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Influence of Nutrient Regulation on Ricebean (*Vigna umbellata* (Thunb.) Ohwi and Ohashi) Growth and Dry Matter

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Within the realm of sustainable agriculture and its attendant issues, there exists a compelling need for a viable approach to cropping systems that integrates pragmatic and economically sound crop management tactics. This is imperative to uphold land productivity and secure a lasting provision of crops for human consumption. Acknowledging the pivotal contribution of organic manure when combined with chemical fertilizers in crop cultivation and the safeguarding of soil well-being, a research inquiry was formulated for a noteworthy cropping sequence.

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Study Design: Randomized block design.
Place and Duration: School of Agricultural Sciences, Nagaland University, Medziphema. Duration: 2019-2021.
Methodology: The study took place from 2019 to 2021 at the School of Agricultural Sciences (SAS), Medziphema Campus in Nagaland. The primary aim was to assess the lasting impact of both manure and fertilizers on yield and soil condition in a ricebean system over this two-year duration. In the second week of April in both 2019 and 2020, Dhaincha (*Sesbania aculeata*), a green manure crop, was sown using seeds. After a 30-day decomposition period, this green manure was incorporated into the soil. Soil samples were collected from the upper 0-15 cm layer of each experimental plot and analyzed. The experimental field was laid out in randomized block design with three level of organic manures i.e., poultry manure (PM), pig manure (PGM) and farm yard manure (FYM) along with doses of inorganic fertilizers : 100% RDF, 75% RDF, 50% RDF. The treatment combinations included T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF.
Results: In treatment T_1, which involved the application of a blend of green manure and poultry manure at a rate of 0.7 tons per hectare, coupled with a full dose of RDF, exhibited outstanding outcomes in ricebean cultivation. This resulted in elevated seed yields, improved seed quality, sustained soil health, and maximized economic gains for farmers in the foothill conditions of Nagaland.
Conclusion: The substantial enhancement in ricebean growth parameters can be credited to the rich nutrient content and beneficial micronutrients present in poultry manure. combining Recommended Dose of Fertilizers (RDF) with poultry manure, known for its ability to boost nodule formation in legumes, improved soil fertility, fostered beneficial microbial activity, and promoted legume health, ultimately leading to higher yields. In contrast, farmyard manure (FYM) outperformed pig manure due to its balanced nutrients, microbial activity, organic matter, and positive impact on soil quality, creating an optimal environment for plant growth. Poultry manure's capacity to stimulate nodule formation, enhance soil fertility, and support legume health resulted in increased nitrogen fixation and improved yields in leguminous crops, fostering early root development and robust growth in ricebean crops.

Keywords: Ricebean; poultry manure; growth; development.

1. INTRODUCTION

To ensure food security and the right to food, it's recommended to include legumes, especially lesser-known varieties, in diets following the guidelines of the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). Despite India falling short of its pulse production target, incorporating legumes like rice bean, known for its high protein (over 25%), fiber (5%), and essential nutrients, is crucial. Rice bean is resilient, resisting drought, pests, and diseases, making it suitable for rainfed cultivation in Northeastern India [1]. It is often intercropped with crops like maize, sorghum, or cowpea, contributing to sustainable agriculture with benefits for food, animal feed, and soil health. To address challenges in modern agriculture like declining soil productivity and nutrient depletion, combining chemical fertilizers with organic manures is a promising approach [2,3]. Emphasizing sustainable and profitable crop management and adopting advancements in agricultural technology are vital for improving productivity in crop cultivation [4,5].

2. MATERIALS AND METHODS

Between 2019 and 2021, a research study was carried out at the Medziphema Campus of the School of Agricultural Sciences (SAS) in Nagaland with the primary aim to assess the impact of Integrated Nutrient Management (INM) on the growth, yield, and quality of a ricebean cropping system over this two-year period. The organic manures involved *Sesbania* green manure (GM) combined with poultry manure (PM) at a rate of 0.7 tons per hectare, *Sesbania* GM with pig manure (PGM) at a rate of 0.7 tons per hectare, and *Sesbania* GM with farmyard manure (FYM) at 4 tons per hectare. These organic sources were paired with different doses of inorganic fertilizers: 100% Recommended Dose of Fertilizers (RDF), 75% RDF, and 50% RDF. The treatment combinations included various formulations, each specifying the type and amount of organic and inorganic inputs.

