



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating: 5.20
www.agronomyjournals.com
2025; 8(4): 456-461
Received: 07-02-2025
Accepted: 09-03-2025

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Effect of integrated nutrient management on growth, yield and quality of ryegrass

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DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i4f.2813>

Abstract

An experiment entitled “Performance of ryegrass (*Lolium multiflorum*) under integrated nutrient management” was carried out at Instructional-cum-Research (ICR) Farm of Assam Agricultural University, Jorhat during the *rabi* season of 2019-20. The experiment was laid out in Randomized Block Design (RBD), replicated thrice with eight treatments viz., T₁: Control (No fertilizer), T₂: 100% RDF (inorganic), T₃: 75% RDF (inorganic), T₄: 50% RDF (inorganic), T₅: 75% RDN (inorganic) + 25% vermicompost (organic), T₆: 75% RDN (inorganic) + 25% FYM (organic), T₇: 50% RDN (inorganic) + 50% vermicompost (organic) and T₈: 50% RDN (inorganic) + 50% FYM (organic). The results revealed that the highest growth parameters like plant height, number of tillers/m², dry matter accumulation as well as total green forage yield (307.69 q/ha) and dry matter yield (62.94 q/ha) were recorded under treatment T₂ (100% RDF), which was closely followed by treatment T₅ (75% RDN + 25% vermicompost) and T₆ (75% RDN + 25% FYM). Significantly higher quality parameters like crude protein and crude fat content in all the three cuts were recorded under treatment T₂, which was at par with treatment T₅, T₆ and T₇. The crude fibre content was the highest under treatment T₁ (control) where no fertilizer was applied. Similarly, significantly higher total crude protein yield (6.03 q/ha) was recorded under treatment T₂ which was at par with treatment T₅ while crude fibre yield was the highest (8.25 q/ha) under T₂ but was at par with treatment T₅ and T₆. From economic point of view, the highest B-C ratio (1.71) was recorded under T₂ (100% RDF) followed by treatment T₆ (1.62). Thus, considering the yield and quality parameters as well as soil health and economic feasibility, treatment T₆ with 75% RDN (inorganic) + 25% FYM (organic) could be considered as the best nutrient management practice in ryegrass under the prevailing climatic condition of Assam.

Keywords: Ryegrass, nutrient management, livestock, climate change

Introduction

India occupies 2.4% of the world's total geographical area supporting a livestock population of 536 million heads contributing approximately 15% of the world's total livestock population (20th Livestock Census, 2019). Although, livestock is an essential component of the mixed-farming system, but feeding of livestock mostly on grazing of crop residues in common grazing land, which includes rice-fallows and other cultivable fallows. Henceforth, most of the times, availability of quality feed and fodder is a major bottle-neck for farmers in India due to chronic scarcity of feed and fodder resources, particularly during the *rabi* season in order to maintain optimal milk production and animal draught power (Kumar *et al.*, 2012) [27]. During this period, most livestock remain underfed due to lack of available green fodder, resulting in poor animal health and productivity (Ashraf *et al.*, 2013) [3]. Under such circumstances, Ryegrass (*Lolium multiflorum*), a southern European winter annual bunchgrass related to perennial ryegrass (*Lolium perenne* L.) known for its highest forage production potentials annual *rabi* fodder crop (Acikgoz, 2001) [2] could be one of the is a very feasible option. It is becoming more popular as a forage crop due to its high productivity and nutritive value (Gerdes *et al.*, 2005) [18] as well as its resistance capacity to diseases and cold weather and high animal acceptance (Cassol *et al.*, 2011) [13]. It is mainly grown by farmers involved in intensive dairy farming because of its good herbage production and pasture quality [Garcia *et al.* (2014) [17], van der Colf *et al.* (2015)] [48]. It thrives in areas with high rainfall and fertile soils with pH levels ranging from 6 to 7.

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However, the growth and development as well as quality of fodder is determined by nutrient management practices.

The inorganic nutrient management greatly affect the soil properties, crop yield (Kumar *et al.*, 2016) [25] as well environment (Foley *et al.*, 2005; Godara *et al.*, 2012) [16, 20]. On the other hand, combined application of inorganic and organic sources of nutrients significantly improvement yield and quality parameters of fodder crops (Biswas *et al.*, 2020) [10]. As a integral part of integrated nutrient management the use of organic sources like vermicompost increased the nutrient bioavailability, promoted plant germination and dry matter production (Sabrina *et al.*, 2013; Chavda and Rajawat, 2015) [38, 13]. Sigaye *et al.* (2021) [42] also reported improvement in forage yield and nutrient status of the soil in maize under INM practices. Considering all the above point, the present experiment has been carried out to evaluate the performance of ryegrass under different nutrient management practices.

