rfindings were observed and reported by Zhou *et al*. (2020) and Hariniharishma *et al.* (2025) and lowest is observed in T4@ V_2W_2 (150.52 kg/ha). The data for available P for field pea varieties V_1 and V_2 is given in Table 3. T1@ (V_1W_1) resulted in a highest P availability (16.81 kg/ha) among the four treatments. The lowest P availability among all other treatments was recorded in T4@ (V_2W_2) with Prakash variety (15.0 kg/ha). The highest K availability of 51.2 kg/ha is observed in T1@ (V_1W_1). Residual P released is more from organic P sources than inorganic sources (Singh *et al*., 2012). Residual K availability increases the soil microbial activity which further enhance the release of K in the soil (Bargali *et al*., 2024). Among all the treatments, T4@ (V_2W_2) resulted in lowest K availability of 35.24 kg/ha. The results clearly indicate that W_1 for both field pea varieties in Hengbung consistently outperformed W_2 in terms of yield and residual nutrient availability. K is release in adequate with good nutrient management (Saha *et al*., 2021). The yield increment in zero tillage is due to better moisture conservation and improved soil structure (Bhatt and Khera, 2006, Haque *et al*., 2022). This enhanced yield directly contributed to higher net income despite the slight increase in gross cost over the years. The overall

Table 1: Field pea variety Aman (IPF 5-19) and Prakash (IPFD 1-10).

Variety	Year of release /Notification	Source	Area of adoption Zone/State	Maturity (Days)	Yield (q/ha)	Special feature
Prakash (IPFD 1-10)	2006	IIPR	MP, CG, MH, GJ, BK-UP, PB, HR, DL, RJ, W- UP, Plains of UK, Jand K, HP, UK SK, NG, MG, MN, MZ TR, AP.	94-121	15-20	Res. to PM and Tol. to rust. Mod. resistant to PB and SF. plant height : 38-85 cm.
Aman (IPF 5-19)	2010	IIPR	PB, HR, DL, RJ, W-UP, Plains of UK.	124-137	22-23	Res. to PM and Tol. to rust. Mod. resistant to PB and SF. Plant height: 116 cm.

*Note: AP- Arunachal Pradesh, CG- Chhattisgarh, DL- Delhi, GJ- Gujarat, HP- Himachal Pradesh, HR- Haryana, J and K- Jammu and Kashmir, MP- Madhya Pradesh, MH- Maharashtra, PB- Punjab, RJ- Rajasthan, SK- Sikkim, MG- Meghalaya, MN- Manipur, MZ- Mizoram, NG-mNagaland, TR- Tripura, UP- Uttar Pradesh, BK-UP - Bundelkhand region of Uttar Pradesh; UK- Uttarakhand.
Res.@ Resistant, Tol.@ Tolerant, Mod.@ Moderately, PM@ Powdery Mildew, PB@ Pod Borer and SF@ Stem fly.
Source: www.seednet.gov.in.

Table 2: Performance of field pea varieties with different tillage methods.

Treatments	Days to 50% flowering	Plant height (cm)	No. of pods/ plant	Pod length (cm)	No. of seeds/ pods	Days to 80% maturity	Seed weight/ plot (g)	Seed yield (t/ha)
T1@V_1W_1	69	130.11	15.28	5.58	6.44	126	566.00	1.61
T2@V_1W_2	71	128.92	15.03	5.19	6.03	122	531.00	1.56
T3@V_2W_1	65	90.13	10.62	4.91	4.99	129	426.00	1.31
T4@V_2W_2	68	88.83	10.11	4.77	4.60	127	417.00	1.22
Mean	68.25	109.50	12.76	5.11	5.51	126	485	1.425
Standard deviation	2.5	23.13	2.78	0.36	0.86	2.94	74.80	0.189
SEM	2.45	22.67	2.72	0.35	0.85	2.89	73.30	0.186
CD at 5%	3.59	20.70	21.31	6.85	15.33	2.29	15.11	13.03

findings suggest that zero tillage is a beneficial practice for enhancing the profitability of field pea varieties in RFS.

Interpretation of the residual impact of the two field pea varieties under different tillage practices

