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Response of *rabi* French bean (*Phaseolus vulgaris* L.) to sources of organic nitrogen

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Abstract
The field study was conducted during *rabi* 2021-22 at Certified Organic plot, Agronomy Farm, College of Agriculture, Pune to investigate the response of *rabi* french bean to different organic sources of nitrogen *viz*., FYM, vermicompost, poultry manure and neem seed cake. The experiment was laid out in Randomized Block Design (RBD) with nine treatments and three replications. All the growth, yield contributing characters and yield *viz*., plant height, plant spread, number of branches plant^{-1}, number of functional leaves plant^{-1}, leaf area plant^{-1}, dry matter plant^{-1}, AGR, RGR, CGR, NAR, number of pods plant^{-1}, number of seeds pod^{-1}, dry weight of pod plant^{-1}, seed yield plant^{-1}, stover yield plant^{-1}, test weight, seed yield and stover yield were found significantly higher with the application of 100% RDN through vermicompost (T_3) followed by application of 100% RDN through poultry manure (T_5), respectively. Nevertheless, substantial reduction in all these growth and yield attributes were observed with absolute control.

Keywords: Organic manure, French bean, growth, yield

1. Introduction
The French bean (*Phaseolus vulgaris* L.) is a widely known grain legume that corresponds to the Leguminosae family. Snap bean, common bean, pole bean, navy bean, field bean, kidney bean, dry bean and haricot bean are some of the names given to it in different regions of the world. It was introduced to the world from south Mexico and Central America, which are the primary and secondary sources of origin in the Peruvian-Ecuadorian-Bolvian region of South American continent, respectively (Vavilov, 1951) [37]. The nutritional value of the French bean is excellent. Per 100 g of French bean, it contains 31 kcal of energy, 7.13 g of carbohydrate, 1.82 g of protein, 0.34 g of total fat, and 3.4 g of dietary fibre. Copper, chromium, magnesium, calcium, potassium, silicon, iron, and phosphorus are among the minerals found in it. Beans also provide a range of vitamins, including, B1, B2, B6, K, C, A and E. It contains polyphenolic compounds that have antioxidant and health-promoting properties. Bean consumption lowers the risk of diseases such as diabetes, heart diseases, cancer, and obesity (Chaurasia, 2020) [7]. India is the motherland of organic farming. Ancient Indian farmers are credited with developing environmentally friendly agricultural techniques including crop rotation, mixed farming, and mixed cropping. Green revolution of the mid 1960's and its technologies, which include the use of synthetic agrochemicals like fertilizers and insecticides, too high yielding crop varieties, have increased crop production per hectare. However, this increase in production has slowed, and in certain situations, there is evidence of a fall in production and productivity. The increasing success of the green revolution and industrial farming in the last decade has had an impact on human health, environmental assets, and agriculture itself (Ramesh *et al*., 2005) [26]. Organic farming has been alluring people and gaining attention over the last decade since it is considered to give some solutions to current challenges in agriculture such as global environmental pollution, land degradation etc. Adaption of Organic farming, even on a small scale, could be a positive move because it is built on principles of health, ecology, fairness, and care. The most crucial nutrient for optimum plant growth and their development is nitrogen. It improves crop productivity and hence plays a crucial role in agriculture. All key processes in plants, such as protein synthesis, are mostly dependent on nitrogen, making it an essential nutrient. (Massignam *et al*., 2010). Keeping the views of above aspects, the present research work was performed to find out the response of french bean (*Phaseolus vulgaris* L.) to different sources of organic nitrogen like FYM, vermicompost, poultry manure and neem seed cake during *rabi* season in Pune, India with following objective.

To study the effect of organic sources of nitrogen on growth, yield and quality of french bean.

2. Material and Methods

The field experiment was carried out during *rabi* 2021-22 on Certified Organic Plot, in plot no. B-3, at Agronomy Division, College of Agriculture, Pune. Maharashtra. The experimental field topography was uniform and levelled. The experimental site soil was medium black in colour and well drained, with a uniform depth of up to 90 cm. Firstly, ploughing was done by using mould board plough. After ploughing, harrowing was carried out with the help of disc harrow to crush clods and to get fine tilth and make soil suitable for cultivation. The layout was prepared in two tier system in the experimental plot according to the plan of layout. The flat beds of a gross size area of 3 m X 2.7 m were prepared. Irrigation channels and bunds were prepared for irrigation. The field experiment was laid out in Randomized Block Design with nine treatments and three replications. The treatment comprises of T_1 100% RDN through FYM, T_2 75% RDN through FYM, T_3 100% RDN through vermicompost, T_4 75% RDN through vermicompost, T_5 100% RDN through poultry manure, T_6 75% RDN through poultry manure, T_7 100% RDN through neem seed cake, T_8 75% RDN through neem seed cake, T_9 absolute control. The different organic manures *viz*., FYM, vermicompost, neem seed cake and poultry manure were procured from different sources and markets and analysed for total NPK content in laboratory and based on percentage of NPK content in manures, the respective manures were applied in experimental field as per treatments before sowing and thoroughly mixed in the soil. The N, P and K content in different organic manure as follows FYM (0.48%, 0.32% and 0.63%), vermicompost (1.71%, 1.15% and 1.06%), poultry manure (3.19%, 2.41% and 1.33%) and neem seed cake (4.68%, 0.97% and 1.46%). The breeder seeds of French bean variety *Phule rajmah* (GRB-902) was received from National Agriculture Research Project, Zonal Agriculture Research Station (ZARS), Ganeshkhind, Pune. On November 15th, 2021, the seeds were sown by line sowing in a shallow furrow opened with a marker at 45 cm row to row and 10 cm plant to plant spacing. Before sowing, the seeds of French bean were treated with *Rhizobium*, PSB and *Trichoderma* @ 250 grams/10 kg of seeds except absolute control, dried in the shade and utilized for sowing.

2.1 Sampling techniques

Five plants were selected at random from each net plot to record the periodical observations. The chosen plants were labelled and marked with pegs placed near them. On selected plants, all periodical observations of growth parameters were recorded. These plants were harvested separately so that the individual plant yield and yield contributing characters could be assessed during harvest.

2.2 Growth studies

2.2.1 Plant height (cm)

The height of five randomly selected plants in each net plot was measured from the base of the crop to the tip of the fully opened top leaf at 28, 42, 56 DAS and at harvest. An average height of the plants was recorded.

2.2.2 Plant Spread (cm)

The plant spread was measured from five randomly selected plant in each net plot at 28, 42, 56 DAS and at harvest. Measurement was taken from East-West direction from the centre of plant. An average plant spread was calculated.