Materials and Methods

The experiment was carried out at the Instructional-cum-Research Farm, Assam Agricultural University, Jorhat, Assam during the *rabi* season of 2019 -2020. During the crop growth period the maximum and minimum temperature ranged from 20.7 to 29.5 °C and 8.4 to 16.2 °C, respectively. The weekly average relative humidity during the morning hours ranged from 91-100% while mean evening relative humidity ranged from 56-74%. The climate of Jorhat is subtropical humid with warm summers and cold winters. The pre-monsoon showers start from mid-March to April and the seasons are characterized by a gradual increase in temperature. The monsoon starts from June and extends up to the month of September-October. The rainfall intensity progressively decreases from mid-October to a minimum during December- January. During this period, rainfall is considerably low, and dry spells might occur extending till the end of March. The total rainfall recorded throughout the whole period of experimentation was 48.33 mm. The bright sunshine hours during the crop growing period ranged 1.1-8.2 h/day. The total evaporation during the crop growth period was 29.9 mm. The crop received adequate rainfall during the mid and late vegetative stages, least rainfall during the early vegetative stage. Furthermore, available soil moisture content measured during the experimental period was found to be lower in the early crop growth stage, resulting in moisture stress. The experiment consisted of eight treatments viz., T₁: Control (No fertilizer), T₂: 100% RDF (inorganic), T₃: 75% RDF (inorganic), T₄: 50% RDF (inorganic), T₅: 75% RDN (inorganic) + 25% vermicompost (organic), T₆: 75% RDN (inorganic) + 25% FYM (organic), T₇: 50% RDN (inorganic) + 50% vermicompost (organic) and T₈: 50% RDN (inorganic) + 50% FYM (organic), which was laid out in Randomized Block Design (RBD) and replicated thrice. The experimental site was sandy loam in texture, acidic in reaction (pH 5.42), medium in organic carbon (0.52%) and available K₂O (155.45kg/ha) and low in available N (235.62 kg/ha) and available P₂O₅ (20.12 kg/ha) with 40.44% water holding capacity and bulk density of 1.48 Mg/m³. The ryegrass variety Makkhan grass was sown as per treatment. Before application of manures in field their nutrient content was pre-evaluated (Table1) and were applied as per treatment.

Table 1: Nutrient content of organic manures used in the experiment

Sl. No.	Particulars	FYM	Vermicompost
1.	Total nitrogen (%)	0.60	1.9
2.	Total phosphorus (%)	0.28	0.89
3.	Total potassium (%)	0.58	1.07

Results and Discussion

Effect of INM practices on growth parameters of ryegrass

Influence of INM practices on growth parameters of ryegrass was observed to be equivalent in comparison to inorganic fertilizers alone (Table1). Result revealed that at 1st, 2nd, and 3rd cut, the plant height (39.73cm, 56.43 and 51.2 cm in respectively) significantly increased with the application 100% RDF (T₂) which was at par with treatment 75% RDN + 25%VC (T₅) and 75% RDN (inorganic) + 25% FYM (T₆). Application of treatment T₂ resulted significant improvement in plant height to the tune of 56.60, 76.73 and 72.79% at 1st, 2nd and 3rd cut, respectively, over the treatment T₁ (control). Similarly, the number of tillers/m² increased significantly in the same trend at the 1st, 2nd, and 3rd cut with a recorded value of 175.33, 194.33 and 192.67 which was 54.24, 57.56, and 58.37%, respectively higher, over T₁ (control). The treatment T₂ also recorded maximum DMA of 4.93g at 1st cut which gradually increased to 6.03g during 2nd cut and again declined to 5.87 g during 3rd cut which was found to be at par with 75% RDN + 25%VC (T₅). The 1st cut had the lowest plant height and the lowest number of tillers among the three cuts, which might be due to the low temperature and insufficient rainfall during that time period. Growth parameters such as tiller numbers and plant height also showed an increasing trend towards the 2nd cut, which could be attributed to adequate rainfall received during the crop's mid-vegetative stage, which preceded the 2nd cut. Furthermore, the number of tillers/m² increased in subsequent cuts, which could be attributed to the fact that cutting encourages the development of new shoots (Bora *et al.*, 2019) [11].

