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Research Article

Productivity of Rice-toria-greengram Cropping Sequence as Influenced by Integrated Nutrient Management Practices and Rice Establishment Techniques

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Abstract

Aim: To study the effect of integrated nutrient management practices on performance and productivity of crops in rice-toria - greengram cropping sequence under different rice establishment techniques.

Methodology: Two years field experiment was conducted with two different establishment techniques of rice *viz*., Transplanted rice (M_1) and Direct seeded rice (M_2) in main plot and five different nutrient management practices *viz.,* Control(N_1), 100% RDF (N_2), 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer (N_3), 75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer (N_4) and 100% N as vermi-compost + bio-fertilizer (N_5) in sub-plots. Data were collected and analysed following the standard procedures. The growth and yield attributing parameters in rice-toria-greengram cropping sequence were studied.

Results: Transplanted rice significantly affected the plant height, grain and straw yield of rice in rice-toria-greengram cropping sequence. Significantly, higher plant height (112.94 cm and 113.97cm), grain yield (45.18q/ha and 45.91 q/ha) and straw yield (64.35 q/ha and 65.17q/ha) was recorded in transplanted rice during both the years, respectively. In terms of nutrient management, the treatment 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer *significantly affected* the growth and yield of rice and greengram. In rice, the highest *grain yield (*50.25q/ha and 51.41 q/ha*),* and *seed yield* (9.49 q/ha and 10.06 q/ha*)* in greengram was recorded under 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer during both the years. In toria, nutrient management with 75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer recorded the highest *seed yield (*6.49q/ha and 6.82q/ha) and stover yield(17.14 q/ha and17.74 q/ha)in both the years.

Interpretation: Based on the findings of the two years study, it was found that the integrated nutrient management package through application of 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer and 75 % RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer registered the best performance in terms of growth and yield in rice, greengram and in toria. Thus, integrated nutrient management package through application of 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer with transplanted technique of rice establishment under rice-toria-greengram cropping sequence can be suggested for enhancing productivity of rice, toria and greengram.

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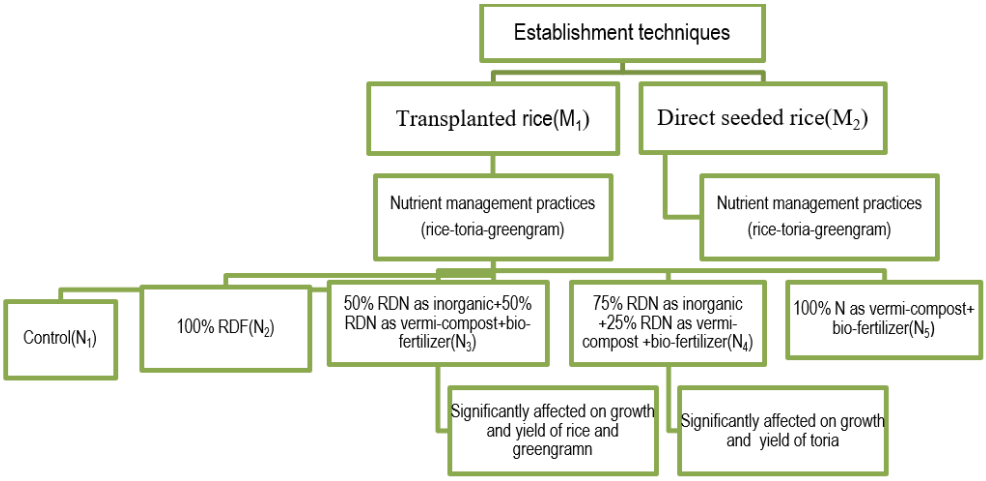

Introduction

The demand for rice increases with increasing population and to meet this demand, assured supply of quality rice has become a formidable challenge for a developing country like India for sustaining economic growth and food security. In India the average annual population growth rate is 1.5%, the per capita consumption estimate of rice per day is about 400g and the demand is expected to be 140 million tonnes by 2025 [1]. Therefore, rice production has to be enhanced by 38% to meet the growing demand of present population [2]. The continuous cultivation of rice under poor soil and crop management practices for longer periods resulted in the loss of soil fertility due to multi-nutrient deficiencies and deterioration of soil physical properties [3]. On the other hand, to meet the growing demands of ever increasing population the importance of highly intensive crop sequence which is not only highly productive and profitable but also stable over time and maintains the soil fertility is well recognized. Depending on the need of the area, to fulfill the demand of cereals, oilseed and pulses, intensification of cropping sequences is very essential.

