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Integrated Nutrient Management on Semi *Rabi* Green Gram

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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

An experiment was conducted to study the response of organic sources on the growth, yield, and quality of semi-*rabi* green gram. The experiment was conducted during semi rabi season 2021, at Agronomy Farm, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, comprising one chemical treatment with nine integrated nutrient management and *biofertilizer* treatments *i.e.* total 10 integrated organic manures treatments impose in semi *rabi* green gram. The layout of experiment was done according to Randomized complete block design with three replications. Growth attributes like plant height, number of branches, dry matter accumulation plant^{-1} and dry weight of nodules plant^{-1} of green gram as influenced by an application of 75% N through vermicompost + ST (*5 ml* kg seed^{-1}) of *Rhizobium* + Bio NPK consortium 1 L ha^{-1}.

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Significantly higher green gram yield attributing character and biological yield was observed significantly higher where application done by 75% N through vermicompost + ST (*5 mL* kg $seed^{-1}$) of *Rhizobium* + Bio NPK consortium 1 L ha^{-1}. Quality parameter and content is most important factors for green gram, an application of 75% N through vermicompost + ST (*5 ml* kg $seed^{-1}$) of *Rhizobium* + Bio NPK consortium 1 L ha^{-1} treatment reported significantly higher seed and straw NPK content and uptake.

Keywords: Biofertilizer consortium; green gram; organic sources; seed; stover yield.

1. INTRODUCTION

India is a largest producer of Pulses [1,2] and its universally utilized as food legumes, which come in second position in terms of produce and utilization after cereals. Being an essential component of the food of the great majority of vegetarians and the foundation of sustainable agricultural production. For livelihood activities, about 65-70% of the population depend on agricultural and its relative activities. Nearly agricultural contributes 17% of domestic growth. Pulses have a rich content in protein (25-26%), vitamins (3%), fibres, carbohydrate (51%) and minerals nutritional like iron, zinc and magnesium also having essential amino acids, which play a vital role in human health [3]. Due to its many uses, g human consumption, mainly green gram is a major pulse crop in India, where it is growing under a different agroclimatic conditions [4].

Pulses, which are high in protein and play an active part in human food, are the second most significant section of Indian agriculture after grains [5]. In India, pulse farming is important role in agriculture [6]. These crops are grown for domestic human consumption, mainly by vegetarian people due to nutritional factors. Pulses have capacity to fix atmospheric nitrogen (average 30-50 kg ha^{-1}) into soil and ultimately to improve soil fertility, being recognized as natural fertilizer factory [7]. Pulses are called “marvel of nature” and are cultivated in kharif, *rabi* as well as summer season. They are pointed out as fundamental sources of protein, presenting 14% of total protein in the typical Indian diet. As a third important pulse crops, can be used as vegetables, fodder and green manuring in India [8]. Pulse seed is more palatable, nutritive, digestible and not flatulent than other pulse grown in country [9]. In current agriculture system, chemical products can demonstrate a lack of sustainability and generate harmful effects such as soil erosion, associated plant nutrient losses, surface and ground water pollution from agrochemical and sediment; also affecting the low farm income from higher cost [1]. One of the most essential agronomic practices for boosting crop output and preserving soil fertility is nutrient management [10]. A sustainable farming system must have pulse. They improve soil health and fix nitrogen into the soil, which reduces the requirement for water [11].

“Green gram is a staple meal that has a protein content of roughly 25%, which is about three times that of grains [12]. Overall, the area planted with pulses has grown over time, however the productivity level is not very satisfying because of continuous cropping and negligence about inorganic fertilizers. The crop is often grown using only conventional fertilizers, without the use of biofertilizers or any other supplemental sources of nutrients [13]. Integrated plant nutrition management promotes economic yield as well as the physicochemical aspects of the soil [14]. When crop residues are applied along with chemical fertilizers, the chemical characteristics, specifically the organic carbon content and nutrient availability, improve. The use of fertilizer, organic manures, and biofertilizers in tandem, also known as integrated nutrient management, is the most effective technique for satisfying plant nutrient demands, resolving the issue of nutrient mining, and preserving soil health [14]. The important component of enhanced yield is nutrient balance. Excessive and unbalanced fertilizer usage has resulted in soil mining, which has reduced agricultural output and, ultimately, soil health [15].