However, significant response to growth parameters such as plant height and number of tillers/plant to 100% RDF (inorganic) could be attributed to the use of chemical fertilizers because they become more readily available to the plants immediately after application, especially in terms of major nutrients like N, P, and K, which aided in increasing vegetative growth through increase in protoplasmic constituent that accelerate the process of cell division, expansion, and differentiation, resulting in luxuriant growth. These findings are in conformity with Patidar and Mali (2004) [36], Kumar *et al.* (2004) [29], and Sheoran and Rana (2005) [41]. Significant improvement DMA could be attributed to the availability of applied nutrients, particularly nitrogen, which plays an important role in photosynthetic activity of leaves, allowing the plants to accumulate more biomass and increase their dry matter content. These findings are in agreement with those of Ayub *et al.* (2009) [5] and Bhilare *et al.* (2010) [9]. However, any significant difference was observed in case of leaf stem ratio during all the growth stages. However, no significant variation in leaf: stem ratio was observed under different nutrient treatments in all the cuts. This could be due to proportionate growth of both leaf and stem, irrespective of the treatments. Similar results were reported by Tollenaar *et al.* (2006) [46] and Biswas *et al.* (2020) [10].

Table 2: Effect of INM practices on growth parameters of rye grass

Treatment	Plant Height (cm)			Tillers (per m ²)			DMA (g/plant)			Leaf stem ratio		
	1 st cut	2 nd cut	3 rd cut	1 st cut	2 nd cut	3 rd cut	1 st cut	2 nd cut	3 rd cut	1 st cut	2 nd cut	3 rd cut
T ₁	25.37 ^e	31.93 ^e	29.63 ^e	113.67 ^f	123.33 ^e	121.67 ^f	2.13 ^e	3.15 ^f	2.88 ^f	2.27 ^a	2.34 ^a	2.3 ^a
T ₂	39.73 ^a	56.43 ^a	51.2 ^a	175.33 ^a	194.33 ^a	192.67 ^a	4.93 ^a	6.03 ^a	5.87 ^a	2.45 ^a	2.72 ^a	2.65 ^a
T ₃	35.33 ^c	51.43 ^c	45.07 ^c	164 ^d	185.67 ^c	183.67 ^d	4.34 ^b	5.28 ^d	5.12 ^d	2.24 ^a	2.59 ^a	2.52 ^a
T ₄	30.8 ^d	48.73 ^d	40 ^d	161.67 ^e	181.67 ^d	178.33 ^e	4.17 ^d	5.06 ^e	4.88 ^e	2.2 ^a	2.37 ^a	2.34 ^a
T ₅	39.13 ^a	56.3 ^a	50.87 ^a	172.33 ^b	193 ^a	191.67 ^{ab}	4.88 ^a	5.94 ^{ab}	5.8 ^{ab}	2.35 ^a	2.65 ^a	2.62 ^a
T ₆	38.67 ^a	55.4 ^a	50.53 ^a	172 ^b	192.33 ^a	190 ^b	4.8 ^a	5.8 ^b	5.7 ^b	2.32 ^a	2.62 ^a	2.58 ^a
T ₇	37.37 ^b	53.63 ^b	47.1 ^b	168 ^c	189.33 ^b	186.33 ^c	4.5 ^b	5.54 ^c	5.42 ^c	2.28 ^a	2.53 ^a	2.49 ^a
T ₈	36.8 ^b	51.9 ^b	45.6 ^c	166.67 ^c	186.67 ^c	183.33 ^d	4.32 ^{cd}	5.32 ^d	5.24 ^d	2.26 ^a	2.51 ^a	2.44 ^a

Effect of INM practices on yield of ryegrass

Among the yield parameters, the highest green forage yield of 78.21 q/ha, 115.77q/ha and 113.71 q/ha at 1st, 2nd, and 3rd cut, respectively was recorded under treatment T₂, which was at par with treatment T₅ and T₆ respectively (Table2). The treatment T₂ recorded an increase of green forage yield by 111.83, 102.67, and 106.22% over treatment T₁ (control). Similarly, significantly higher dry matter yield of 15.51q/ha at 1st cut, 24.14 q/ha at 2nd cut and 11.63 q/ha at 3rd cut was recorded under T₂, which was at par with treatment T₅. The dry matter yield recorded under T₂ was increased by 117.22, 107.5, and 109.81% over T₁ (control) at the 1st, 2nd, and 3rd cuts, respectively.

