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Effect of Nutrient Management on Ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi]- linseed (*Linum usitatissimum* L.)

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ABSTRACT

Background: Soil fertility depletion is a major constraint on agricultural production, necessitating a balanced application of inorganic and organic nutrients while effective crop residue management post-harvest enhances soil quality and structure, mitigates evaporation and aids carbon fixation. In Nagaland, agriculture faces challenges like nutrient loss from erosion and minimal use of external inputs while sustainable agriculture requires a viable cropping system and effective crop management; technological advancements in agro-techniques, particularly in cropping systems and nutrient management, are crucial for improving productivity in a ricebean-based linseed cropping system.

Methods: A field experiment was conducted to focus on green manuring followed by cultivating a legume crop, rice bean and subsequently linseed in 2019-2021, the investigation would carry out to study the growth, yield and quality parameter and the study was laid in randomized block design with three replications and nine treatments with sources of organic manures and inorganic fertilizers.

Result: The study revealed substantial influence of growth and yield which included a combination of poultry manure at 0.7 tons ha^{-1} along with 100% RDF exhibited superior performance in ricebean, a similar trend was also observed in the subsequent crop, which was linseed and also yielded promising results in terms of plant height, nodules, pods $plant^{-1}$, seeds $pods^{-1}$ and yield and concluded to achieve higher seed yield, improve seed quality, preserve soil quality.

Key words: FYM, Linseed, Nutrient management, Pig manure, Poultry manure, Ricebean.

INTRODUCTION

In the present century, legumes with high-quality protein that are not extensively utilized as food have become a key focus to address food security issues. According to WHO and FAO, utilizing underutilized legumes can significantly contribute to “Food security and the right to food.” These legumes, rich in protein, dietary fibre and micronutrients, offer numerous health benefits (Katoch, 2015) while India still hosts about 24% of the undernourished global population (Sharma *et al*., 2016), highlighting the crucial role of pulses in ensuring food and nutrition security.

Ricebean (*Vigna umbellata*), an underutilized legume, has gained attention for its potential to contribute to the global food supply and the seeds are rich in protein, fat, fibre, tryptophan and vitamins and has high nutritional quality, high grain yield and multiple uses, including food, animal feed; cover crop and green manure. It is often intercropped with maize, sorghum, or cowpea, especially in the NER of India under rainfed conditions and shifting cultivation. Dried seeds are consumed as pulses, while immature pods are used as vegetables and are also an excellent green manure and cover crop (Rajerison, 2006).

In Nagaland, ricebean, known as Naga dal, is grown on 4900 ha with a production of 5620 Mt (Statistical Handbook of Nagaland, 2017), which has a higher fat, potassium, magnesium, calcium, sodium, iron, copper and chromium content and superior cooking quality compared to other varieties (Bepary *et al*., 2017). However, modern agriculture’s reliance on chemical additives has led to soil productivity loss, nutrient depletion and groundwater pollution, necessitating a shift towards organic practices. Traditionally, Nagaland cultivates rice during the *kharif* season, leaving the land fallow during rabi for cattle grazing. India has about 11.7 million hectares of fallow land post-rice harvest, with 324 hectares in Nagaland. Effective crop management can transform cereal-based systems into sustainable ones by utilizing these fallow lands; an emerging opportunity in Nagaland is growing linseed as a succeeding crop after rice harvest.

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Linseed, an oilseed *rabi* crop, thrives in marginal soils and globally, it spans 27.64 lakh hectares, yielding 29.25 lakh tonnes and in India, linseed covers 3.30 lakh hectares, producing 1.72 lakh tonnes (DES 2017-18), ranking third in acreage and fifth in production. Soil fertility depletion is a significant challenge, necessitating a balanced use of inorganic and organic nutrients. Organic fertilizers from decomposed materials enhance soil properties and crop productivity (Chandrashekara *et al*., 2000), while inorganic fertilizers should be used judiciously to avoid environmental issues. Effective crop residue management can improve soil quality and productivity. Nagaland's agriculture faces challenges like nutrient loss from erosion and limited external inputs; sustainable agriculture requires a viable cropping system and effective crop management. Technological advancements in agro-techniques, especially in cropping systems and nutrient management, are crucial to improving productivity in a ricebean-based linseed cropping system.