Organic manure involves both micro and macro nutrients, and it enhances soil fertility, soil physical, chemical, and biological qualities; it also maintains soil microbial population balance. population balance. Furthermore, reduce soil erosion and increase plant nutrient availability through the mineralization process [16,17]. It is widely acknowledged that the combination of organic manures and biofertilizers plays a critical role in boosting soil production [16]. Biofertilizers made from microalgae have been found to be an excellent alternative to toxic chemical fertilizers in the agriculture sector [18]. Biofertilizers are primarily responsible for boosting nutrient availability by using various microorganisms; they are also beneficial in enhancing atmospheric nitrogen fixation in soil and for increasing the availability of nutrients in soil that are easily accessible to plants. The use of organic manures and biofertilizer is crucial for soil structure and nutrient management. They improve nutrient availability and soil health by converting a fixed form of nutrient into a soluble form, increasing soil fertility and productivity [19].

The need for an inexpensive alternative to inorganic fertilizer has grown significantly in popularity due to the high price of inorganic fertilizer, growing environmental awareness, and the energy crisis. Given this, the current study on integrated nutrient management is more beneficial for enhancing the physical, chemical, and biological aspects of the soil as well as the production of healthy foods, increasing income, and lowering cultivation costs.

Organic manures and biofertilizer have the ability to promote development and provide immunity in the plant system by lowering the soil microbial population. Excessive and inefficient application of inorganic fertilizers reduced crop quality and harmed the soil. As a result, total yields increase. This may be accomplished by substituting different nutrients using organic methods. This research was designed to examine integrated nutrient management affects the development, production, quality and economics of green gram under semi-*rabi* conditions.

2. METHODOLOGY

The present research investigation was carried out in the semi *rabi* season (2021) at the Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India. The experimental site is located at 22°-35' N latitude 72°-55' longitude and an altitude of 45.1 meters above mean sea level in the Anand district of Gujarat. Metrological data are presented in Fig. 1. The soil of top 15 cm depth of experimental site was loamy sand in texture, low in organic carbon (0.30%) and available nitrogen (210 kg ha^{-1}), medium in available phosphorus (40 kg ha^{-1}) and available potash (285 kg ha^{-1}) with 8.05 soil ph. The details of the ten treatments viz., (T_1) 100% RDF (20:40:0 kg NPK ha^{-1}), (T_2) 100% N through farm yard manure (FYM), (T_3) 100% N through vermicompost, (T_4) 100% N through castor cake, (T_5) 75% N through FYM + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1}, (T_6) 75% N through vermicompost + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1}, (T_7) 75% N through castor cake + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1}, (T_8) 50% N through FYM + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1}, (T_9) 50% N through vermicompost + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1} and (T_{10}) 50% N through castor cake + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1}. The inputs nutrient was analyzed before sowing (FYM, vermicompost, castor cake containing 0.32, 1.21 and 3.24 % N, respectively) while initial microbial count 117.60 10^7 cfu/g observed in soil. Tested organic manures were applied 10 days before planting and integrated into the soil, r*hizobium* was used as a seed treatment, and Bio NPK consortium was applied by soaking and irrigation. At the maturity five randomly selected plants from each plot were harvested separately to study the growth and yield attributing parameters. The crop was harvested, threshed and cleaned manually and seed and stover yield per plot have been recorded. The results from the field experiment were statistically analyzed to compare treatments using analysis of variance techniques (ANOVA) for RBD design and the result were interpreted at 5% level of significance [20].

3. RESULTS AND DISCUSSION

3.1 Response on Growth Attributes

Perusal of data depicted in Table 1 indicated that response of integrated nutrient management treatment on green gram was found to be significant. Application of 75% N through vermicompost + seed treatment (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1} (T_6) reported significantly higher plant height (52.32 and 54.33 cm at 60 DAS (days after sowing) and at harvest, respectively) as well as higher number of branched per plant (5.20) at harvest as compared to treatments. Manure treatment may have encouraged improved root proliferation, increased phosphorous solubility, and hence enhanced biological nitrogen fixation, nutrient absorption, and during the plant growth nutrient availability of all nutrients during the growth phase. As a result, the plant grew taller [21]. Vermicompost and FYM has improved nutrient availability due to speedy mineralization and improved nutrient availability to plants, advancing plant growth and development. The use of organic manures and biofertilizers enhanced green gram growth. The maximum number of branches per plant might be due to synergistic result; it is well recognized that organic manures increase chlorophyll concentration, cell division, shoot growth, and photosynthetic rate [22]. According to the findings, adding manure to the soil increased nutrient availability over time and had a positive effect on plant height. A more balanced diet might have resulted in faster development and growth. Nitrogen is one of the most significant components influencing the leaf area index, which may have aided in agricultural photosynthesis and productivity. The response of organic manures on lead area index might be due to [23,24] supply of macro and micronutrients, vitamins, and growth hormones like as gibberellins, which increased leaf area and hence photo assimilates. Another reason might be due to the practice of keeping soil fertility and plant nutrient delivery at an optimal level in order to sustain goal productivity by optimizing the benefits from all viable organic and biological components except inorganic is referred to as integrated organic nutrient management [25,26].