In terms of inorganic fertilizers, urea, single super phosphate (SSP), and muriate of potash (MOP) were applied at concentrations of 100%, 75%, and 50% the day before crop sowing. A uniform 20 kg of nitrogen was applied as a basal dose in all treatments, placed in open furrows. The recommended agronomic practices were adhered to, and post-harvest, the crops were dried, separated, and the harvested seeds were appropriately labelled for each plot. During the experiment, Bidhan-1 ricebeans were cultivated using a randomized plot design with the suggested spacing. Three organic manures were combined with varying doses of inorganic fertilizers at the recommended levels. The green manure was sown in the middle of March 2019 and the first week of April 2020, and it was integrated into the soil in May for both crop seasons.

3. RESULTS

Plant height: This study investigates how different combinations of nutrients affect the growth, yield, and quality of ricebean, as detailed in Table 1. The results highlight the significant impact of nutrient management on plant height at various stages, with Treatment T_1 showing the highest plant height at harvest, while T_6 consistently had the lowest. T_1 also influenced the number of branches and nodules, especially at different growth stages, with the addition of poultry manure and recommended fertilizers significantly increasing nodules. These findings align with previous research on the effectiveness of rhizobium in cowpea with poultry manure. The study indicates a notable increase in dry matter at different growth stages for ricebean, emphasizing the positive impact of poultry manure on growth and yield. This suggests that poultry manure effectively releases essential nutrients, complementing its strong nitrogen-fixing capabilities. The increase in plant height observed with the full dose of Recommended Dose of Fertilizers (RDF) may be attributed to the assistance of nutrients in various physiological processes. These include supporting photosynthetic activity, promoting cell and internodal elongation, and maintaining higher auxin levels. These factors collectively contribute to taller plants compared to other treatments, a phenomenon supported by the findings of Jeet et al. [6]. Similar results were reported by Msaakpa [7], indicating that poultry manure is likely to enhance the height of cowpea plants. This highlights the ability of poultry manure to rapidly release essential nutrient elements crucial for plant vigor and growth, in addition to its high nitrogen-fixing capability, as supported by Ewulo [8].

Leaf area Index: The study, presented in Table 2, examines the Leaf Area Index (LAI) of ricebean under different nutrient management conditions. In 2019, at 30 days after sowing (DAS), treatment T_1, involving poultry manure at 0.7 t ha^{-1} and 100% RDF, showed the highest LAI (0.537), while T6 had the lowest (0.463). Similar trends were observed in 2020 and pooled data. Increasing poultry manure and RDF levels significantly affected LAI at various stages, with T_1 consistently recording the highest values. At 60 DAS and 90 DAS in 2019 and 2020, T_1 consistently exhibited superior LAI compared to other treatments, emphasizing the positive impact of poultry manure and RDF on LAI. These results suggest that the application of poultry manure at 0.7 t ha^{-1} with 100% RDF in T_1 consistently promotes higher LAI, likely due to its positive effects on essential nutrient supply, plant growth, and canopy density. The study underscores the potential benefits of incorporating organic manures like poultry manure for sustained improvements in crop productivity and ecosystem functioning.

Dry Matter: The study's data in Table 3 indicates that at 30 DAS, dry matter production was significantly higher with the application of poultry manure at 0.7 t ha^{-1} along with 100% RDF in T_1. This trend persisted at 60 DAS and 90 DAS, with T_1 consistently showing maximum dry matter accumulation in both years and in pooled data. The reason behind this could be the higher concentrations of nitrogen, phosphorus, and potassium in poultry manure compared to other treatments. At 90 DAS, the combination of GM (*Sesbania)* + PM (0.7 t ha^{-1}) + 100% RDF (T_1) exhibited positive responses, recording the highest dry matter accumulation in both years, these results related to plant height and dry matters are in agreement with the findings of Kannan et al. [9] in soybean and Pramanick et al. [10] in green gram.

Table 1. Effect of nutrient management on plant height at different growth stages in ricebean