2.2.3 Number of branches plant^{-1}

The number of branches was counted from five randomly selected plants in each net plot, by excluding the main shoot at 28, 42, 56 DAS and at harvest. A mean number of branches plant^{-1} were recorded.

2.2.4 Number of functional leaves plant^{-1}

The number of functional leaves were counted from the five randomly selected plants in each net plot and recorded at 28, 42, 56 DAS and at harvest. An average functional leaves plant^{-1} were recorded.

2.2.5 Leaf area plant^{-1} (dm^2)

Leaf area is the area of photosynthetic surface produced by the individual plant over a period of interval of time and expressed in dm^2. The leaf area plant^{-1} was worked out from the plant taken out for the dry matter study at 14-day interval from 28 DAS to 56 DAS. Leaves were separated out from the plant and grouped into three different categories, *viz*., large, medium and small according to their size. Number of leaves in each category was counted and from each group one representative leaf was taken and traced on graph paper and its leaf area was measured. Then as per the leaf area of that representative leaf, it was multiplied by number of leaves in that category. By summing the leaf area of each group, the total leaf area per plant was worked out.

2.2.6 Number of root nodules and fresh weight of nodule plant^{-1} (g)

Data on number of root nodules per plant were recorded from two randomly selected plants taken for dry matter study from each net plot at 50% flowering. Before uprooting, the watering was done to selected plants, so that plant will easily uproot and no nodule were left in the soil. These plants were carefully uprooted from each plot. The roots were thoroughly washed in water and active nodules from the roots of each selected plant were separately collected and counted.

Fresh weight of the nodules were recorded and an average fresh weight of nodule plant^{-1} was recorded.

2.2.7 Dry weight of nodule plant^{-1}(g)

The nodules from roots of two plants from each net plot were dissected, dried in a oven at 60 °C ± 5 °C temperature till constant weight was obtained. An average dry weight of nodule plant^{-1} was recorded.

2.2.8 Days to 50% flowering

The number of days required for 50% flowering was recorded by observing all plant from each net plot. When 50% plants from each net plot were flowered, it is considered as days to 50% flowering.

2.2.9 Dry matter plant^{-1} (g)

Two representative plants from each net plot were uprooted at 28, 42, 56 DAS and at harvest to determine the dry matter plant^{-1} and its component parts *viz*., leaves, stem and pods. The roots were cut off and the leaves, stem, and pods were separated. Then the leaves were used for recording leaf area immediately. The leaves, pods and stem were packed into brown paper bag and labelled properly and kept for air drying for 48 hours. Then oven dried at 62 °C ± 2 °C temperature till constant weight was obtained. The final constant dry weight was recorded separately for different component parts and total dry matter was computed by summing the dry weight of component parts of plant. The mean value was expressed as dry matter plant^{-1}.

2.2.10 Absolute growth rate (AGR)
It is the dry matter production per unit time (g day^{-1}) and was calculated by using the following formula (Radford, 1967) [25]

$$AGR = \frac{(W_2-W_1)}{(t_2-t_1)}$$

Where,
W_1 = Dry weight of the plant at time t_1.
W_2 = Dry weight of the plant at time t_2.

2.2.11 Relative growth rate (RGR)
It is the rate of increase in the dry weight per unit dry weight already present and expressed as g g^{-1} day^{-1} (Radford, 1967) [25] and was calculated as:

$$RGR = \frac{(\log_e W_2 - \log_e W_1)}{(t_2-t_1)}$$

Where,
W_1 = Total dry weight of the plant (g) at time t_1.
W_2 = Total dry weight of the plant (g) at time t_2.
t_1 and t_2 = Time interval in days

2.2.12 Crop Growth Rate (CGR)
Crop growth rate is the rate of dry matter production per unit ground area per unit time (Watson, 1952) [38]. It was calculated by using the formula and expressed as g m^{-2} day^{-1}.

$$CGR\ (g\ m^{-2} day^{-1}) = \frac{(W_2-W_1)}{(t_2-t_1)} X \frac{1}{A}$$

Where,
W_1 = Dry weight of the plant at time t_1
W_2 = Dry weight of the plant at time t_2
A = Unit land area
t_1 and t_2 = Time interval in days

2.2.13 Net assimilation rate (NAR)
It is the rate of dry weight increase per unit leaf area per unit time (Radford, 1967) [25]. It is expressed as g dm^2 day^{-1} and calculated as,

$$NAR = \frac{(W_2-W_1)\ X\ (\log_e A_2 - \log_e A_1)}{(t_2-t_1)\ X\ (A_2-A_1)}$$

Where,
A_1W_1 = Leaf area (dm^2) and dry weight of the plant respectively at time t_1.
A_2W_2 = Leaf area (dm^2) and dry weight of the plant respectively at time t_2.
t_1 and t_2 = Time intervals in days.

2.2.14 Days to maturity
The crop in each net plot was observed carefully at the maturity. When leaves started yellowing and drying simultaneously, at this stage grains from the plants of gross plot were observed carefully. When the grains from pod were tough to feel then it was considered that plants reached to physiological maturity. When all plants from each net plot were completely dried, it is considered as days to maturity. The number of days were counted from sowing to maturity.

2.3 Post harvest studies
2.3.1 Number of pods plant^{-1}
The pods from five randomly selected plants from each net plot were picked and total number of pods were counted at harvest and an average number of pods plant^{-1} were recorded and reported.

2.3.2 Number of seeds pod^{-1}
The number of seed pod^{-1} of five randomly selected plant was obtained by dividing the number of grains plant^{-1} by the number of pods plant^{-1}.

2.3.3 Dry weight of pod plant^{-1} (g)
Dry pods from five randomly chosen plants from each net plot were picked and weighed. An average dry weight of pods plant^{-1} was calculated and reported.

2.3.4 Seed yield plant^{-1} (g)
All the pods of five randomly selected plants from each net plot were threshed separately weight it on scientific balance and average seed yield plant^{-1} was estimated and reported.

2.3.5 Stover yield plant^{-1} (g)
All five randomly selected plants from each net plot were weighed and grain weight was deducted from it and an average stover yield plant^{-1} was worked out and reported.

2.3.6 Seed yield (kg ha^{-1})
The seed yield per net plot was recorded after threshing all plants from net plot. The seed yield ha^{-1} was worked out from the yield obtained from net plot and by adding the yield of 5 observational plants. It was converted to per hectare basis and reported.

2.3.7 Stover yield (kg ha^{-1})
Stover dry weight was obtained by reducing the weight of grain from total biological yield of each net plot and stover yield was worked out. It was converted to per hectare and reported.

2.3.8 100 seeds weight (g)
Hundred seeds were counted from each bulk representative samples of each net plot and weighted individually. Hundred seeds weight was recorded in gram and reported.