Presented Table 1 indicated that application organic manures with biofertilizer combination reported its significant response on dry matter accumulation and dry weight of root nodules per plant. Higher dry matter accumulation (31.87 g plant^{-1}) and dry weight of root nodules per plant at 45 DAS (45.67 g) were observed higher in treatment T_6 (75% N through vermicompost + seed treatment (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1}) than other treatments. Organic manure application may have increased organic matter content and microbial activity and ultimately improved soil conditions for nutrient availability, whereas the addition of biofertilizers may have enhanced the biochemical processes of nitrogen fixation and phosphorus solubilization, boosting nutrient availability and promoting crop development. Nutrient availability improved due to higher microbial availability and activities ultimately improved by using biofertilizers. Biofertilizers have improved soil nutrient availability by improving microbial activity and releasing nutrients from soil, which aids in adequate nutrient absorption and utilization by plants [27,28]. In general, proper provision of plant nutrients as per crop requirement via solubilization of insoluble phosphorus and potassium, as well as favorable environmental conditions in the rhizosphere, which supported the crop's longer vegetative and reproductive phases [29].

3.2 Effect of Treatment on Yield Attributes and Yield

The yields varied significantly because of diverse organic nutrient sources and their combinations. (Table 2 and Fig. 1). Dry matter accumulation and dry weight of root nodules per plant of green gram as affected by different organic manure treatments depicted in Table 2. An application of 75% N through vermicompost + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1} (T_6) reported significantly higher pods per plant (33.20) and length of pod (8.60 cm) it was found to be significantly superior over all the treatments. Significantly maximum seed (1481 kg ha^{-1}) and straw (2008 kg ha^{-1}) yield than rest of treatments (Fig. 1). As compared to RDF treatment (T_1), treatment T_6 (75% N through vermicompost + seed treatment (*5 ml* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1}) reported 12.48% higher seed yield. The improved seed yield and yield-attributing characteristics of green gram due to organic soil application may be increased nutrient availability to plants, in addition to increased water holding capacity and other physical properties, which may be due to the formation of more root nodules, vigorous root development, and better nitrogen fixation [30], the development of plant growth leading to higher photosynthesis activity and translocation resulted in improvement of yield attributes and finally higher seed yield [31]. Another explanation for increased economic output might be the reaction of yield-attributing variables such as number of pods per plant, length of pods, number of seeds per pod, and test weight to improved yield resulting in a greater economic yield. Nutrient availability may also have increased photosynthate synthesis and improved translocation within plants led in enhanced growth of photosynthate sink source ratio. Improvement in higher biological yields recorded could be attributed to better plant growth and dry matter accumulation as recorded under these treatments [27].

3.3 Quality Parameters

3.3.1 NPK content, uptake and protein content

The evaluation of seed quality criteria of the resulting seed crop is a critical component in determining the planting value and the performance of seeds as a result of treatments. The use of organic manures in conjunction with biofertilizers altered seed nutrient content, absorption, and protein content of green gram.

Table 1. Response of treatments on growth parameters of semi *rabi* green gram

Treatment	Plant height (cm)		Branches/plant	Dry matter accumulation/plant (g plant^{-1})	Dry weight of root nodules/plant
	60 DAS	**At harvest**	**At harvest**		**45 DAS**
T_1	48.87	51.15	4.90	28.33	23.00
T_2	44.67	46.78	3.73	24.67	29.73
T_3	45.60	47.74	3.93	25.67	32.20
T_4	39.52	41.35	2.40	24.33	23.77
T_5	50.27	52.62	5.13	30.33	44.40
T_6	52.32	54.33	5.20	31.87	45.67
T_7	49.33	51.65	4.93	29.27	44.13
T_8	47.04	49.23	4.33	26.33	43.40
T_9	47.93	50.18	4.53	27.50	43.87
T_{10}	46.57	48.74	4.13	26.00	42.20
SEm ±	1.98	2.06	0.35	1.29	1.54
CD (p=0.05)	5.89	6.12	1.03	3.83	4.56