The variety, V_1@Aman (IPF 5-19) shows higher nutrient release than V_2@Prakash (IPFD- 1-10) and within the same variety, treatment under zero tillage showed higher released of soil nutrient N, P, K. Under zero tillage system (W_1), which is T1 and T3, the residual N availability of V_1 (T1@ 162.65 kg/ha) is higher than V_2 (T3@ 161.48) by 0.7% (Fig 2, Table 3), P availability by 50.5% (Fig 3) from T3@ 11.17 kg/ha to T1@ 16.81 kg/ha (Table 3) and K availability by 29.9% (Fig 4) from T3@ 39.42 kg/ha to 51.2 kg/ha (Table 3) showing that both V_1 and V_2 releases N in similar range but V_1 releases P and K way more efficient than V_2 but the release of P is to a much greater extend that zero tillage proves to release P efficiently with V_1. Under conventional tillage system (W_2) which is T2 and T4, the residual N in the soil is higher in V_1 than V_2 by 1.1% (T2@ 152.11 kg/ha, T4@ 150.52 kg/ha) which shows both variety releases N with minor difference and both field pea variety is a good source of N released in the soil. V_1 releases P and K to higher extend to V_2 by 45.5% (T2@ 15.27 kg/ha, T4@ 10.49 kg/ha) and 42.1% (T2@ 50.08 kg/ha, T4@ 35.24 kg/ha) showing that under conventional tillage practices, the release of both P and K is in similar range. Within the same variety, from Table 3, both variety showed better release of nutrients in zero tillage. The N, P, K released for Aman (IPF 5-19) under T1@V_1W_1 (162.65 kg/ha) is higher than T2@V_1W_2 (152.11 kg/ha) by 6.9%, 10.1% (T1@ 16.81 kg/ha, T2@ 15.27 kg/ha) and 2.2% (T1@ 51.2 kg/ha, T2@ 50.08 kg/ha) and for Prakash (IPFD 1-10) N released under T3@V_2W_1 (161.48 kg/ha) is higher than T4@V_2W_2 (150.52 kg/ha) by 7.3%, P released by 6.5% (T3@ 11.17 kg/ha, T4@ 10.49 kg/ha) and K released by 11.9% (T3@ 39.42 kg/ha, T4@ 35.24 kg/ha). The recorded data from the present study shows that both variety releases N with similar efficiency whereas V_1 resulted in higher P release and V_2 resulted in higher K release in the soil after harvest.

Economic analysis of field pea variety under zero and conventional tillage system

As per the data in Table 4, the variety Aman (IPF 5-19) showed an increase in yield by 5% from 1.56 t/ha under conventional tillage (T2) to 1.61 t/ha under zero tillage system (T1). The gross cost is more in T2 with total expenditure of Rs.48819.43/- and Rs.46823.95/- in T1. The net income for T1@ Rs.32953.24/-) is higher than T2@Rs.16600.57/- by 49.62%. The variety Prakash (IPFD 1-10) is recorded with an increase in yield by 9% from 1.22 t/ha under conventional tillage (T4) to 1.31 t/ha under zero tillage system (T3). The gross cost is more in T4@ Rs.47500/- and lesser in T3@Rs.43256/-. The net income for T3@ Rs.32060/- is higher than T4@ Rs.15321/- by 52.21%. The profit benefits the farmer by improving the economic

Table 3: Release of soil nutrient NPK in the soil initial and final readings after harvest at 130 days.

Treatments	Available N (kg/ha)			Available P_2O_5 (kg/ha)			Available K_2O (kg/ha)		
	Initial	After harvest (130 days)	Released N	Initial	After harvest (130 days)	Released P	Initial	After harvest (130 days)	Released K
T1@V_1W_1	350.12	512.77	162.65	36.40	53.21	16.81	119	170.2	51.2
T2@V_1W_2	351.33	503.44	152.11	35.30	50.57	15.27	118.52	168.6	50.08
T3@V_2W_1	350.16	511.64	161.48	31.9	43.07	11.17	112.78	152.2	39.42
T4@V_2W_2	351.47	501.99	150.52	31.6	42.09	10.49	112.06	147.3	35.24

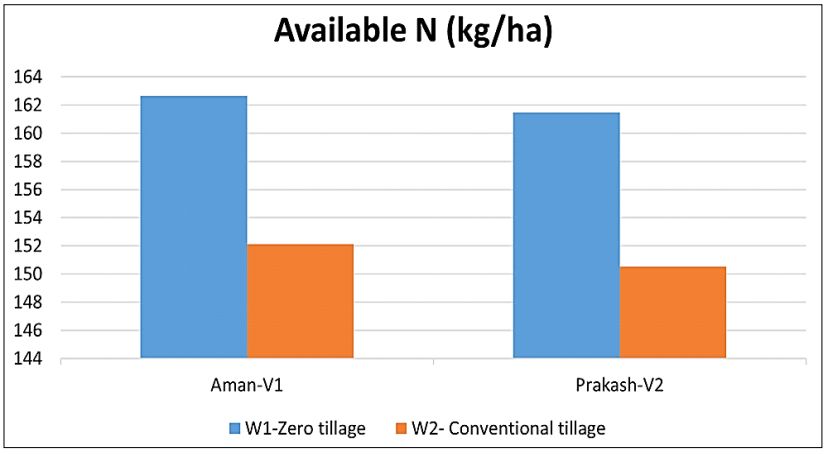

Fig 2: Residual N of the two varieties under tillage and no tillage condition.