2.4 Quality studies
2.4.1 Protein content in grain (%)
Protein content in grains of French bean was calculated by multiplying nitrogen percentage in grain with the conversion factor 6.25 (A.O.A.C., 1960) [1].

3. Result and Discussion

The findings obtained from this investigation are presented and discussed in tables with various headings and subheadings.

3.1 Growth studies
The data regarding french bean growth contributing characters *viz*., plant height (cm), plant spread (cm), number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1} (dm^{2}), number of nodules plant^{-1}, fresh weight of nodule plant^{-1} (g), dry weight of nodule plant^{-1} (g), days to 50% flowering, dry matter plant^{-1} (g), absolute growth rate (g day^{-1}), relative growth rate (g g^{-1} day^{-1}), crop growth rate (g m^{-2} day^{-1}), net assimilation rate (g dm^{-2} day^{-1}) and days to maturity as affected by different organic sources of nitrogen at different growth period are presented and discussed with the help of tables.

3.1.1 Plant height (cm)
The results with regard to the mean plant height (cm) of the French bean as influenced periodically due to different organic sources of nitrogen is presented in the table 1.

It is observed from the data that, the mean plant height was increased with advancement of crop age and highest plant height was recorded at harvest. The plant's height was increased rapidly up to 56 DAS and same there-after at harvest. Among different treatments, application of 100% RDN through vermicompost (T_3) recorded significantly maximum plant height at 42, 56 DAS and at harvest (27.66, 33.63 and 33.63cm), respectively over rest of the treatments except treatments application of 75% RDN through vermicompost (T_4) and 100% RDN through poultry manure (T_5). The treatment application of 75% RDN through vermicompost (T_4) was found at par with application of 100% RDN through vermicompost (T_3) at 42 DAS. Whereas, the minimum plant height of French bean was registered in treatment of absolute control (T_9) throughout crop growths stages except 28 DAS. The maximum plant height in application of 100% RDN through vermicompost was possibly as a fact that, vermicompost enhances the soils physical, chemical, and biological properties while also providing nearly all of the essential nutrients needed for plant growth and development. In light of this, it is possible that healthy seedling growth and enhanced root development were produced by balanced nutrition in a suitable environment. Similar results were noticed by Sitaram *et al*. (2013) [35] while working on green gram recorded maximum plant height at harvest with application of vermicompost. The results are also in accordance with the findings stated by Kumawat *et al.* (2006) [16], Cheizey and Odunze (2009) [8], Singh and Chauhan (2009) [33].

3.1.2 Plant spread (cm)
The collected information concerning plant spread of French bean owing to the influence of different organic sources of nitrogen is reported in a table 1.

The findings demonstrated that, with the exception at 28 DAS, the application of various organic sources of nitrogen substantially affected the mean plant spread (cm) of the French bean throughout all phases of crop growth. The mean maximum plant spread of French bean was expanded with the increment in crop age up to 56 DAS (32.67cm) and declined with maturity of crop attributable to shedding of leaves at harvest. A perusal of data showed that, application of 100% RDN through vermicompost (T_3) recorded maximum plant spread at 28, 42, 56 DAS and at harvest (23.87, 33.93, 36.77 and 34.57 cm), respectively as compared to other treatments under field investigation. However, it was found statistically at par with application of 100% RDN through poultry manure (T_5) at 42, 56 DAS and at harvest. While, the minimum plant spread was noted in treatment of absolute control (T_9) during all crop growth stages. Maximum crop growth and production from vermicompost may be connected to the improvement of the soil's physicochemical qualities, and it may be used as a resource for the largest plant spread, that's why the application of 100% RDN through vermicompost (T_3) resulted in a more plant spread. According to Singh and Chauhan's (2009) [33] report on French bean, vermicompost causing the greatest plant expansion. These outcomes are also in corroboration of the findings registered by Singh and Chauhan (2009) [33] and Halge (2021) [13].

3.1.3 Number of branches plant^{-1}
The consequences for the number of branches plant^{-1} of the French bean as impacted by different organic nitrogen sources on a periodic basis are proffered in the table 2.

The statistically analyzed data referring to number of branches plant^{-1} indicates that, the various sources of organic nitrogen significantly impacted the number of branches plant^{-1} except at 28 DAS. The mean number of branches plant $^{-1}$ at 28, 42, 56 DAS and at harvest were 2.99, 3.61, 4.33 and 4.33, respectively. The number of branches plant^{-1} was rose with progression of crop age and achieving a maximum at 56 DAS (4.33). At 42, 56 DAS and at harvest, significantly maximum number of branches plant^{-1} (4.27, 5.40) was registered under application of 100% RDN through vermicompost (T_3) and it was found at par with application of 100% RDN through poultry manure (T_5) (4.00, 5.13). While, the absolute control (T_9) marked the lowest number of branches plant^{-1} at all crop growth stages. These findings are most probably attributable to vermi compost's improving soil physical conditions and enhanced crop availability of major (NPK) and micro nutrients throughout the growing season. By delivering assimilates to the roots, vermicompost aid in root growth and proliferation, nodule formation, and nitrogen fixation. They also improve CEC, water retention capacity, and phosphate availability in soil, resulting in a healthier rhizosphere environment for growth and development. Such favourable impacts of vermicompost, along with an improved edaphic environment available to the crop, may have increased crop development overall. The increased in number of branches plant^{-1} due to application of vermicompost was reported by Kumawat *et al.* (2009) in green gram. These results are in harmony with those findings of Gohain and Kikon (2017) [12], Aritonang and Sidauruk (2020) [2], Kushwaha *et al.* (2021) [17].

3.1.4 Number of functional leaves plant^{-1}
The data concerning number of functional leaves plant^{-1} of french bean as influenced periodically by different organic sources of nitrogen are acquainted in table 2.

The data exhibited in the table divulge that, the mean number of functional leaves plant^{-1} was substantially impacted at all crop growth stages owing to different organic sources of nitrogen under study except at 28 DAS and at harvest. The mean number of functional leaves plant^{-1} were increased up to 56 DAS, nevertheless it was diminished at harvest owing to senescence of leaves. The highest mean number of functional leaves plant^{-1} was recorded at 56 DAS (15.73). The findings of the present investigation lay bare that, including the different treatment, application of 100% RDN through vermicompost (T_3) registered significantly a greater number of leaves plant^{-1} at 28, 42 and 56 DAS (6.20, 11.93 and 17.93), respectively over other treatments. But statistically, it was equitable with that of application of 100% RDN through poultry manure (T_5) at 42 (11.33) and 56 DAS (17.27). The treatment absolute control (T_9) recorded significantly lowest number of functional leaves plant^{-1} compared to rest of the treatments at all growth stages of French bean. The higher number of functional leaves plant^{-1} with application of 100% RDN through vermicompost (T_3) was might be due to maximum crop productivity from vermicompost may be linked to the enhancement of the soil's physicochemical characteristics, and it may be utilised as a resource for the highest production of leaves. Singh and Chauhan (2009) [33] reported maximum number of functional leaves plant^{-1} due to addition of vermicompost in French bean. This result was found consistent and accordance with the report of Bahrampour and Ziveh (2013) [5], Enujeke E.C. (2013) [9], Feleafel and Mirdad (2014) [11].