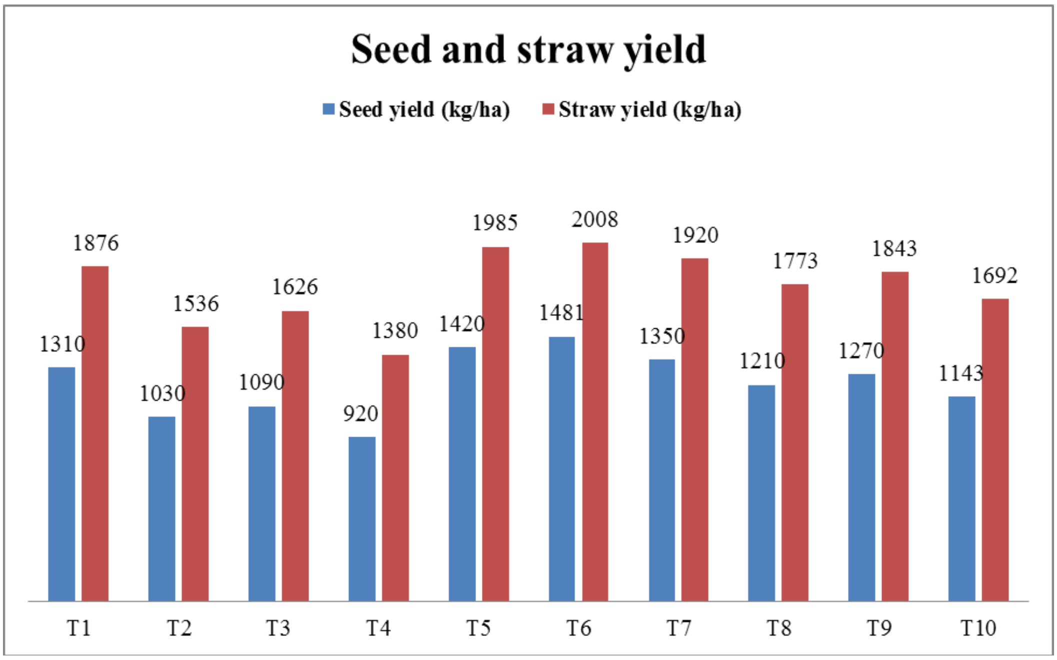

Fig. 1. Effect of integrated organic manures treatments on seed and straw yield

Table 2. Response of treatments on yield attributes and yield of semi *rabi* green gram

Treatment	Pods/plant	Pod length (cm)	Test weight (g)	Protein content in seed (%)	Net return (₹/ha)	B:C ratio
T_1	29.60	7.60	45.25	21.42	40583	2.46
T_2	27.60	5.80	44.61	20.38	27367	1.87
T_3	29.27	6.00	44.88	20.60	27134	1.77
T_4	22.80	5.47	44.17	20.17	19932	1.61
T_5	31.40	8.00	45.36	21.77	50613	2.66
T_6	33.20	8.60	45.41	22.48	51231	2.54
T_7	30.40	7.80	45.32	21.52	45802	2.46
T_8	28.60	7.20	45.11	21.10	40307	2.39
T_9	29.20	7.40	45.17	21.23	41878	2.36
T_{10}	28.20	7.00	44.95	20.94	35944	2.22
SEm ±	1.34	0.33	0.92	0.27	-	-
CD (p=0.05)	3.99	0.99	NS	0.80	-	-

Selling price of green gram: Seed @ ₹50/kg for RDF, @ ₹55/kg seed from organic sources, and straw @ ₹1.5/kg