MATERIALS AND METHODS

The present investigation was conducted at the experimental farm of School of Agricultural Sciences, Nagaland University, Medziphema campus, Nagaland during from 2019 - 2021 and the farm was located at an altitude of 310 msl with monthly temperature, relative humidity and rainfall during the cropping period ranged from 9.6 to 33.1°C, 34 to 97%, 0 to 274.5 mm respectively. The soil was clayey loam with acidic pH of 4.6, high in organic carbon (1.47%), available N (293.78 kg ha^{-1}), available P (36.02 kg ha^{-1}) and medium in available K (152.63 kg ha^{-1}). The experiment was laid out in randomized block design with three replications with of three different organic manures: poultry manure; pig manure and farm yard manure with inorganic fertilizers: 100% RDF, 75% RDF, 50% RDF with inorganic fertilizers, including urea, SSP and MOP, were applied the day before crop sowing and placed in open furrows and recommended agronomical methods were followed. In April 2019-2020, dhaincha, green manure crop was sown and integrated into the soil after 30 days with soil samples from the top 0-15 cm layer were analysed. The experiment followed a randomized RBD in three replications per treatment and each plot 3 m $\times$3.6 m^2. In the experiment, Bidhan-1 ricebean and Ruchi linseed varieties were grown with recommended spacing and three organic treatments were paired with varying doses of inorganic fertilizers. Dhaincha was sown in March-mid week 2019 and the first week of April 2020 and incorporated into the soil in May for both seasons; residues from the previous ricebean crop, along with locally sourced well-decomposed farmyard manure, pig manure and poultry manure, were used for the subsequent linseed crop according to treatment specifications. Statistical analysis of data recorded during the course of the investigation was computed by following the standard ANOVA procedure.

RESULTS AND DISCUSSION

The data on growth, yield parameters are presented while discussion and data on the effects have been omitted from the paper due to the lack of significant findings.

Growth attributes

The results indicated that nutrient management has a significant impact on plant height as, it is a crucial factor affecting yield in fodder crops, as it reflects how different nutrient treatments affect plant growth and vitality. As depicted Table 1, at the time of harvest, the maximum plant height was observed in T_1, reaching 167.93 cm in 2019, 174.70 cm in 2020. In table 2, T_1 also recorded significant effect of nutrient management on number of branches at 30,60,90 and harvest, similarly with number of nodules as it was recorded that the addition of poultry manure with RDF had significant increasing effect on the number of nodules relative to the other treatments as depicted in Table 1, these finding were similar to those reported by Panda *et al*. (2012) who revealed that poultry manure improve the effectiveness of rhizobium in cowpea and consequently, the highest number of nodules (196) was obtained in the pot that had poultry manure at 2t ha^{-1}. The observed phenomenon is likely due to poultry manure containing significant quantities of organic phosphates, in addition to nitrogen and other elements (Msaakpa, 2016). Incorporating more green materials like dhaincha into the soil brought about an increase in the presence of organic matter. Consequently, this enhancement contributed to greater quantities of vital nutrients accessible to plants, ultimately resulting in improved growth and crop yield; poultry manure's ability to rapidly release essential nutrients needed for plant vigor and growth, along with its strong nitrogen-fixing capabilities, contributes to this effect. The higher nutrient levels found in poultry manure compared to other sources further support these findings, consistent with previous research (Diwale *et al*. 2020).

Yield attributes

T_1 showed the highest number of pods per plant, while the residual effect of green manure may have improved soil fertility in ricebean by adding organic matter and essential nutrients. These findings align with studies showing that organic matter enhances plant growth and photosynthesis, leading to increased seed yield. Jasim and Mhanna (2014), who observed an enhanced yield in broad beans, it attributed that the yield increase to the contribution of organic matter in providing vital nutrients to plants, thereby promoting the growth of vegetative elements and subsequently improving the photosynthesis process (Anuja and Vijayalakshmi, 2014). The residual effect of green manure likely improved soil fertility in ricebean by enhancing organic matter, nitrogen, P and K levels, boosting root nodulation and nitrogen fixation. Additionally, the application of poultry manure, rich in essential nutrients, may have further enhanced micronutrient availability, directly improving crop yield and nutrient concentration.