3.1.5 Leaf area plant^{-1} (dm^2)
The data disclosed regarding leaf area plant^{-1} of french bean as influenced periodically by different organic sources of nitrogen is demonstrated in table 3.

The mean leaf area plant^{-1} of French bean was increased up to 56 DAS and it was declined thereafter at harvest due to senescence and shading of leaves. The mean maximum leaf area plant^{-1} was increased exponentially with development of crop age and noted higher leaf area plant^{-1} at 56 DAS (9.29 dm^2). The mean leaf area plant^{-1} recorded at 28, 42, 56 DAS and at harvest were 3.05, 6.73, 9.29 and 0.20 dm^2, respectively. The treatment of application of 100% RDN through vermicompost (T_3) produced significantly largest leaf area plant^{-1} at 28, 42 and 56 DAS (4.25, 8.87 and 11.69 dm^2), respectively as compared to rest of the treatments. However, it was comparable with the treatment application of 100% RDN through poultry manure (T_5) at 42 and 56 DAS. The minimum leaf area plant^{-1} was noticed in treatment of absolute control (T_9) at all growth phases of french bean, as compared to rest of the treatments, The highest leaf area plant^{-1} with application of 100% RDN through vermicompost (T_3) could be linked to the favourable effect of vermicompost on soil physiological parameters is due to its function as source of plant nutrients. It is an excellent site of both macro and micronutrients, vitamins, PGPRs and advantageous microflora, which stimulates microbial and metabolic activity in the rhizosphere. Similar findings were ascertained by Singh *et al*. (2013) [34] in case of lentil and reported that, rise in leaf area plant^{-1} by addition of vermicompost and seed inoculation with *rhizobium* and PSB. These results are in agreements with the previous investigation of Cheizey and Odunze (2009) [8], Sitaram *et al.* (2013) [35], Feleafel and Mirdad (2014) [11].

3.1.6 Dry matter plant^{-1} (g)
Data arising with reference to total dry matter accumulation plant^{-1} (g) as a result of different organic sources of nitrogen are outlined in table 3.

The data revealed that, total dry matter plant^{-1} (g) was profoundly differed at each stage of French bean growth except at 28 DAS. The mean total dry matter plant^{-1} (g) was rose significantly with the increment in the crop's age till maturity. The mean highest dry matter plant^{-1} was noticed at harvest of crop (14.88 g). The dry matter accumulation plant^{-1} recorded at 28, 42, 56 DAS and at harvest were 4.95, 8.52, 12.02 and 14.88 g plant^{-1}, respectively. Including different treatments, application of 100% RDN through vermicompost (T_3) registered significantly maximum dry matter accumulation plant^{-1} over the rest of treatments at 28, 42, 56 DAS and at harvest (5.74, 10.68, 16.29 and 20.13 g), respectively. Whereas, this treatment was found at par with application of 100% RDN through poultry manure (T_5) at 42, 56 DAS and at harvest. On the contrary, the minimum accumulation of dry matter plant^{-1} of French bean was determined in absolute control (T_9) at all growth phases of French bean. The dry matter production plant^{-1} had been consistently greater at all growth stages with the application of 100% RDN through vermicompost (T_3), which could be credited to an increase in plant growth parameters, furthermore an enhancement in the accessibility of nutrients, prolonged availability of macro and micro nutrients from vermicompost, which aided in the acceleration of multiple metabolic processes such as photosynthesis, energy transfer reaction, and symbiotic biological N-fixation process, which led to greater dry matter accumulation. Similar consequences were noted by Kushwaha *et al.* (2021) [17] while working on chick pea. The findings are also identical to the results of Shrimal and Khan (2017) [31], Soremi *et al.* (2017) [36], Yadav *et al.* (2017) [40].

3.1.7 Absolute growth rate (g day^{-1})
The data in terms of absolute growth rate of French bean as influenced periodically by different organic sources of nitrogen is demonstrated in table 4.

Numerically, maximum absolute growth rate was noticed in treatment 100% RDN through vermicompost (T_3) during each growth stages of French bean over other treatments. It was (0.371 g day^{-1}) at 28-42 DAS, (0.487 g day^{-1}) at 42-56 DAS and (0.258 g day^{-1}) at 56 DAS- at harvest. However, this treatment was found at par with treatment application of 100% RDN through poultry manure (T_5) at all growth stages of crop. Whereas, the lower absolute growth rate was recorded in treatment absolute control (T_9) during all growth phases of french bean. Vermicompost has the highest mean absolute growth rate could be attributed to an improvement in photosynthetic efficiency caused by increasing leaf thickness and conserving greater chlorophyll content, as well as efficient photosynthate translocation. It could possibly be because of the efficacy of these treatments in increasing dry matter production as well as the pace of increase in total dry matter production. Ashwini (2005) [3] reported a consistent finding in French bean. Similar outcomes have been documented by Rawat *et al*. (2015) [28] and Singh and Kumar (2016) [32].

3.1.8 Relative growth rate (g g^{-1} day^{-1})
The consequences for the relative growth rate of French bean as influenced by different organic nitrogen sources on a periodic basis are furnished in table 4.

As compared to rest of the treatments under investigation, the significantly maximum relative growth rate was registered in application of 100% RDN through vermicompost (T_3) at all growth phases of crop. It was 0.0243, 0.0135 and 0.0089 g g^{-1} day^{-1}, respectively. Nevertheless, it was found at par with treatment application of 100% RDN through poultry manure (T_5) at 28-42 DAS. While the minimum relative growth rate (RGR) was noted in treatment absolute control during all growth stage of experimental crop. Vermi compost's highest relative growth rate can be attributed to enhanced photosynthetic efficiency brought on by larger leaves that retain more chlorophyll and more effective photosynthate transfer. It might be as a result of how well these treatment work at boosting dry matter production as well as how quickly dry matter accumulation has been rising overall. A consistent finding in French bean was reported by Ashwini (2005) [3]. The present findings are in consonance with those of Rawat *et al*. (2015) [28] and Singh and Kumar (2016) [32].