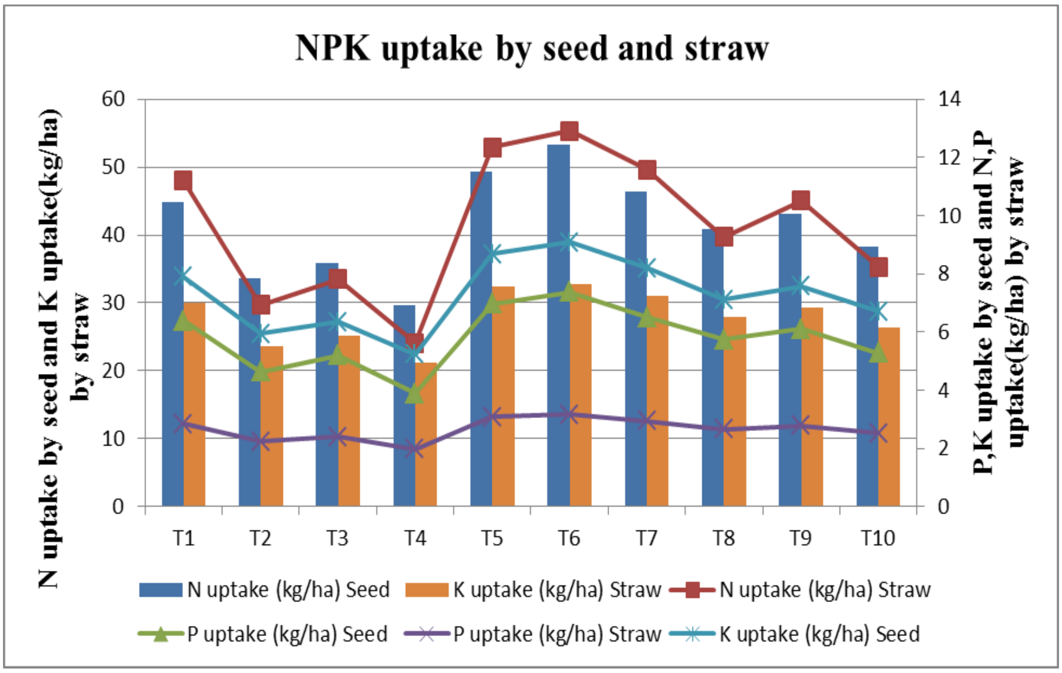

Fig. 2. Effect of different organic sources on NPK uptake by seed and straw

Different organic manures on nutrient content and uptake by seed and straw were found to be significant (Fig. 2). Application of 75% N through vermicompost + seed treatment (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1} (T_6) reported higher nitrogen content in seed and straw (3.6 and 0.65 %, respectively) but it remains statistically at par with treatment T_5 (75% N through FYM + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1}. An application of 75% N through vermicompost + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1} (T_6) reported higher NPK uptake by seed (53.27, 7.38 and 9.08 NPK kg ha^{-1}) and straw (12.91, 3.16 and 32.78 NPK kg ha^{-1}). Data presented in Table 2 revealed that green gram seed protein content (22.48%) reported higher by application of 75% N through vermicompost + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1} (T_6). Higher nitrogen concentration in biological products might be attributed to organic manure, which contains all macro and trace nutrients and is gradually and slowly released, helping to crop nutrition balance. It also improves the soil environment for root development and proliferation. As a result, plants will absorb more nutrients. Resulting in higher nutrient content in seed and stover in green gram [32] and Singh et al. [33]. In general, the use of organic manure alone or combinations with *Rhizobium* and PSB, was found to improve NPK absorption by both seed and stover, with the combined treatment resulting in a greater uptake (Fig. 2).

Ascribed to improved soil fertility and greater nutrient availability and higher nutrient absorption by crop might to due to combined application of organic manures and biofertilizers [27]. The significantly protein content by application of integrated organic manures treatments might be due to nitrogen levels are continuously available at all stages of the crop growth; culminating in slow release of nitrogen through organic sources and resulting in later increased protein content in seed. Then, resulting later stage nitrogen availability through increased protein content in seed.

3.4 Economics

The Perusal of data show in Table 2 indicated that net returns in green gram were influenced significantly due to various treatments of organic manures. Results presented in Table 2 indicated that the higher net return (₹51231/ha) and B:C ratio (2.66) were obtained with application of 75% N through vermicompost + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1} and 75% N through FYM + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1} respectively, which could be due to the higher seed yield during the growing season, higher selling price of organic treated seed and low cost of FYM. The lowest B:C ratio of 1.61 was recorded under 100% N through castor cake.

4. CONCLUSION

In order to increase seed yield and quality of green gram as well as maintain soil health, the use of organic sources for fulfilling nutrient requirement to sustain crop productivity and safeguard soil human-environment health is recommended. Thus, it can be concluded that the application of 75% N through vermicompost + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1} gave significantly higher seed yield (1480 kg ha^{-1}), net return (₹51231/ha) and B:C ratio (2.66) with the application of 75% N through FYM + ST (*5 mL* kg^{-1} seed) of *Rhizobium* + Bio NPK consortium 1L ha^{-1}.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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