Table 1: Effect of nutrient management on growth attributes of ricebean.

Treatment	Plant height 60 DAS			90 DAS			At harvest			Number of branches (60 DAS)			90DAS			Number of nodules (70 DAS)		
	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled
T_1	75.0	81.3	78.2	118.3	133.7	126.0	167.9	174.7	171.3	8.3	8.5	8.4	9.4	9.7	9.6	36.1	38.2	37.1
T_2	69.1	76.5	72.8	116.8	130.4	123.6	164.4	168.5	166.5	8.2	8.4	8.3	9.3	9.6	9.5	35.1	37.4	36.3
T_3	68.3	73.1	70.7	113.3	126.6	119.9	164.1	168.2	166.2	8.2	8.4	8.3	9.3	9.5	9.4	33.9	35.9	34.9
T_4	58.6	66.5	62.5	105.4	108.7	107.0	135.9	140.7	138.3	7.7	8.0	7.8	8.7	8.8	8.7	29.1	31.5	30.3
T_5	57.7	66.0	61.9	104.6	107.7	106.2	129.0	130.9	130.0	7.4	7.5	7.5	8.5	8.7	8.6	28.4	31.4	29.9
T_6	54.1	60.8	57.4	103.2	105.6	104.4	121.9	124.8	123.4	7.1	7.3	7.2	8.1	8.4	8.3	27.7	32.0	29.9
T_7	64.7	68.1	66.4	112.3	120.9	116.6	164.3	174.8	169.5	8.2	8.2	8.2	9.2	9.3	9.3	33.5	34.5	34.0
T_8	62.9	66.8	64.8	109.5	113.1	111.3	152.4	166.4	159.4	8.1	8.2	8.1	9.1	9.2	9.2	32.5	34.5	33.5
T_9	61.9	66.5	64.2	109.4	110.2	109.8	156.9	151.5	154.2	7.8	8.1	8.0	8.9	8.9	8.9	31.9	33.7	32.8
SEm±	3.3	2.8	2.2	3.1	5.4	3.1	10.0	11.9	7.8	0.2	0.3	0.2	0.2	0.2	0.2	1.5	1.5	1.1
CD (P=0.05)	9.9	8.3	6.2	9.2	16.1	8.9	30.0	35.5	22.3	0.6	0.8	0.5	0.7	0.7	0.5	4.4	4.6	3.0

Table 2: Effect of nutrient management on yield attributes in ricebean.

Treatment	No. of pods plant^{-1}			No of seeds pod^{-1}			Pod length (cm)			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	13.00	15.33	14.17	8.87	9.61	9.24	8.90	9.51	9.20	1161.83	1217.77	1189.80	1893.33	1904.28	1898.80
T_2	12.83	14.77	13.80	8.67	9.50	9.08	8.84	9.40	9.12	1102.06	1217.10	1159.58	1860.77	1901.05	1880.91
T_3	12.23	14.67	13.45	8.57	9.57	9.07	8.68	9.33	9.01	1088.70	1199.83	1144.26	1814.23	1895.95	1855.09
T_4	10.17	12.23	11.20	8.07	8.27	8.17	7.90	8.67	8.28	1028.94	1084.41	1056.68	1638.34	1850.42	1744.38
T_5	9.17	12.10	10.63	8.03	8.37	8.20	7.90	8.13	8.02	1012.18	1080.92	1046.55	1621.40	1759.47	1690.43
T_6	8.40	11.40	9.90	6.97	7.13	7.05	7.70	7.93	7.82	1000.44	1079.07	1039.75	1604.32	1704.64	1654.48
T_7	11.25	13.90	12.58	8.33	8.53	8.43	8.75	9.30	9.03	1079.14	1172.77	1125.96	1792.81	1888.14	1840.47
T_8	10.39	13.53	11.96	8.47	8.65	8.56	8.60	8.90	8.75	1057.73	1105.94	1081.84	1731.41	1884.94	1808.18
T_9	10.47	13.06	11.77	8.13	8.47	8.30	8.57	8.70	8.63	1038.65	1101.37	1070.01	1693.87	1872.57	1783.22
SEm±	0.99	0.67	0.60	0.26	0.46	0.27	0.28	0.35	0.22	28.74	37.27	23.53	65.77	42.75	39.22
CD	2.96	2.02	1.72	0.79	1.39	0.77	0.84	1.03	0.64	86.15	111.74	67.78	197.17	128.17	112.98