The rice–oilseed–pulse cropping sequence holds substantial importance from a nutritional perspective, as it integrates the complementary dietary contributions of three distinct crop groups. Rice serves as a staple source of carbohydrates, supplying the primary energy requirements, albeit with limited protein and micronutrient content. Oilseeds contribute essential fatty acids and fat-soluble vitamins (A, D, E and K), playing a crucial role in improving dietary quality and energy density. Pulses, being rich in high-quality protein, dietary fiber, iron, zinc, and B-complex vitamins, address key nutritional deficiencies, particularly protein-energy malnutrition and micronutrient insufficiencies prevalent in developing regions.Beyond human nutrition, this cropping sequence also enhances soil fertility and ecological sustainability. Pulses improve soil nitrogen status through biological nitrogen fixation, reducing the dependence on chemical fertilizers. Oilseeds, when introduced as intermediate crops, facilitate nutrient mobilization, especially phosphorus and sulfur, and contribute to improved soil structure. The diversified nutrient uptake patterns among these crops help maintain a balanced soil nutrient profile and prevent long-term nutrient mining.

In intensive agriculture use of high yielding rice varieties evolved in the heavy withdrawal of nutrients from the soil and imbalanced & indiscriminate use of inorganic fertilizer leads to deterioration of soil health [4]. This decline in soil quality results in a decrease in factor productivity and overall crop productivity. On the other hand most of the cultivated soils have organic matter content of below 1.5% and addition of organic matter is very low. Therefore, suitable combination of inorganic and organic sources of nutrient is necessary for suitable crop yield. Experiences from fertilizer experiments showed that integrated use of Farm Yard Manures(FYM), vermi-compost, bio-compost, *etc.* with inorganic fertilizers is promising not only in maintaining higher productivity but also in providing maximum stability in crop production. The response of N as chemical fertilizer generally increases when it is used in combination with Farm Yard Manure(FYM), vermi-compost, *etc.* and saves N fertilizer. By keeping all these facts in view, the field investigation was carried out on "Productivity of rice-toria-greengram cropping sequence as influenced by integrated nutrient management practices and rice establishment techniques" to study the effect of integrated nutrient management practices on performance and productivity of crops in rice- toria - greengram cropping sequence under different rice establishment techniques.

Materials and methods

Assam has approximately 15.8 lakh hectares of sandy loam soils, accounting for around 20% of the state's total geographical area, predominantly distributed across the well-drained alluvial plains, upland terraces, and foothill regions. These soils are characterized by moderate water-holding capacity, good aeration, and favorable physical tilth, making them ideal for diverse cropping systems. Traditionally, these soils have been used for kharif rice monoculture, which, over time, leads to soil nutrient depletion, pest and disease proliferation, and a decline in factor productivity. Inclusion of oilseed crop such as toria during the rabi season offers a sustainable alternative to rice monoculture. Oilseed crop are well-suited to sandy loam soils due to their requirement for good drainage and aeration. It improve soil physical condition and contribute to soil fertility which fixes atmospheric nitrogen. Furthermore, the

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integration of **pulse** crop such as **greengram** as a **third crop** in the summer season completes a **rice–oilseed–pulse** rotation. Greengram, being a short-duration leguminous crop, utilizes residual soil moisture efficiently and adds organic matter and nitrogen to the soil. Its inclusion aids in disrupting pest and disease cycles, enhancing soil microbial activity, and improving overall system sustainability. It also contributes to food and nutritional security through dietary protein supplementation. Hence, promoting a **rice–oilseed–pulse cropping sequence** in Assam's sandy loam regions presents a low-input, high-efficiency system that supports climate resilience, enhances soil health, and ensures higher economic returns for small and marginal farmers. Considering all these facts in view the field experiment was carried out at Instructional-cum-Research Farm of Assam Agricultural University, Jorhat during 2016-17 and 2017-18 to study the effect of integrated nutrient management in rice-toria-greengram cropping sequence under different rice establishment techniques. The soil of the experimental plot was sandy loam in nature, acidic in reaction (pH 5.8), medium in organic carbon content (0.61%), available N (299.67kg ha^{-1}), available K_2O (139.71 kg ha^{-1}) and low in available P_2O_5 (21.59kg ha^{-1}).The experiment was laid out in split-plot design with three replications. The treatments consisted of two different establishment techniques of Sali rice *viz.*, Transplanted rice (M_1) and Direct seeded rice (M_2) in main plot and five different nutrient management practices *viz.*, Control(N_1), 100% RDF (N_2), 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer (N_3), 75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer (N_4) and 100% N as vermi-compost + bio-fertilizer (N_5) in sub-plots.