In case of total dry matter yield, significantly higher total dry matter yield (62.94 q/ha) was obtained under T₂ followed by treatment T₅, which was at par with treatment T₆. The significant increase in forage yield with increase in fertility levels could be attributed to a favorable effect of nutrients on plant root and

shoot growth, which has resulted in increased growth parameters such as plant height and tillers/m². The results of present investigation are in close agreement with findings of Kumar *et al.* (2004) [29] and Sheoran and Rana (2005) [41]. The various organic and inorganic fertilizer combinations produced significantly higher forage yield than the control. The treatment T₅ produced the highest green forage and dry matter yield among these combinations with an increases of 109.58, 110.43, and 104.08% for green forage yield and 116.24, 106.27 and 107.56% for dry matter yield at 1st, 2nd, and 3rd cut, respectively, over the treatment T₁ (control). This increase in yield can be attributed to the increased values in growth parameters due to the integration of vermicompost and FYM with chemical fertilizers. Godara *et al.* (2012) [20] obtained similar results in oat, reporting that instead of using organic or inorganic nutrient sources alone, combining both improved the green forage yield.

Table 3: Effect of INM practices on yield of ryegrass

Treatments	Green forage yield (q/ha)				Dry matter yield (q/ha)			
	1 st cut	2 nd cut	3 rd cut	Total	1 st cut	2 nd cut	3 rd cut	1 st cut
T ₁	36.92 ^e	57.12 ^e	55.14 ^e	149.18 ^f	7.14 ^e	11.63 ^f	11.10 ^f	29.87 ^g
T ₂	78.21 ^a	115.77 ^a	113.71 ^a	307.69 ^a	15.51 ^a	24.14 ^a	23.29 ^a	62.94 ^a
T ₃	70.75 ^c	106.65 ^c	104.67 ^c	282.07 ^d	13.87 ^c	22 ^d	21.22 ^d	57.09 ^e
T ₄	65.37 ^d	101.15 ^d	99.1 ^d	265.62 ^e	12.76 ^d	20.74 ^e	20.02 ^e	53.52 ^f
T ₅	77.38 ^a	115.29 ^a	112.83 ^a	305.5 ^{ab}	15.44 ^a	23.99 ^{ab}	23.04 ^{ab}	62.35 ^b
T ₆	77.17 ^a	114.2 ^a	112.53 ^a	303.9 ^b	15.32 ^a	23.73 ^b	22.94 ^b	62.12 ^b
T ₇	73.15 ^b	110.77 ^b	108.26 ^b	292.04 ^c	14.42 ^b	22.95 ^c	21.95 ^c	59.32 ^c
T ₈	71.69 ^c	107.36 ^c	105.63 ^c	284.68 ^d	14.12 ^{bc}	22.22 ^d	21.45 ^d	57.79 ^d

Quality parameters

The different quality parameters as influenced by INM practices in presented in Table3 &4. From the result it was revealed that the crude protein content progressively reduced with advancement in cutting days and comparatively higher values was observed at 1st cut (60 DAS) than the 2nd (90 DAS) or 3rd cut (120 DAS) (Table 3). Similar trend in crude protein content has also been reported by Tesema *et al.*, 2002; Bayble *et al.*, 2007 [44, 8] and, However, among the treatments, T₂ recorded significantly higher crude protein content of 9.69%, 9.56% and 9.44% at 1st, 2nd, and 3rd cut respectively which was also at par with treatment T₅, T₆ and T₇ respectively. The use of 100% RDF (inorganic) (T₂) resulted in an increase in crude protein content of 24.07, 23.35, and 23.72% as compared to the control (T₁) at 1st, 2nd, and 3rd cuts, respectively. Increase in crude protein content in case of integrated treatment i.e T₅, T₆ and T₇ might be due to increased nitrogen concentration that directly resulted in higher crude protein content in the plants. Similar results were obtained by Singh and Singh (2005) [43] and Kumawat and Jat (2005) [30]. Similarly, maximum crude protein yield at 1st, 2nd and 3rd cut viz., 1.50 q/ha, 2.31 q/ha and 2.20 q/ha respectively, was recorded under treatment T₂, which was statistically at par with

treatment T₅ and T₆. The higher crude protein content and dry matter yield could have resulted in higher crude protein yield in treatment T₂. These findings corroborate the finding of Rajkhowa *et al.* (2000) [37].