Incorporating poultry manure along with green manuring and recommended dose fertilizer (RDF) in T_1 resulted in the highest seed yield (1161.83 kg ha^{-1}), while T_4 and T_9 had similar yields. The lowest yield was recorded with pig manure application. T_1 also provided the highest stover yield in both 2019 and 2020 in Table 2. Poultry manure in T_1 resulted in the highest harvest index, while the lowest values were observed in T_6. The variation in nutrient sources and fertilizer combinations significantly affected both seed and stover yield, consistent with previous research showing the benefits of nitrogen accumulation from fertilizers and organic manures in increasing production and yields. Similar results were found by Reddy (2008), Ghosh *et al*. (2014) and Getachew and Tilahun (2017). The increase in yield and related factors may be due to the preference for chicken manure over other animal manures like pig or kraal manure, because of its high nutritional value containing elevated levels of NPK; this combination of recommended dose fertilizer (RDF) and nutrient-rich poultry manure directly and indirectly boosted crop yields by promoting growth and productivity (Kawikhonliu 2022). In parallel to the findings, Soysal (2021) recorded that applying 1000 kg ha^{-1} of poultry manure resulted in the highest seed yield in faba bean, with yields of 2119 kg ha^{-1} in 2017 and 2083 kg ha^{-1} in 2018. All yield-related parameters were influenced by poultry manure doses, with the 1000 kg ha^{-1} dose being the most effective.

Even in nutrient uptake as showed in Table 3, in 2019, 2020 and pooled value, T_1 exhibited the highest total nitrogen this was at par with the findings of Sugihara *et al*. (2010) found that early application of poultry manure during crop growth increases microbial biomass nitrogen and prevents nitrogen leaching into the environment and also noted that poultry manure enhances nitrogen absorption by crops, supported by Kawikhonliu's (2022) findings. Poultry manure's richness in essential nutrients, including major, secondary and micronutrients, makes them more available for crop growth, ensuring better nutrient content in crops. Thus, besides major nutrients, poultry manure provides a range of micronutrients, making it an excellent choice for crop fertilization. This combined approach of using both organic and inorganic nutrient sources has the potential to boost overall agricultural productivity and support sustainable farming practices, is in line with findings from Maiksteniene and Arlauskiene (2004), Goulding *et al*. (2008), Senthivalavan and Ravichandran (2019).

Table 3: Effect of nutrient management on total uptake (kg ha^{-1}) after harvest in ricebean plant.

Treatment	Total N uptake			Total P uptake			Total K uptake		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	84.45	92.75	88.60	13.80	15.94	14.87	49.38	52.49	50.94
T_2	81.18	91.46	86.32	11.91	15.05	13.48	44.62	50.38	47.50
T_3	78.11	90.36	84.23	11.47	13.32	12.39	40.67	49.51	45.09
T_4	68.55	77.59	73.07	11.03	13.61	12.32	41.43	48.88	45.16
T_5	67.42	74.81	71.11	9.33	11.85	10.59	36.85	43.95	40.40
T_6	64.64	72.18	68.41	8.73	9.51	9.12	34.43	43.18	38.80
T_7	76.36	88.31	82.34	11.95	14.21	13.08	44.49	51.01	47.75
T_8	73.28	81.96	77.62	10.84	11.49	11.16	37.78	46.54	42.16
T_9	70.77	79.65	75.21	9.72	9.37	9.55	36.27	45.13	40.70
SEm±	1.84	2.50	1.55	0.46	1.01	0.55	1.98	2.03	1.42
CD (P=0.05)	5.51	7.49	4.47	1.38	3.02	1.60	5.93	6.07	4.08

Table 4: Effect of nutrient management on yield parameters in linseed.