For rice, germinated seeds were treated with bio-fertilizer and sown accordingly in nursery for transplanted method. After 30 days, seedlings were transplanted in 20cm × 20cm spacing in 5cm depth of soil. For direct seeded rice seed sowing was done directly in the main field by placing the seeds at 4-5 cm depth in the furrows opened at 20 cm apart. After harvesting of the *kharif* rice within the same plots the field was ploughed. The final land preparation was done by levelling manually to achieve fine bed suitable for germination of late sown toria. Before sowing, seeds were treated with bio-fertilizer as per treatments and Shade dried. A thin layer of soil and pressed were used firmly to cover the seed. Similarly, for greengram within the same plots, the field was ploughed after the harvesting of toria and bio-fertilizer treated seeds were sown.

For observation of plant height in rice, toria and greengram five representative plant samples were selected randomly from individual plot, tagged and respective plant height in centimetre (cm) of those tagged plants were measured from the ground level to the tip of the longest leaf of the plant and the averages were calculated out. For calculating plant population, from inside the net plot, one square metre area at three randomly selected spots were measured and number of tillers/plant were counted and average was calculated out to record the total tiller/plant m^{-2}. Grain/seed and straw/stover yield was measured from the crop harvested from the net area. The bundled, dried crop was threshed and after threshing, grains/seeds were cleaned by winnowing. For statistical calculation, plot yields were converted to quintals per hectare. The weights of the straw/stover after threshing/ separating the seeds were taken separately for each plot and for statistical calculation plot yields were converted to quintals per hectare.

Results and discussion

Growth attributes

Rice: The growth and yield of rice was significantly affected by establishment techniques of rice and nutrient management *practices. The higher plant height* (112.94 cm and 113.97cm) *was recorded under* transplanted rice than direct seeded rice (103.66 cm and 105.11cm) in both the years, respectively (Table 1). Similar result was also reported by Ehsanulla, et al. [5], Aslam, et al. [6], Birhane, et al. [7] and Dileep, et al. [8]. The higher plant height under transplanted rice might be due to availability of soil moisture under flooded condition providing good conditions for crop growth. The result was in full agreement with the findings of Jnanesha and Kumar [9]. In terms of plant population, transplanted rice recorded significantly higher plant population (310.00 nos. and 313.27nos.) than direct seeded rice (288.93 nos.and 293.33 nos.) during both the years, respectively (Table 2). Similar findings was also reported by Jnanesha and Kumar [9] and Dileep, et al. [8]. The higher plant population might be due to availability of sufficient amount of nutrients and moisture due to reduced weed growth at tiller initiation stage and better establishment of roots at desired plant spacing.

Nutrient management *practices significantly affected the plant height of rice.* The highest plant height (112.50cm and 115.15cm) was recorded *in* nutrient management *with* 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer *followed by*75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer (112.02 cm and 113.12 cm). The *lowest* plant height was recorded in control (97.17 cm and 97.65 cm) during both the years, respectively (Table 1).The increase in plant height under the treatment might be due to the increased availability of nitrogen through balanced integrated nitrogen

Table 1: Effect of establishment techniques of rice and nutrient management on plant height (cm) in rice-toria –greengram cropping sequence.

Treatment	Rice		Toria		Greengram	
	2016	2017	2016-17	2017-18	2017	2018
Transplanted rice (M_1)	112.94	113.97	97.23	99.58	73.53	76.73
Direct seeded rice (M_2)	103.66	105.11	96.04	97.90	72.93	76.08
SEm±	0.38	0.50	1.39	1.13	0.93	0.93
CD(p = 0.05)	2.30	2.14	NS	NS	NS	NS
Nutrient management (N)						
Control (N_1)	97.17	97.65	88.24	89.24	69.17	70.33
100% RDF (N_2)	111.45	112.60	100.50	103.67	76.33	79.33
50% RDN as inorganic + 50% RDN as VC + bio-fertilizer (N_3)	112.50	115.15	96.38	97.76	77.00	79.50
75% RDN as inorganic + 25% RDN as VC + bio-fertilizer (N_4)	112.02	113.12	104.32	105.98	73.50	77.09
100% N as VC + bio-fertilizer (N_5)	108.37	109.18	93.73	97.07	70.17	75.78
SEm±	3.09	4.29	3.45	3.32	2.17	2.16
CD(p = 0.05)	9.26	9.10	10.36	9.94	NS	NS
Interaction (M×N)	NS	NS	NS	NS	NS	NS

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Table 2: Effect of establishment techniques of rice and nutrient management on plant population (numbers) in rice-toria-greengram cropping sequence.