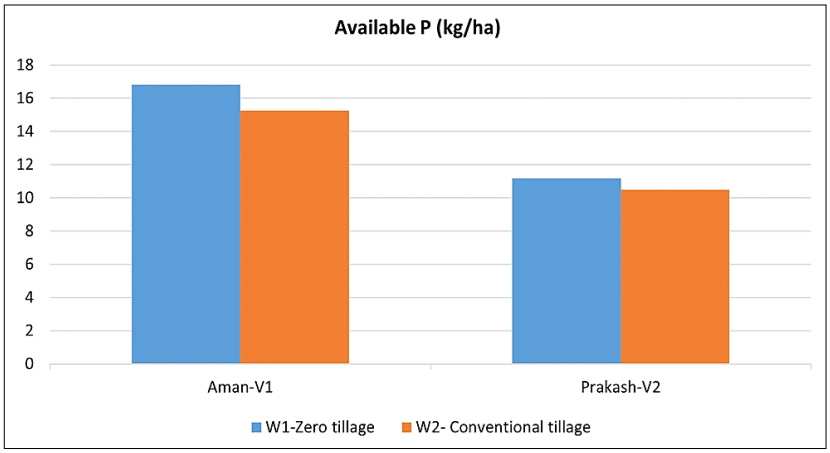

Fig 3: Residual P of the two varieties under tillage and no tillage condition.

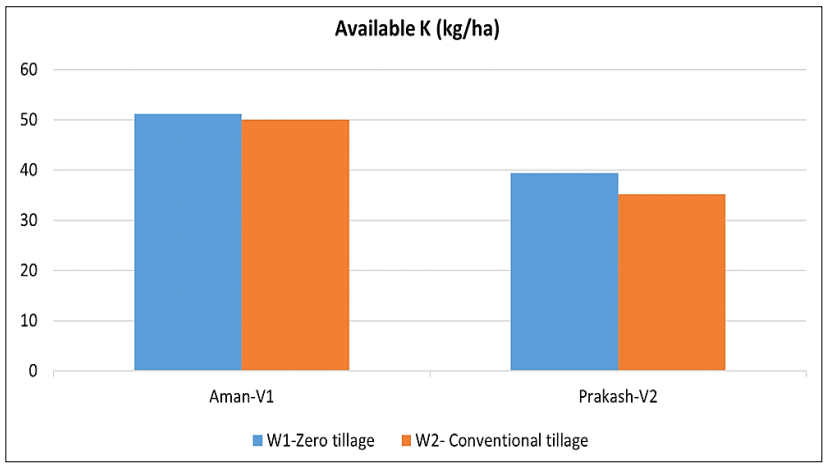

Fig 4: Residual K of the two varieties under tillage and no tillage condition.

Table 4: Economic analysis of field pea varieties under zero and conventional tillage system.

Parameters	Prakash (IPFD 1-10)		Aman (IPF 5-19)	
	Zero tillage (T3)	Conventional tillage (T4)	Zero tillage (T1)	Conventional tillage (T2)
Yield (t/ha)	1.31	1.22	1.61	1.56
Gross revenue (Rs.)	75316	62821	79776.95	65420
Gross cost (Rs.)	43256	47500	46823.95	48819.43
Net income (Rs.)	32060	15321	32953.24	16600.57

*Note: Gross revenue= Yield (t/ha) × Market price per tonnes (Rs/t).
Gross cost = Total expenditure on cultivation (seeds, labor, fertilizers, *etc*.).
Net income = Gross revenue - Gross cost.

stability and farmer's income (Nandan *et al*., 2018; Kumar *et al*., 2020; Kumar *et al*., 2025).

CONCLUSION

This study highlights the significant benefits of adopting zero tillage practices for field pea cultivation under rice fallow system in Hengbung. Treatment under zero tillage showed better result as compared to T2 and T4 with conventional tillage within the same variety. The field pea variety V_1 (Aman) is more productive and gives higher yield than V_2 (Prakash) therefore for Hengbung region with soil having acidic characteristic, clay loam texture with higher organic carbon availability, Aman (IPF 5-19) is most suitable. This study suggested selection of better performing varieties like Aman (IPF 5-19) over Prakash (IPFD 1-10) in rice-fallow regions and adopting minimum tillage could lead to enhanced productivity, economic stability and maintenance of sustainability of agriculture in the region.

ACKNOWLEDGEMENT

The authors did not receive any financial funding from an external body but is totally grateful to the authorities of

FEEDS Group of Institution, Hengbung for providing the raw materials, technical assistance and facilities for the successful completion of the research.

Disclaimer

The experiment, views and results conveyed and shown in this article is an original work. The authors take full responsibility for the accuracy of the information provided, but will not be held responsible for losses that may result from the utilization of this work.

Conflict of interest

The author declares that there is no conflict of interest for the publication of this article and preparation of the manuscript.

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