The total crude protein yield also increased significantly with nitrogen application. The maximum total crude protein yield was recorded under treatment T₂ where 100% RDF which might be due to combined factor of increased protein content and increased dry matter yield that led to overall increase in total crude protein yield. Unlike protein, the crude fibre content of ryegrass decreased significantly with the application of nitrogenous fertilizers (Table 4). Treatment T₁ (control) recorded the highest crude fibre content (13.63%,14.08% and 14.32%) at 1st, 2nd, and 3rd cuts, which was at par with treatments T₃ and T₄. However, significantly higher crude fibre yield of 1.98, 3.18 and 3.09 q/ha at 1st, 2nd and 3rd cut, respectively was recorded under treatment T₂, which was statistically at par with treatment T₅ and T₆. The total crude fibre yield was also highest under treatment T₂, accounting 96.42% higher than the control. This could be due to a higher proportion of dry matter yield than a decrease in crude fibre content with nitrogen application. Similar findings were reported by Oduntan *et al.* (2012) [34] and Vajinder and

Sharma (2015) [47].

The data presented in Table 4 also revealed that with the addition of nitrogenous fertilizers, the crude fat content of ryegrass increased significantly. Treatment T₂ significantly exhibited the highest crude fat content at first, second, and third cut, which was at par with all of the combined organic and inorganic treatments, namely T₅, T₆, T₇, and T₈. The application of treatment T₂ resulted in an increase in crude fat content by 11.78, 10.9, and 11.76% over control at the 1st, 2nd, and 3rd cuts, respectively.

The higher crude fat content in plants may be due to increased nitrogen application, which increases the chlorophyll content of leaves, resulting in production of more food material through photosynthesis (Dhaliwal *et al.*, 1989) [15]. Similar results were

also obtained by Vajinder and Sharma (2015) [47].

Table 4: Effect of INM practices on crude protein content and yield

Treatments	Crude protein content (%)			Crude protein yield (q/ha)			
	1 st cut	2 nd cut	3 rd cut	1 st cut	2 nd cut	3 rd cut	Total
T ₁	7.81 ^d	7.75 ^d	7.63 ^d	0.56 ^e	0.9 ^e	0.85 ^e	2.31 ^f
T ₂	9.69 ^a	9.56 ^a	9.44 ^a	1.46 ^a	2.34 ^a	2.23 ^a	6.01 ^a
T ₃	8.81 ^{bc}	8.75 ^c	8.63 ^c	1.2 ^c	1.94 ^c	1.86 ^c	4.98 ^d
T ₄	8.31 ^{cd}	8.25 ^d	8.06 ^d	1.03 ^d	1.7 ^d	1.65 ^d	4.38 ^e
T ₅	9.56 ^a	9.44 ^a	9.31 ^a	1.44 ^a	2.3 ^a	2.17 ^a	5.9 ^{ab}
T ₆	9.38 ^{ab}	9.31 ^{ab}	9.19 ^{ab}	1.4 ^a	2.23 ^{ab}	2.16 ^a	5.76 ^b
T ₇	9.31 ^{ab}	9.25 ^{abc}	9.06 ^{abc}	1.3 ^b	2.12 ^b	2.04 ^b	5.45 ^c
T ₈	8.94 ^b	8.81 ^{bc}	8.76 ^{bc}	1.24 ^{bc}	1.99 ^c	1.91 ^c	5.10 ^d

Table 5: Effect of INM practices on crude fibre content, crude fibre yield and crude fat content of ryegrass