Treatment	Rice		Toria		Greengram	
	2016	2017	2016-17	2017-18	2017	2018
Transplanted rice (M_1)	310.00	313.27	31.79	32.44	32.35	33.13
Direct seeded rice (M_2)	288.93	293.33	32.12	32.84	32.56	32.56
SEm±	1.82	1.41	0.35	0.14	0.38	0.23
CD(P=0.05)	11.05	8.57	NS	NS	NS	NS
Nutrient management (N)						
Control (N_1)	280.67	288.17	30.81	31.38	30.97	31.39
100% RDF (N_2)	304.00	305.83	32.32	33.33	33.33	33.33
50% RDN as inorganic + 50% RDN as VC + bio-fertilizer (N_3)	320.83	321.83	32.00	32.83	33.33	33.33
75% RDN as inorganic + 25% RDN as VC + bio-fertilizer (N_4)	305.17	310.67	33.33	33.33	32.32	33.33
100% N as VC + bio-fertilizer (N_5)	286.67	290.00	31.31	32.32	32.32	32.83
SEm±	12.40	14.38	0.86	0.43	0.76	0.52
CD(P=0.05)	NS	NS	NS	NS	NS	NS
Interaction (M×N)	NS	NS	NS	NS	NS	NS

management practices. The result was in agreement with the findings of Imade [10]. The highest plant population (320.83 nos. and 321.83 nos) was recorded in nutrient management *with* 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer in both the years, respectively (Table 2). The highest plant population might be due to increased availability of macro and micro nutrients under the treatment. Combined application of inorganic fertilizer along with vermi-compost and bio-fertilizer treatment might have increased the availability of macro and micro nutrients during the growth stage due to adequate supply of nutrient directly through inorganic fertilizer at initial stage and through slow releasing vermi-compost at latter stage.

Toria: Establishment techniques of rice revealed non-significant difference on plant height and plant population of toria during both the years. Nutrient management with 75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer recorded the highest plant height (104.32cm and 105.98cm) *during both the years of the study, respectively (Table 1).* However, the treatment was at par with 100% RDF (100.50cm)and 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer(96.38cm) in the first year and with 100% RDF (103.67cm), 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer (97.76cm) and 100% RDN as vermi-compost + bio-fertilizer (97.07cm) in the second year. The increase in plant height might be due to availability of nutrients under balanced application of fertilizer. Integrated use of inorganic and organic fertilizers facilitates the availability of nutrients in the soil for longer period which leads to proper utilization of nutrients by plants as a result plant height increased. This result was in full agreement with the findings of Bisht, et al. [11]. However, nutrient management failed to bring significant difference in plant population of toria.

Greengram: The effect of establishment techniques of rice on plant height and plant population of greengram was non -significant during both the year respectively.

Different nutrient management practices *significantly affected the plant height of greengram. The highest plant height (77.00cm and 79.50cm) was recorded in* nutrient management *with*50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer *but it was non- significant with other* treatments during both the years respectively (Table 1). This result was in full agreement with the findings of Thesiya, et al. [12] and Singh, et al. [13]. The highest plant height under the treatment might be due to more nutrient availability under the treatment combination of inorganic and organic sources of nitrogen and seed inoculation with bio-fertilzer that increased the plant height than sole use of inorganic or organic fertilizers.Seed inoculation with bio-fertilzer increased nodulation which encouraged the growth of plant through symbiosis. Addition of organic matter in soil increases the content of organic matter in soil and reduces the bulk density and soil compaction. As a result plants get a suitable growing environment for growth and development as a result plant height increased. Thesiya, et al. [12] reported the same results. In terms of plant population nutrient management practices could not bring significant effect (Table 2).