Treatment	No of pods plant^{-1}			No of seeds pod^{-1}			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	43.70	45.60	44.65	7.91	11.00	9.46	769.32	776.04	772.68	1426.83	1440.28	1433.55
T_2	42.11	44.33	43.22	7.87	10.86	9.37	706.33	685.60	695.97	1360.80	1381.31	1371.06
T_3	40.11	42.55	41.33	7.83	10.31	9.07	703.79	673.97	688.88	1333.80	1347.25	1340.52
T_4	35.07	37.27	36.17	6.89	8.50	7.70	631.07	640.15	635.61	1252.39	1238.53	1245.46
T_5	36.78	38.97	37.87	6.55	7.54	7.05	600.27	598.71	599.49	1223.22	1220.74	1221.98
T_6	30.53	33.87	32.20	6.22	7.00	6.61	576.95	595.91	586.43	1204.08	1217.10	1210.59
T_7	40.00	43.48	41.74	7.48	10.56	9.02	702.82	706.51	704.67	1246.55	1225.47	1236.01
T_8	41.74	42.02	41.88	7.55	9.18	8.36	661.39	693.87	677.63	1213.99	1208.87	1211.43
T_9	40.22	41.27	40.74	7.19	9.08	8.13	646.30	643.88	645.09	1227.41	1227.66	1227.53
SEm±	2.25	1.56	1.37	0.35	0.87	0.47	33.55	20.92	19.77	41.43	37.76	28.03
CD (P=0.05)	6.74	4.67	3.94	1.05	2.61	1.35	100.57	62.73	56.95	124.21	113.21	80.74

In the current study, it was observed that consistent results when examining the lasting impact of nutrient management on the following crop, which happened to be linseed in Table 4 in yield parameters specifically, using 0.7 tons ha^{-1} of poultry manure (T_1) led to significant improvements in yield-related factors like pod count, seed yield, stover yield. The increased growth and yield of linseed after a green manure crop aligns with the findings by Thakuria and Thakuria (2018) where green manuring with dhaincha enhanced all yield attributes and boosted seed and stover yields due to the higher biomass added by dhaincha and in parallel. Irin and Biswas (2023) reported that green manure crops accumulate phosphorus and their decomposition releases bicarbonates that solubilize soil phosphorus, improving availability for subsequent crops and increase soil organic carbon, lower pH, reduce phosphate fixation and enhance phosphorus availability.

CONCLUSION

The superior growth observed is credited to the nutrient-rich poultry manure, which enhances nodule formation in legumes, improves soil fertility and stimulates beneficial microbes. Combining RDF with poultry manure resulted in higher yields due to improved legume health and growth while FYM outperformed pig manure, providing balanced nutrients, microbial activity and positive soil quality impact, promoting plant growth.

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Conflict of interest

All authors declare no conflict of interest.

REFERENCES

Anuja, S. and Vijayalakshmi, N. (2014). Effect of organic nutrients on growth and yield of vegetable cowpea. The Asian Journal of Horticulture. 9(1): 136-139

Bepary, R., Wadikar, D. Neog, S. and Patki, P. (2017). Studies on physico-chemical and cooking characteristics of rice bean varieties grown in NE region of India. Journal of Food Science and Technology. 54(4): 973-986.

Chandrashekara, C.P., Harlapur, S.I., Murlikrishna, S. and Girijesh, G.K. (2000). Response of maize to organic manures with inorganic fertilizers. Karnataka Journal of Agricultural Sciences. 13(1): 144-46

DES. (2018). Annual Progress Report, Directorate of Economic Survey, Govt. of India.