3.1.9 Net assimilation rate (g dm^{-2} day^{-1})

Data arising in relation to net assimilation rate (g dm^{-2} day^{-1}) as a result of different sources of organic nitrogen are outlined in table 4.

The treatment 100% RDN through vermicompost (T_3) showed higher NAR at 28-42 DAS (0.0705 g dm^{-2} day^{-1}) and 42-56 DAS (0.0837 g dm^{-2} day^{-1}) over rest of the treatments. However, this treatment (T_3) was found at par with treatment application of 100% RDN through poultry manure (T_5). Significantly, the lowest NAR was positioned in treatment absolute control (T_9) at 28-42 DAS (0.0366 g dm^{-2} day^{-1}) and 42-56 DAS (0.0467 g dm^{-2} day^{-1}), respectively. The greater build-up of total dry matter and leaf area may be the cause of the higher NAR in vermicompost. The outcomes on leaf area and total dry matter exhibit that both parameters were greatly boosted by this treatment. Ashwini (2005) [3] reported a similar conclusion while working on the pole bean at UAS Dharwad.

3.1.10 Crop growth rate (g m^{-2} day^{-1})

The disclosure on mean crop growth (g m^{-2} day^{-1}) of French bean as an impact of different organic sources of nitrogen is illustrated in table 5.

Numerically, the highest crop growth rate was observed in treatment application of 100% RDN through vermicompost (T_3) at all growth stages of French bean over rest of the treatments. It was 6.97, 7.25 and 4.77 g m^{-2} day^{-1} at 28-42 DAS, 42-56 DAS and 56 DAS-at harvest, respectively. However, this treatment (T_3) was found comparable with treatment application of 100% RDN through poultry manure (T_5). While, the lowest crop growth rate was recorded under treatment absolute control (T_9) at all growth phases of crop. The uttermost crop growth rate in application of vermicompost was might be related to the solubilization of nutrients, production of growth hormones like 1-amino cyclopropane-1-carboxylate (ACC) deaminase and significant increase in soil enzyme activity, including urease, phosphomonoesters, phosphodiesterases and arylsulphatase, may have contributed to the highest crop growth rate following the application of vermicompost. Thus, it leads to an increase in plant overall growth, total dry matter production, and ultimately crop yield. Similar outcomes with French bean were mentioned by Ashwini (2005) [3]. Similar sequels are consonance with those of Rawat *et al*. (2015) [28] and Singh and Kumar (2016) [32].

3.1.11 Number of root nodules, Fresh and dry weight of nodule plant^{-1} (g)

The research findings on the number of nodule plant^{-1}, Fresh and dry weight of nodule plant^{-1} as impacted by different organic sources of nitrogen are reported in table 5.

Treatment application of 100% RDN through vermicompost recorded numerically maximum number of root nodule plant^{-1} (35.67) over rest of the treatments. The absolute control treatment (T_9) registered minimum number of root nodule plant^{-1} (28.00) of French bean. This was might be attributed to improved nutrient availability from vermicompost as well as effective conversion of nutrients from vermicompost such as Fe, Mg, and Zn supplied at the photosynthetic site. Because there is a direct relationship between the number of root nodules and higher nitrogen fixation, the usage of vermicompost produced a greater number of nodules and effective root nodules, resulting in the incarnation of higher growth and yield of French bean. These results were observed by Yadav *et al*. (2017) [40] in chick pea. The presence of more hormones and a balanced pH in vermicompost, which maintain a favourable environment for the maximum growth of the bacteria present in root nodules, may be the cause of the highest number of root nodules. Vermicompost also serves as a source for the bacterial development and activities. Similar outcomes were documented by Bajracharya and Rai (2009) [6] in the case of chick pea. The above findings are in congruent with Bajracharya and Rai (2009) [6], Kumawat *et al*. (2009), Yadav *et al*. (2017) [40]. The data unambiguously demonstrated that, mean fresh weight and dry weight of nodule plant^{-1} of French bean at 50% flowering did not vary significantly due to different organic sources of nitrogen. The mean fresh and dry weight of root nodules plant^{-1} were 0.23 and 0.05g, respectively. The 100% RDN through vermicompost treatment (T_3) managed to produce the considerably highest fresh weight of nodule plant^{-1}. While in comparison, absolute control (T_9) treatment marked lowest fresh (0.19 g) and dry weight (0.04) of root nodules plant^{-1} of all other treatments investigated.

3.1.12 Days to 50% flowering and maturity

The relevant information on the days to 50% flowering and maturity of French bean as influenced by different organic sources of nitrogen is summarized in table 5.

The data showed in the table 5 elaborates that, the mean number of days required to 50% flowering and maturity of French bean were not impacted significantly due to different sources of organic nitrogen. The mean number of days to 50% flowering were (34.67) and number of days to physiological maturity were (77.59). Numerically highest number of days to 50% flowering (35.67) and maturity (79.33) were recorded in treatment 100% RDN through poultry manure (T_5). However, the minimum number of days to 50% flowering (33.33) and maturity (75.00) were noted in treatment of absolute control (T_9).

3.2 Yield studies

The data pertaining yield contributing characteristics of investigated french bean, *viz*., number of pods plant^{-1}, number of seed pod^{-1}, dry weight of pod plant^{-1} (g), seed yield plant^{-1} (g), stover yield plant^{-1} (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and test weight (g) as influenced by different organic sources of nitrogen are showcased in table 7.

3.2.1 Number of pods plant^{-1}

The data on the mean number of pods plant^{-1} of french bean was stastistically impacted by different organic sources of nitrogen shows that, the mean number of pods plant^{-1} at harvest was (12.66). The treatment 100% RDN through vermicompost (T_3) recorded a significantly highest number of pods plant^{-1} (15.27) as compared to rest of the treatments. However, this treatment (T_3) was found at par with the treatment of application of 100% RDN through poultry manure (T_5). Significantly, lowest number of pods plant^{-1} were observed with treatment absolute control (T_9). This outcome may be attributable to vermicompost manure's contains substaintal organic matter, which can intensify the soil's physical properties.Organic material that can strengthen soil structure and increase the soil's capacity to absorb nutrients. Similar findings were disclosed by Aritonang and Sidauruk (2020) [2] in soybean. These result are also in similar line with the earlier finding of Yadav and Vijayakumari (2003) [39], Singh and Chauhan (2009) [33], Cheizey and Odunze (2009) [8].