Yield

Rice: The result showed that establishment techniques of rice and nutrient management significantly affected grain and straw yield of rice (Table 3). Significantly higher grain yield (45.18q/ha and 45.91 q/ha) was recorded in transplanted rice than direct seeded rice (39.57q/ha and 40.03 q/ha) during both the years, respectively. Dileep, et al. [8] revealed the similar result. The higher grain yield in transplanted rice might be due to good crop conditions and efficient utilization of resources which resulted in higher number of tillers, panicles per unit area and grain per panicle. The result was also in agreement with Aslam, et al. [6] and Javaid, et al. [14]. Jaiswal and Singh [15] also reported that transplanted rice produced maximum paddy yield than broadcasting and direct seeding techniques. In terms of straw yield transplanted rice showed higher straw yield (64.35 q/ha and 65.17q/ha) as compared to direct seeded rice (56.54 q/ha and 57.50 q/ha) during both the years, respectively. Similar result was also reported by Dileep,, et al. [8]. Maximum straw yield in transplanted rice might be due to less crop weed competition that led to taller plants, more number of tillers and dry matter production which in turn resulted in higher straw yield. The result was in full agreement with the findings of Subramanyam, et al. [16] and Parameswari and Sriniva [17].

Nutrient management significantly affected grain yield and straw yield of rice during both the years of the study: *Among the all* nutrient management practices the *highest grain yield* (50.25q/ha and 51.41 q/ha) was recorded in nutrient management with 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer which was significantly higher than all the *other* treatments in the first years and being at par with 75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer in the second year (Table 3). It was found that the percent increase in *seed* yield in 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer was 78.95% and 81.98%, 11.10% and 13.36%, 9.19% and 9.34%, 18.77% and 20.06% higher than control, 100% RDF, 75% RDN as inorganic + 25% RDN as vermi-

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Table 3: Effect of establishment techniques of rice and nutrient management on grain/seed and straw/stover yield (q/ha) in rice-toria- greengram cropping sequence.

Treatment	Rice				Toria				Greengram			
	Grain		Straw		Seed		Stover		Seed		Stover	
	2016	2017	2016	2017	2016-17	2017-18	2016-17	2017-18	2017	2018	2017	2018
Transplanted rice (M_1)	45.18	45.91	64.35	65.17	4.87	5.29	13.38	13.91	7.75	8.01	17.15	17.62
Direct seeded rice (M_2)	39.57	40.03	56.54	57.50	4.42	4.82	12.37	12.97	7.07	7.65	16.51	17.12
SEm±	0.31	0.31	0.36	0.69	0.11	0.15	0.33	0.36	0.13	0.19	0.22	0.31
CD(p = 0.05)	1.88	1.87	2.19	4.18	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient management (N)												
Control (N_1)	28.08	28.25	40.20	40.67	2.99	3.31	7.68	8.11	3.98	4.71	9.63	10.64
100% RDF (N_2)	45.20	45.35	62.09	63.09	5.48	5.94	14.96	15.56	8.20	8.47	18.90	19.40
50% RDN as inorganic + 50% RDN as VC + bio-fertilizer (N_3)	50.25	51.41	72.33	74.92	4.23	4.83	12.67	13.27	9.49	10.06	19.70	20.53
75% RDN as inorganic + 25% RDN as VC + bio-fertilizer (N_4)	46.02	47.02	65.67	66.00	6.49	6.82	17.14	17.74	7.91	8.14	18.14	18.36
100% N as VC + bio-fertilizer (N_5)	42.31	42.82	61.92	61.98	4.03	4.36	11.92	12.52	7.47	7.76	17.76	17.91
SEm±	1.17	1.55	3.34	3.07	0.32	0.32	0.58	0.56	0.33	0.31	0.55	0.95
CD(p = 0.05)	3.50	4.64	10.00	9.20	0.95	0.96	1.75	1.68	1.00	0.93	1.64	2.84
Interaction (M×N)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

compost + bio-fertilizer and 100% N as vermi-compost + bio-fertilizer, respectively. However, the lowest seed yield (28.08q/ha and 28.25 q/ha) was recorded in control during both the years. The highest grain yield might be due to sustained nutrient supply and better utilization of applied nutrient under the treatment. Combined application of balance inorganic fertilizer along with vermi-compost and bio-fertilizer might have attributed to sustain nutrient supply and also better utilization of applied nutrient through improved micro environmental condition, especially due to the activities of soil microorganism involved in nutrient transformation and fixation. The results corroborate with the findings of Imade [10]. Similarly, the nutrient management with 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer recorded the highest straw yield (72.33q/ha and 74.92 q/ha) which was significantly higher than all other treatment being at par with 75% RDN as inorganic + 25% RDN as vermin-compost + bio-fertilizer (65.67q/ha and 66.00 q/ha) during both the years, respectively (Table 3).The increase in straw yield might be due to increased availability of N and minimizing N loss that resulted better growth and yield attribute which ultimately produced highest straw yield in rice. These finding was in agreement with the result obtained by Satyanarayana, et al. [18], Virdia and Mehta [19], Senthivalue, et al. [20], Naing,, et al. [21] and Imade [10].