	30DAS (cm)			60DAS (cm)			90 DAS (cm)			Harvest (cm)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	41.86	48.79	45.33	75.02	81.30	78.16	118.34	133.68	126.01	167.93	174.70	171.32
T_2	41.49	43.66	42.57	69.06	76.54	72.80	116.84	130.37	123.60	164.40	168.51	166.45
T_3	38.81	43.03	40.92	68.25	73.09	70.67	113.33	126.56	119.94	164.11	168.24	166.18
T_4	34.91	37.19	36.05	58.55	66.49	62.52	105.35	108.72	107.04	135.85	140.71	138.28
T_5	34.45	36.35	35.40	57.69	66.03	61.86	104.55	107.74	106.15	129.04	130.88	129.96
T_6	32.74	33.08	32.91	54.05	60.83	57.44	103.23	105.63	104.43	121.89	124.83	123.36
T_7	37.87	42.83	40.35	64.71	68.10	66.41	112.34	120.87	116.61	164.25	174.77	169.51
T_8	37.25	41.97	39.61	62.88	66.78	64.83	109.52	113.07	111.29	152.37	166.36	159.37
T_9	35.82	40.13	37.97	61.92	66.53	64.23	109.38	110.20	109.79	156.92	151.47	154.20
SEm ±	1.66	2.35	1.44	3.30	2.77	2.15	3.06	5.38	3.10	10.00	11.85	7.75
CD (P=0.05)	4.97	7.04	4.14	9.89	8.30	6.20	9.18	16.14	8.92	29.97	35.53	22.33

Table 2. Effect of nutrient management on LAI in ricebean

Treatment	**30DAS**			**60DAS**			**70 DAS**		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	0.537	0.535	0.536	0.972	0.966	0.969	1.518	1.521	1.519
T_2	0.526	0.532	0.529	0.968	0.964	0.966	1.510	1.515	1.513
T_3	0.524	0.528	0.526	0.958	0.954	0.956	1.510	1.512	1.511
T_4	0.466	0.473	0.469	0.935	0.929	0.932	1.493	1.495	1.494
T_5	0.469	0.473	0.471	0.922	0.926	0.924	1.489	1.492	1.491
T_6	0.463	0.464	0.463	0.920	0.923	0.922	1.477	1.465	1.471
T_7	0.511	0.512	0.511	0.956	0.952	0.954	1.503	1.503	1.503
T_8	0.499	0.507	0.503	0.951	0.953	0.952	1.501	1.501	1.501
T_9	0.469	0.481	0.475	0.939	0.930	0.935	1.497	1.498	1.497
SEm ±	0.004	0.004	0.003	0.003	0.005	0.003	0.003	0.007	0.004
CD (P=0.05)	0.013	0.013	0.009	0.008	0.016	0.009	0.008	0.021	0.011

Table 3. Effect of nutrient management on dry matter

Treatment	30DAS (g plant^{-1})			60DAS (g plant^{-1})			90 DAS (g plant^{-1})			Harvest (g plant^{-1})		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	5.85	6.16	6.00	21.28	26.17	23.73	42.88	44.14	43.51	135.19	139.07	137.13
T_2	5.77	5.97	5.87	20.90	24.23	22.57	42.62	43.50	43.06	134.87	138.23	136.55
T_3	5.68	5.81	5.74	20.49	23.96	22.22	41.54	43.08	42.31	134.55	138.00	136.27
T_4	5.22	5.59	5.40	16.93	16.38	16.66	35.67	38.52	37.10	115.83	129.45	122.64
T_5	5.09	5.37	5.23	13.26	15.97	14.61	35.44	37.81	36.62	113.30	124.10	118.70
T_6	4.97	5.14	5.05	14.84	15.61	15.23	31.01	35.92	33.47	113.23	121.46	117.35
T_7	5.44	5.80	5.62	18.95	21.79	20.37	40.86	43.07	41.96	128.43	136.70	132.57
T_8	5.38	5.72	5.55	17.83	21.61	19.72	37.59	42.26	39.93	128.43	137.70	133.07
T_9	5.33	5.61	5.47	17.05	18.66	17.85	35.99	40.11	38.05	127.57	130.47	129.02
SEm ±	0.19	0.17	0.13	1.12	2.37	1.31	1.72	1.72	1.21	5.33	3.31	3.14
CD (P=0.05)	0.56	0.52	0.37	3.35	7.12	3.78	5.16	5.15	3.50	15.97	9.94	9.04