3.2.2. Number of seeds pod^{-1}

The mean number of seeds pod^{-1} as impacted by different sources of organic nitrogen was 2.92. The data revealed that, application of 100% RDN through vermicompost (T_3) registered significantly maximum number of seeds pod^{-1} than other treatments(3.40). But, treatments 100% RDN applied through poultry manure (T_5) (3.26), 100% RDN applied through Neem seed cake (T_7) (3.09) and 100% RDN applied through FYM (T_1) (2.98) were found at par with application of 100% RDN through vermicompost (T_3). Whereas, the lowest number of seeds pod^{-1} was found in the absolute control treatment (T_9) (2.42). This result might be linked to the positive influence of vermicompost on seed production may be attributable to its capacity to maintain nutrient availability throughout the growing season. The enhanced C: N balance may have boosted the synthesis of carbohydrates, improving yield characteristics like the number of seeds pod^{-1}. The same consequences were reported by Murugan *et al.* (2020) [21] in groundnut. The same results were mentioned by Mathivanan *et al*. (2012) [19], Azarpour *et al*. (2012) [4], Sen *et al.* (2021) [30].

3.2.3 Dry weight of pod plant^{-1} (g)

The result illustrated in table shows that, the mean dry weight of pod plant $^{-1}$ recorded as a result of the various organic sources of nitrogen treatments was 6.21. Treatment 100% RDN through vermicompost (T_3) showed significantly the highest dry weight of pod plant^{-1} (7.16 g) over rest of the treatments. Conversely this treatment (T_3) was found at par with treatment 100% RDN through poultry manure (T_5) (6.92 g) and 100% RDN through neem seed cake (T_7) (6.71 g). Among the different treatments, treatment of absolute control (T_9) recorded considerably the lowest dry weight of pod plant^{-1} (4.87 g). This performance could have been brought about by the combination of macro-and micronutrients in vermicompost and its impact on nutrient uptake, which promotes plant nutrition, growth, photosynthesis, and chlorophyll content in the leaves. Rekha *et al*. (2018) [29] observed similar results, registering the highest dry weight of pod plant^{-1} in *capsicum annum* with vermicompost treatment. The present facts are in confirmation to earlier report of Islam *et al*. (2016) [14], Mohmoud and gad (2020) [20].

3.2.4 Seed yield and Stover yield plant^{-1} (g)

A review of statistical data revealed that, seed and stover yield plant^{-1} of French bean were significantly altered by application of different organic sources of nitrogen. The mean seed yield and stover yield plant^{-1} of French bean were 5.18 g and 10.39 g, respectively. Significantly, the highest seed yield (6.33 g) and stover yield plant^{-1} (12.33 g) were obtained under the treatment of 100% RDN through vermicompost (T_3) over rest of the treatments but it was found at par with treatment of 100% RDN through poultry manure (T_5). The lowest seed yield and stover yield plant^{-1} was registered in the treatment absolute control (T_9). The highest seed and stover yield plant^{-1} with treatment of 100% RDN through vermicompost might be related to vermicompost has been shown to increase microbial activity, which may have enhanced nutrient availability through mineralization, improved canopy coverage, increased photosynthesis and transfer of photosynthates from source to sink. (Jeevansab, 2000) [15]. The formation of beneficial free-living and symbiotic microbes is greatly aided by vermicompost, which also boosts the population of actinomycetes and bacteria that fix nitrogen. The improved availability of soil phosphorus and nitrogen as a result of the enhanced microbial activity increases the crop's final yield. (Yadav and Vijay kumari, 2003) [39]. The observed impacts are in line with the report of Natesh *et al.* (2005) [23], Pandiyan *et al*. (2020) [24].

3.2.5 100 seed weight (g)

Data presented in table 7 clearly indicates that application of 100% RDN through vermicompost (T_3) logged significantly higher 100 seed weight (26.60 g) as compared to rest of the treatments. Nevertheless, 100% RDN through poultry manure (T_5) (25.77 g) was found equivalent with this treatment. Whereas, the lowest weight of 100 seeds was noticed in absolute control treatment i.e. (T_9) (18.37gm). This might be owing to higher nitrogen and phosphorous content in vermicompost, chicken manure, and increased nutrient uptake by plants may have contributed to the significant increase in 100 seed weight. These elements may also have stimulated the rate of various physiological processes in plants, causing rose in growth and yield parameters additionally pod and haulm yield. Similar results were disclosed by Sen *et al*. (2021) [30] in groundnut and Gohain and Kikon (2017) [12] in green gram and Yadav *et al*. (2017) [40] in chick pea.

3.2.6 Seed yield (kg ha^{-1})

The mean seed yield of French bean was 958.75 kg ha^{-1}. The statistical data demonstrates that, different sources of organic nitrogen have a substantial impact on the seed yield ha $^{-1}$ of French bean. Among different organic treatments, treatment 100% RDN through vermicompost (T_3) produces significantly the highest seed yield (1247.86 kg ha^{-1}) and it is outperforming over other treatments. However, treatment 100% RDN through poultry manure (T_5) was found comparable with the treatment 100% RDN through vermicompost (T_3). In comparison with other treatments of organics, absolute control treatment (T_9) registered the lowest seed yield (485.61 kg ha^{-1}) of all the other organic sources treatments. Higher seed yield of french bean under the application of 100% RDN through vermicompost (T_3) could be attributed better yield contributing characters like number of seeds pod^{-1}, number of pods plant^{-1}, seed yield plant^{-1}, stover yield plant^{-1} and test weight. Greater availability of nutrients in vermicompost may also increase photosynthate production and enhance translocation within plants, which would improve the sink source ratio of photosynthates. Gohain and Kikon (2017) [12] noted similar results in green gram. These results correlated with seed yield are in support with the findings of Nasab *et al.* (2015) [22], Yadav *et al.* (2017) [40], Kushwaha *et al.* (2021) [17].

3.2.7 Stover yield (kg ha^{-1})

The mean stover yield of French bean was 1922.90 kg ha^{-1}. The data revealed that, different sources of organic nitrogen had significant impact on the stover yield of French bean. The stover yield was significantly higher in treatment application of 100% RDN through vermicompost (T_3) (2498.57 Kg ha^{-1}) over rest of the treatments and it was at par with 100% RDN through poultry manure (T_5) (2323.35 kg ha^{-1}). The lowest stover yield of French bean was perceived with treatment absolute control (T_9) (927.92 Kg ha^{-1}) over other treatments. Significantly higher stover yield with the application of 100% RDN through vermicompost (T_3), may be attributed to increased nutrient availability and uptake, higher photosynthesis and translocation of photo assimilates. Seed treatment of *Rhizobium* and PSB under this treatment may result in increased nitrogen fixation in soil, solubilization of native phosphorous and production of secondary metabolites, all of which increase the availability and uptake of phosphorous and nitrogen. Additionally, this treatment may result in better root growth and higher root nodule, which increases nutrient uptake and promotes plant growth and development. While speedy mineralization of vermicompost may increase the nutrients availability to plants by promoting their growth characteristics *viz*., plant height and dry matter accumulation and thus stover yield of plant. Identical results were confirmed by Gohain and Kikon (2017) [12] in green gram. Increased stover yield with application of 100% RDN through vermicompost and poultry manure has also been mentioned by Farhad *et al.* (2009) [10], Kushwaha *et al.* (2021) [17].