Treatments	Crude fibre content (%)			Crude fibre yield (q/ha)				Crude fat content (%)		
	1 st cut	2 nd cut	3 rd cut	1 st cut	2 nd cut	3 rd cut	Total	1 st cut	2 nd cut	3 rd cut
T ₁	13.63 ^a	14.08 ^a	14.32 ^a	0.97 ^d	1.64 ^e	1.59 ^d	4.2 ^e	3.31 ^c	3.55 ^c	3.4 ^c
T ₂	12.79 ^b	13.15 ^b	13.25 ^b	1.98 ^a	3.18 ^a	3.09 ^a	8.25 ^a	3.7 ^a	3.94 ^a	3.8 ^a
T ₃	13.3 ^a	13.8 ^a	13.86 ^a	1.85 ^b	3.04 ^b	2.94 ^b	7.82 ^b	3.47 ^b	3.75 ^b	3.57 ^b
T ₄	13.36 ^a	13.83 ^a	13.88 ^a	1.71 ^c	2.87 ^d	2.78 ^c	7.36 ^d	3.43 ^b	3.72 ^b	3.52 ^b
T ₅	12.81 ^b	13.19 ^b	13.28 ^b	1.97 ^a	3.17 ^a	3.08 ^a	8.21 ^a	3.66 ^a	3.93 ^a	3.78 ^a
T ₆	12.83 ^b	13.21 ^b	13.32 ^b	1.95 ^a	3.14 ^a	3.06 ^a	8.16 ^a	3.65 ^a	3.93 ^a	3.76 ^a
T ₇	12.85 ^b	13.22 ^b	13.36 ^b	1.85 ^b	3.03 ^b	2.93 ^b	7.82 ^b	3.64 ^a	3.92 ^a	3.75 ^a
T ₈	12.87 ^b	13.28 ^b	13.38 ^b	1.81 ^b	2.95 ^c	2.87 ^b	7.64 ^c	3.67 ^a	3.91 ^a	3.73 ^a

Economics

Economics of cultivation is the most important factor which decides the adoption of any improved practices by the grower. The economics of ryegrass as influenced by INM practices are presented in Table 5. Results revealed that, application of treatment T₂ [100% RDF (inorganic)] yielded the highest gross return (Rs. 61,538.00 /ha) and net return (Rs. 38,801.90/ha). This increase in gross return could be attributed to higher productivity, while the increase in net return could be attributed

to lower cultivation costs and higher productivity.

Another important criterion that determines a treatment's usefulness and acceptance by a grower is its efficiency. Similar to gross and net returns, T₂ also recorded the highest benefit cost ratio (2.71) followed by treatment T₆ [75% RDN (inorganic) + 25% RDN through FYM (organic)] (2.62), which is due to the higher yield and low cost of cultivation. Hooda *et al.* (2004) [21] and Kumar (2007) [23] also obtained the higher net returns with the use of recommended dose of fertilizers.

Table 6: Effect of INM practices on economics of rye grass

Treatment	Cultivation cost (Rs./ha)	Gross Return (Rs./ha)	Net Return (Rs./ha)	B:C Ratio
T ₁	18,500.00	29,836.00	11,336.00	1.61
T ₂	22,736.10	61,538.00	38,801.90	2.71
T ₃	21,677.08	56,414.00	34,736.92	2.60
T ₄	20,618.05	53,124.00	32,505.95	2.58
T ₅	27,989.08	61,100.00	33,110.92	2.18
T ₆	23,177.08	60,780.00	37,602.92	2.62
T ₇	33,250.05	58,408.00	25,157.95	1.76
T ₈	23,618.05	56,936.00	33,317.95	1.41

Conclusion

From the present study, it was evident that application of 100% recommended dose of fertilizers (RDF) *i.e.* treatment T₂ resulted in the highest plant height, tillers/m², green fodder yield and economic return in case of ryegrass, which was at par with treatment T₅ [75% RDN (inorganic) + 25% RDN through vermicompost (organic)] and T₆ [75% RDN (inorganic) + 25% RDN through FYM (organic)]. However, treatment T₂ [100% RDF (inorganic)] failed to maintain the soil health, and T₅ [75% RDN (inorganic) + 25% RDN through vermicompost (organic)] treatment also provided comparatively low benefit: cost (B: C) ratio, making them less profitable to farmers. Nevertheless, T₅ may be recommended to those farmers who are capable of producing vermicompost on their own. Otherwise, application of 75% RDN (inorganic) + 25% RDN through FYM (organic) *i.e.* T₆ may be considered to be the most suitable treatment for ryegrass cultivation in the acid soils of Assam, for achieving a

higher B: C ratio while still maintaining the soil health. Because these findings are the result of only one year of analysis, at least two more years of research in these areas may be required to reach a valid conclusion before making recommendations to the farming community.

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