Diwale, S.R., Gokhale, N.B., Khobragade, N.H., Wahane, M.R., Joke, A.A. and Dhopavkar, R.V. (2020). Effect of organic manures on yield and nutrient uptake by cowpea and changes in soil nutrient status. The Pharma Innovation Journal. 9(9): 564-567.

Getachew, A and Tilahun, A. (2017). Integrated soil fertility and plant nutrient management in tropical agro-ecosystems: A review. Pedosphere. 27(4): 662-680.

Ghosh, C., Biswas, P. and Dhangrah, V.K. (2014). Effect of organic and inorganic sources of nitrogen on growth and yield of French bean. Vegetos. 27(1): 23-25.

Goulding, K., Jarvis, S. and Whitmore, A. (2008). Optimizing nutrient management for farm systems. Philosophical Transactions of the Royal Society B. 363: 667-680.

Irin, I.J. and Biswas, P.K. (2023). Residual effect of green manure on soil properties in green manure transplant aman-mustard cropping pattern. Indian Journal of Agricultural Research. 57(1): 67-72. doi: 10.18805/IJARe.AF-696.

Jasim, A.H and Mhanna, Q.L. (2014). Effect of some organic fertilizers treatments on dry seed yield of broad bean (*Vicia faba* L.). Scientific Papers. Series A. Agronomy, 57: 218-222.

Katoch, R. (2015).Nutritional potential of ricebean. Journal of Food Science. 78(1): 8-16.

Kawikhonliu, Z. (2022). Zinc biofortification of maize and integrated nutrient management in foothill condition of Nagaland. PhD thesis. NU:SAS.

Maiksteniene, S. and Arlauskiene A. (2004). Effect of preceding crops and green manure on the fertility of clay loam soil. Agronomy Research. 2(1): 87-97.

Msaakpa, T.S. (2016). Effects of variety and poultry manure on growth and yield of selected cowpea [*Vigna unguiculata* (L) Walp] varieties at Makurdi, Nigeria. International Journal of Scientific and Research Publications. 6(8): 522-528.

Panda, P.K, Nandi. A., Swain, P.K, Patnaik, S.K, Patnaik, M. (2012). Soil amendment on growth, nodulation, yield, soil health and economics of Cowpea. International Journal of Vegetable Science. 18: 284-297.

Rajerison, R. (2006). Vigna umbellata (Thunb.) Ohwi and H.Ohashi. In: Brink, M. Belay, G. (Eds.). PROTA 1: Cereals and pulses/Céréales et légumes secs. [CD-Rom]. 2006; PROTA, Wageningen, Pays Bas.

Reddy, P.P. (2008). Organic Farming for Sustainable Horticulture, Scientific Publishers, Jodhpur, India. 1-2.

Senthivalavan, P. and Ravichandran, M. (2019). Residual effect of nutrient management practises on the yield, NPK uptake and profitability of rice fallow black gram. Asian Journal of Science and Technology. 7(1): 2305-2310.

Sharma, P., Dwivedi, S. and Singh, D. (2016). Global Poverty, Hunger and Malnutrition: Situational Analysis. In: Bio-Fortification of Food Crops. (Eds). Springer, India, New Delhi. pp 19-30

Soysal, S. (2021). Effects of different doses of poultry manure application on yield components and yield of different faba bean (*Vicia faba* L.) varieties. Legume Research. 44(11): 1338-1342. doi: 10.18805/LRF-640.

Statistical Handbook of Nagaland (2017). Directorate of Economics and Statistics. Government of Nagaland.

Sugihara, S., Funakawa, S., Kilasara, M. and Kosaki, I. (2010). Dynamics of microbial biomass nitrogen in relation to plant nitrogen uptake during the crop growth period in a dry tropical cropland in Tanzania. Soil Science and Plant Nutrition. 56(1): 105-114.

Thakuria, K. and Thakuria, C. (2018). Influence of green manuring and organic sources of nutrient application on scented rice (*Oryza sativa*) - linseed (*Linum usitatissimum*) cropping system. Indian Journal of Agricultural Research. 52(6): 704-707. doi: 10.18805/IJARe.A-5006.