3.3 Quality studies

3.3.1 Protein content (%)

The data in table 7 confirmed that, the mean protein content in grains of French bean was not differed significantly with different organic nitrogen sources treatments. The mean protein content of French bean noted was 19.76%. The treatment of 100% RDN through vermicompost (T_3) registered numerically more protein content (20.39%) compared to rest of the treatments. Nevertheless, the lower protein content in grains of French bean (19.04%) was found under absolute control treatment (T_9). The relatively high grain protein content with application of vermicompost (T_3) might be owing to enhanced protein synthesis utilizing amino acids as a result of N-metabolism. The effect of vermicompost and seed treatment with biofertilizers (*rhizobium* and PSB) to enhancing seed quality may be due to their important function in governing photosynthesis, root elongation, and boosted microbial activity. These findings are in close resemblance with the report of Nasab *et al.* (2015) [22], Ravimycin (2016) [27], Sen *et al.* (2021) [30].

Table 1: Plant height, plant spread of French bean as influenced periodically due to different treatments

Tr. No.	Treatment	Plant height (cm)				Plant Spread (cm)			
		28 DAS	42 DAS	56 DAS	At harvest	28 DAS	42 DAS	56 DAS	At harvest
T_1	100% RDN through FYM	19.18	24.87	30.75	30.75	22.77	30.00	32.90	30.77
T_2	75% RDN through FYM	18.45	22.70	28.90	28.90	22.09	28.07	30.93	27.67
T_3	100% RDN through vermicompost	19.68	27.66	33.63	33.63	23.87	33.93	36.77	34.57
T_4	75% RDN through vermicompost	17.61	25.77	29.43	29.43	22.57	30.25	33.07	30.93
T_5	100% RDN through poultry manure	19.59	26.37	32.03	32.03	23.56	32.57	35.07	33.00
T_6	75% RDN through poultry manure	17.57	24.78	28.73	28.73	22.68	29.07	32.99	30.45
T_7	100% RDN through neem seed cake	18.51	25.25	31.20	31.20	23.21	30.42	33.20	31.00
T_8	75% RDN through neem seed cake	18.21	23.43	28.27	28.27	22.44	28.87	31.50	28.93
T_9	Absolute control	17.65	20.19	27.11	27.11	20.03	24.13	27.57	25.50
S. Em. ±		0.89	0.76	0.74	0.74	1.20	1.12	1.05	1.00
C.D. at 5%		NS	2.30	2.22	2.22	NS	3.37	3.16	3.01
General Mean		18.49	24.56	30.01	30.01	22.58	29.70	32.67	30.31

*All the observations are mean of three replications.

Table 2: Number of branches $plant^{-1}$, number of functional leaves $plant^{-1}$ as influenced periodically due to different treatments

Tr. No.	Treatment	Number of branches $plant^{-1}$				Number of functional leaves $plant^{-1}$			
		28 DAS	42 DAS	56 DAS	At harvest	28 DAS	42 DAS	56 DAS	At harvest
T_1	100% RDN through FYM	3.07	3.60	4.27	4.27	5.87	10.07	15.87	0.33
T_2	75% RDN through FYM	3.00	3.53	3.73	3.73	5.40	9.33	14.80	0.00
T_3	100% RDN through vermicompost	3.13	4.27	5.40	5.40	6.20	11.93	17.93	0.20
T_4	75% RDN through vermicompost	3.07	3.47	4.20	4.20	5.67	10.07	15.80	0.33
T_5	100% RDN through poultry manure	3.07	4.00	5.13	5.13	6.00	11.33	17.27	0.67
T_6	75% RDN through poultry manure	3.07	3.40	4.00	4.00	5.53	9.93	15.67	0.00
T_7	100% RDN through neem seed cake	3.00	3.73	4.67	4.67	5.93	10.20	15.93	0.08
T_8	75% RDN through neem seed cake	3.07	3.47	3.93	3.93	5.40	9.60	15.60	0.47
T_9	Absolute control	2.47	3.10	3.60	3.60	5.07	8.67	12.73	1.33
S. Em. ±		0.14	0.15	0.21	0.21	0.35	0.54	0.65	0.47
C.D. at 5%		NS	0.47	0.63	0.63	NS	1.63	1.95	NS
General Mean		2.99	3.61	4.33	4.33	5.67	10.13	15.73	0.38

Table 3: leaf area plant^{-1} and dry matter plant^{-1} of French bean as influenced due to different treatments

Tr. No.	Treatment	Leaf area plant^{-1} (dm^2)				Dry matter plant^{-1}(g)			
		28 DAS	42 DAS	56 DAS	At harvest	28 DAS	42 DAS	56 DAS	At harvest
T_1	100% RDN through FYM	3.40	6.81	9.86	0.30	5.33	8.77	12.38	15.83
T_2	75% RDN through FYM	2.34	5.65	8.19	0.00	4.79	7.35	9.28	12.10
T_3	100% RDN through vermicompost	4.25	8.87	11.69	0.16	5.74	10.68	16.29	20.13
T_4	75% RDN through vermicompost	3.19	6.75	9.48	0.23	4.83	8.59	10.97	12.42
T_5	100% RDN through poultry manure	3.42	8.39	10.73	0.44	5.65	9.90	15.29	18.05
T_6	75% RDN through poultry manure	2.37	6.62	8.81	0.00	4.41	8.30	11.27	14.38
T_7	100% RDN through neem seed cake	3.38	6.84	10.08	0.26	5.18	9.01	13.79	16.37
T_8	75% RDN through neem seed cake	2.64	6.16	8.57	0.30	4.35	7.94	10.06	12.86
T_9	Absolute control	2.47	4.49	6.22	0.07	4.29	6.15	8.82	11.73
S. Em. ±		0.45	0.66	0.52	0.18	0.39	0.45	0.81	1.0
C.D. at 5%		NS	1.98	1.56	NS	NS	1.36	2.42	3.15
General Mean		3.05	6.73	9.29	0.20	4.95	8.52	12.02	14.88

Table 4: Absolute growth rate, relative growth rate and net assimilation rate of French bean as influenced due to different treatments