Toria

The establishment techniques of rice failed to bring significant effect on seed and stover yield of toria during both the years of the study. On the other hand *different* nutrient management practices revealed the significant effect on grain and straw yield of toria (Table 3). The nutrient management with 75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer recorded *the highest seed yield* (6.49q/ha and 6.82q/ha) which was significantly higher than all other nutrient management practices during both the years, respectively. The treatment was followed by 100% RDF (5.48q/ha and 5.94 q/ha) and 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer (4.23q/ha and 4.83 q/ha) during both the years, respectively. The treatment was 18.43% and 53.42% higher than 100% RDF and 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer. However, the lowest seed yield (2.99 q/ha and 3.31 q/ha) was observed under the control in both the years respectively. The result was in partial agreement with the findings of Kulkarni, et al. [22]. The highest seed yield under the treatment might be due to significant improvement in growth and yield attributes resulting into higher seed yield. The result was in full agreement with the findings of Narkhede, et al. [23], Jaishankar and Wahab [24] and Nayek, et al. [25].

Nutrient management with 75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer recorded the *highest* stover yield (17.14 q/ha and17.74 q/ha) which was significantly higher than all other nutrient management practices during both the years, respectively. However, the lowest stover yield (7.68 q/ha and 8.11q/ha) was recorded in control during both the years, respectively. The increase in straw yield under the treatment might be due to higher production of dry matter in plants that might have improved the values of straw yield due to combination of inorganic and organic fertilizers. The result corroborated with the findings of Deshmukh, et al. [26], Takar, et al. [27] and Kulkarni, et al. [22].

Greengram

The establishment techniques of rice showed non-significant effect on seed and stover yield of greengram in both the years (Table 3). On the other side, nutrient management with 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer showed *the highest seed yield* (9.49 q/ha and 10.06 q/ha) than the *other* treatments in both the years, respectively. It was found that the percent increase in *seed* yield in 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer was 138.44 and 113%, 15.73 and 18.77%, 19.97 and 23.58%,

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27.04and 29.64% higher than control, 100% RDF, 75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer and 100% N as vermin-compost + bio-fertilizer during both the years, respectively. However, the lowest seed yield (3.98q/ha and 4.71q/ha) was recorded in control during both the years, respectively. The results were in full agreement with the findings of Thesiya, et al. [12]. The increase in seed yield might be due to good growth parameters in the treatment combination that resulted in to maximum values of yield attributes. Growth and yield parameters showed positive and significant correlation with seed and stover yield and ultimately it influenced positively on the yield of greengram. Similar results were also reported by Imade [10] and Mansuri [28]. In terms of stover yield the highest stover yield (19.70q/ha and 20.53 q/ha) *was recorded in* 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer which was significantly higher than all other nutrient management practices during both the years, respectively, being at par with 100% RDF, 75% RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer in the first year and with 100% RDF in the second year. However the lowest straw yield (9.36 q/ha and 10.64 q/ha) was recorded in control during both the years, respectively. Similar result was also reported by Thesiya, et al. [12]. The increase in stover yield under the treatments might be due to increased vegetative growth in terms of plant height, number of branches and dry matter accumulation in greengram. The results corroborate the findings of Gaud [29], Gawari and Pawar [30], Maiti, et al. [31], Pillai, et al. [32], Gudadhe, et al. [33] and Porpavai, et al. [34].

In two years study, transplanted techniques of rice establishment recorded significantly higher value of plant height, plant population, grain/seed and straw/stover yield in rice, toria and greengram as compared to direct seeded rice establishment techniques in rice-toria-greengram cropping sequence. The integrated nutrient management package through application of 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer registered the best performance in terms of growth and yield in rice and greengram. In toria nutrient management with 75 % RDN as inorganic + 25% RDN as vermi-compost + bio-fertilizer recorded the highest value in terms of growth and yield. Thus, integrated nutrient management package through application of 50% RDN as inorganic + 50% RDN as vermi-compost + bio-fertilizer with transplanted technique of rice establishment under rice-toria-greengram cropping sequence can be suggested for enhancing productivity of rice toria and greengram.

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Author's contribution

B.Baro conducted the study,planning,monitoring, Statistical analysis of data and manuscript writing; K.Pathak: Helped in Statistical analysis of data and manuscript editing; B.K.Medhi K.Choudhury , M.Saikia, R.Das : Helped in Statistical analysis of data.

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