Table 4. Effect of nutrient management on CGR. RGR and NAR

Treatment	Crop growth rate (g m^{-2} day^{-1})						Relative growth rate (g g^{-1} day^{-1})						Net assimilation rate (g cm^{-2} day^{-1})					
	30 DAS-60DAS			60-90DAS			30 DAS-60DAS			60-90DAS			30-60DAS			60-90DAS		
	2019	2020	Pooled	2019	2019	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	3.42	3.84	3.63	4.25	4.75	4.50	0.046	0.048	0.047	0.023	0.031	0.027	184.0	221.5	202.7	249.6	257.2	253.4
T_2	3.03	3.65	3.34	4.16	4.65	4.41	0.044	0.046	0.045	0.024	0.020	0.022	184.5	217.0	200.8	237.3	244.0	240.6
T_3	2.96	3.63	3.30	4.03	4.52	4.27	0.043	0.045	0.044	0.024	0.020	0.022	174.2	206.4	190.3	234.6	247.0	240.8
T_4	2.34	2.16	2.25	3.95	4.43	4.19	0.039	0.037	0.038	0.026	0.030	0.028	171.3	149.1	160.2	220.1	220.8	220.5
T_5	1.63	2.12	1.88	3.72	3.87	3.79	0.036	0.032	0.034	0.033	0.029	0.031	112.9	143.0	127.9	216.1	218.9	217.5
T_6	1.65	2.35	2.00	3.23	3.93	3.58	0.036	0.039	0.038	0.025	0.027	0.026	101.2	144.6	122.9	215.5	214.8	215.1
T_7	2.70	3.20	2.95	3.91	4.62	4.27	0.042	0.044	0.043	0.026	0.023	0.024	182.3	196.4	189.4	232.1	241.0	236.6
T_8	2.49	3.18	2.83	3.95	4.46	4.21	0.040	0.044	0.042	0.025	0.022	0.024	176.6	171.5	174.1	222.2	232.0	227.1
T_9	2.48	2.81	2.64	3.55	4.46	4.01	0.040	0.042	0.041	0.024	0.026	0.025	172.3	173.8	173.1	221.4	227.5	224.5
SEm ±	0.17	0.41	0.22	0.21	0.30	0.18	0.002	0.004	0.002	0.002	0.004	0.002	20.9	32.2	19.2	30.5	25.0	19.7
CD (P=0.05)	0.52	1.23	0.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Effect of nutrient management on total NPK uptake in ricebean

Treatments	Total N uptake (kg ha^{-1}) (Seed + stover)			Total P uptake (kg ha^{-1}) (Seed + stover)			Total K uptake (kg ha^{-1}) (Seed + stover)		
	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

Referring to the data in Table 3, poultry manure significantly enhanced dry matter accumulation at all stages, with a pooled value of 137.13 g plant^{-1}. In 2019, T_1 showed the highest dry matter accumulation, while in 2020, T_1 again displayed the maximum value. The increased availability of nutrients, especially macro nutrients, promoted early root development, contributing to improved growth and higher dry matter accumulation. Poultry manure, in particular, played a crucial role in enhancing these attributes, consistent with previous findings in soybean and green gram. These results align with studies on soybean plant height and dry matter accumulation at harvest, emphasizing the positive impact of nutrient availability from organic sources.

CGR, RGR and NAR: The highest Crop Growth Rate (CGR) from 30-60 days after sowing (DAS) was observed in T_1, which utilized poultry manure (0.7 t ha^{-1}) and 100% RDF, with values of 3.42 g m^{-2} day^{-1} in 2019 and 3.84 g m^{-2} day^{-1} in 2020 in Table 4. When considering pooled data, T_1 consistently showed the maximum CGR at 3.63 g m^{-2} day^{-1}. On the contrary, T_5 consistently reported the lowest CGR values, averaging 1.88 g m^{-2} day^{-1} in pooled data. However, examining the data for the period of 60-90 DAS, there were no significant differences in crop growth rates among treatments in both years and pooled data. It's essential to interpret this information cautiously, indicating a potential gap in knowledge in this particular area, suggesting the need for further research.

RGR: The data obtained in Table 4 revealed that the treatments did not different significantly in terms of relative growth rate during the two years and pooled value.

Net Assimilation Rate (NAR): There was no significant response to the effect of nutrient management on the net assimilation rate in both the years as well as in pooled value in Table 4.

4. CONCLUSION

The notable improvement in various growth parameters in ricebean can be attributed to the abundant nutrient content and beneficial micronutrients found in poultry manure. The combination of Recommended Dose of Fertilizers (RDF) with poultry manure, known for its ability to enhance nodule formation in legumes, contributed to enhanced soil fertility, encouraged beneficial microbial activity, and supported the health and growth of legumes, ultimately resulting in higher yields. In comparison, farmyard manure (FYM) surpassed pig manure due to its balanced nutrients, microbial activity, organic matter, and positive impact on soil quality, creating a more favorable environment for plant growth. Poultry manure's capacity to stimulate nodule formation, improve soil fertility, and support legume health resulted in increased nitrogen fixation and improved yields in leguminous crops, promoting early root development and robust growth in ricebean crops.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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