Tr. No.	Treatment	Absolute growth rate (g day^{-1})			Relative growth rate (g g^{-1} day^{-1})			Net assimilation rate (g dm^{-2} day^{-1})	
		28 -42	42-56	56-at harvest	28-42	42-56	56-at harvest	28-42	42-56
T_1	100% RDN through FYM	0.275	0.364	0.182	0.0139	0.0017	0.0077	0.0549	0.0651
T_2	75% RDN through FYM	0.215	0.289	0.125	0.0132	0.0073	0.0041	0.0403	0.0508
T_3	100% RDN through vermicompost	0.371	0.487	0.258	0.0243	0.0135	0.0089	0.0705	0.0837
T_4	75% RDN through vermicompost	0.268	0.335	0.170	0.0167	0.0108	0.0071	0.0502	0.0591
T_5	100% RDN through poultry manure	0.344	0.436	0.215	0.0219	0.0131	0.0086	0.0685	0.0792
T_6	75% RDN through poultry manure	0.256	0.327	0.162	0.0164	0.0108	0.0065	0.0505	0.0647
T_7	100% RDN through neem seed cake	0.286	0.390	0.195	0.0170	0.0130	0.0078	0.0557	0.0710
T_8	75% RDN through neem seed cake	0.256	0.301	0.162	0.0162	0.0094	0.0051	0.0494	0.0586
T_9	Absolute control	0.133	0.203	0.0916	0.0116	0.007	0.0014	0.0366	0.0467
S. Em. ±		0.02	0.03	0.01	0.0021	0.0023	0.0033	0.0049	0.0040
C.D. at 5%		0.07	0.09	0.05	0.0064	NS	NS	0.014	0.012
General Mean		0.27	0.35	0.17	0.02	0.01	0.01	0.05	0.07

Table 5: Crop growth rate, number of nodules plant-1, Fresh and dry weight of nodule plant-1, days to 50% flowering and maturity of French bean as influenced due to different treatments

Tr. No.	Treatment	Crop growth rate (g m^{-2} day^{-1})			At 50% flowering			Day to flowering	Days to maturity
		28-42	42-56	56-at harvest	No. of nodules plant^{-1}	Fresh weight of nodule plant^{-1} (g)	Dry weight of nodule plant^{-1} (g)		
T_1	100% RDN through FYM	5.46	5.83	3.94	33.33	0.23	0.05	34.00	76.67
T_2	75% RDN through FYM	4.86	5.16	3.27	31.67	0.22	0.05	33.67	75.33
T_3	100% RDN through vermicompost	6.97	7.25	4.77	35.67	0.25	0.05	35.00	78.33
T_4	75% RDN through vermicompost	5.29	5.77	3.98	33.00	0.23	0.05	34.67	77.67
T_5	100% RDN through poultry manure	6.20	6.81	4.45	34.67	0.24	0.05	35.67	79.33
T_6	75% RDN through poultry manure	5.17	5.72	3.61	32.67	0.22	0.05	35.33	78.67
T_7	100% RDN through neem seed cake	5.41	5.90	4.02	34.33	0.24	0.05	35.33	79.00
T_8	75% RDN through neem seed cake	5.05	5.70	3.39	32.00	0.22	0.05	35.00	78.33
T_9	Absolute control	2.96	3.57	2.42	28.00	0.19	0.04	33.33	75.00
S. Em. ±		0.48	0.40	0.24	3.24	0.02	0.004	0.75	1.006
C.D. at 5%		1.45	1.20	0.72	NS	NS	NS	NS	NS
General Mean		5.27	5.74	3.76	32.81	0.23	0.05	34.67	77.59

Table 6: Yield contributing characters of French bean as influenced due to different treatments

Tr. No.	Treatment	No. of pods plant^{-1}	No. of seeds pod^{-1}	Dry weight of pod plant^{-1} (g)	Seed yield plant^{-1} (g)	Stover yield plant^{-1} (g)	100 seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Protein content (%)
T_1	100% RDN through FYM	13.33	2.98	6.33	5.41	11.04	22.97	995.01	2019.23	19.93
T_2	75% RDN through FYM	11.57	2.63	5.58	4.60	9.20	20.40	842.59	1710.82	19.35
T_3	100% RDN through vermicompost	15.27	3.40	7.16	6.33	12.33	26.60	1247.86	2498.57	20.39
T_4	75% RDN through vermicompost	13.07	2.90	6.28	5.30	10.45	23.17	1021.36	2030.62	19.81
T_5	100% RDN through poultry manure	14.67	3.26	6.92	5.98	11.97	25.77	1166.66	2323.35	20.00
T_6	75% RDN through	12.53	2.80	6.17	5.04	10.11	22.50	969.37	1952.27	19.68

	poultry manure									
T_7	100% RDN through neem seed cake	13.53	3.09	6.71	5.35	11.11	23.83	1002.85	2069.08	20.10
T_8	75% RDN through neem seed cake	12.10	2.78	5.86	4.84	9.73	21.70	897.43	1774.21	19.52
T_9	Absolute control	7.87	2.42	4.87	3.78	7.59	18.37	485.61	927.92	19.04
S. Em. ±		0.52	0.15	0.27	0.28	0.39	0.83	74.98	140.88	0.27
C.D. at 5%		1.58	0.45	0.81	0.84	1.17	2.49	224.79	422.37	NS
General Mean		12.66	2.92	6.21	5.18	10.39	22.81	958.75	1922.90	19.76

4. Summary and Conclusion
Notably, growth parameter *viz*., plant height (33.63 cm), plant spread (34.57 cm), number of branches plant^{-1} (5.40), dry matter plant^{-1}(20.13 g), number of functional leaves plant $^{-1}$ (17.93), leaf area plant^{-1} (11.69 dm^2), absolute growth rate (0.258 g day^{-1}), relative growth rate (0.0243 g g^{-1} day^{-1}), crop growth rate (4.77 g m^{-2} day^{-1}) and net assimilation rate (0.0837 g dm^{-2} day^{-1}), the yield and yield attributing characteristics like number of pods plant^{-1} (15.27), number of seed pod^{-1} (3.40) dry weight of pod plant^{-1} (7.16 g), seed yield plant^{-1} (6.33 g), stover yield plant^{-1} (12.33 g), test weight (26.60 g), seed yield (1247.86 kg ha^{-1}) and stover yield (2498.57 kg ha^{-1}) were significantly higher with application of 100% RDN through vermicompost (T_3). However, this treatment was found at par with application of 100% RDN through poultry manure. In quality investigations, protein content in grain of French bean was non-significant attributed to different organic nitrogen sources during experimental trial. The numerically highest protein content in French bean grains was found in application of 100% RDN applied by vermicompost (20.39%).

To get the highest possible net revenue, it is advocated that, farmers should apply 100% RDN through poultry manure and 100% RDN through vermicompost. Further research is advised before making a farming suggestion, though, given these findings are based on a single season of research.

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