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**Dr. MB Khadadiya**
Ph.D., Department of Agronomy, C. P. College of Agriculture, S.D.A.U., S. K. Nagar, Gujarat, India

**Dr. LJ Desai**
Research Scientist, Centre for Research on IFS, S.D.A.U, S. K. Nagar, Gujarat, India

**Dr. SS Desai**
Ph.D., Department of Agronomy, C. P. College of Agriculture, S.D.A.U., S. K. Nagar, Gujarat, India

**Corresponding Author:**
**Dr. MB Khadadiya**
Ph.D., Department of Agronomy, C. P. College of Agriculture, S.D.A.U., S. K. Nagar, Gujarat, India

# Impact of integrated nitrogen management on wheat (*Triticum aestivum* L.) and its residual effect on greengram (*Vigna radiata* L.)

**Dr. MB Khadadiya, Dr. LJ Desai and Dr. SS Desai**

**Abstract**
A field experiment was conducted during the *rabi* and summer seasons of 2020-21 and 2021-22 at C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, S. K. Nagar, Gujarat, India to study on integrated nitrogen management in wheat and its residual effect on summer greengram under North Gujarat condition. There were six integrated nitrogen management treatments to wheat and eighteen treatment combinations comprising residual effect of preceding six integrated nitrogen management treatments of wheat followed by three levels of recommended dose of nitrogen to greengram. Pooled results over 2 years indicated that, application of 100% recommended dose of nitrogen through inorganic source (urea) to wheat resulted in significantly higher growth attributes, yield attributes, grain yield (4613 kg/ha) and straw yield (5651 kg/ha) of wheat. In summer greengram, the residual effect of 100% recommended dose of nitrogen through organic source (organic source was applied at the rate of 1/3 nitrogen from each of FYM, vermicompost and castor cake) applied to wheat had found significant effect on growth attributes, yield attributes, seed yield (861 kg/ha) and stover yield (2003 kg/ha) of greengram. Direct application of 100% recommended dose of nitrogen to greengram, recorded significantly higher growth attributes, yield attributes, seed yield (850 kg/ha) and stover yield (1919 kg/ha) of greengram.

**Keywords:** Greengram, integrated nitrogen management, inorganic source, organic source, recommended dose of nitrogen, wheat, yield

## Introduction
Wheat is one of the most important crop of India not only in terms of acreage, but also in terms of its versatility for adoption under wide range of agro climatic conditions and crop growing situations. Our country has witnessed spectacular growth in production and productivity of wheat, which has contributed to making the country self-sufficient with respect to food grains. However, there is need to further increase the production to fulfill the requirement of exploding population, maintenance of adequate buffer stock and to meet out demand for processing industries. Greengram (*Vigna radiata* L.) is one of the important pulse crop in India and cultivated since ancient times. It is believed that greengram is a native of India and Central Asia and grown in these regions since prehistoric time. The biological value improves greatly, when wheat or rice is combined with greengram because of the complementary relationship of the essential amino acids. It is particularly rich in Leucine, Phenylalanine, Lysine, Valine, Isoleucine, etc. In addition to being an important source of human food and animal feed, plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen. Greengram, in contrast with green manures, provide grain to augment income and protein as well as reduce the use of mineral nitrogen in wheat-based cropping systems.
The basic concept of integrated nitrogen management (INM) is the maintenance or adjustment of soil fertility of plant nutrients for supply to an optimum level for sustaining the desired crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner. The appropriate combination of inorganic fertilizers, organic manures, crop residues and N fixing crops varies according to the system, land use and ecological, social and economic conditions. Experience from long term fertilizers experiments reveals that integrated use of farm yard manures, vermicompost, biocompost etc. with graded levels of chemical fertilizers is promising not only in maintaining higher productivity, but also in providing maximum stability in crop production.

In this background, a field experiment was conducted to study the performance of wheat-greengram crop sequence and to identify the best feasible integrated nitrogen management practice to increase the production potential of wheat-greengram cropping sequence.

## Material and Methods

A field experiment was conducted during *rabi* and summer season of 2020-21 and 2021-22 at plot number C-13 (24º19' N and 72 º 19' E, 154.42 m altitude), Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat). The site of experiments for both the years remains same. The soil was loamy sand, low in organic carbon (0.15%) and available nitrogen (145 kg/ha), medium in available phosphorus (36.5 kg/ha) and high in available potassium (267.5 kg/ha) status. EC was very low (0.09 dS/m) showing that the soil was free from salinity hazard. Month wise maximum temperature varies from 22.9 to 43 ºC and 21.9 to 43.1 ºC and minimum temperature ranged between 6.7 to 35.2 ºC and 6.0 to 25.4 ºC during 2020-21 and 2021-22, respectively. The morning relative humidity ranged between 52 to 81% and 57 to 80.3%. However, at evening, it ranged between 16 to 56% and 20 to 56.9% during the period of experimentation in corresponding years. The wind velocity ranged between 2 to 10 km/hr and 2.3 to 11.5 km/hr. The potential evaporation range between 2.7 to 8.1 mm and 3.3 to 12.3 mm and bright sunshine hours varies from 6.7 to 11.1 and 4.1 to 10.7 hrs/day during both the years, respectively.

There were six integrated nitrogen management treatments *viz*. 100% RDN through organic source, 75% RDN through organic source + two spray of *panchgavya* @ 2% at 30 and 60 DAS, 100% RDN through inorganic source, 75% RDN through inorganic source + 25% RDN through organic source, 50% RDN through inorganic source + 50% RDN through organic source, 25% RDN through inorganic source + 75% RDN through organic source to wheat (organic source was applied @ 1/3 nitrogen from each of FYM, vermicompost and castor cake before 10 days of sowing, RDF of wheat: 120-60-00 kg N-P-K/ha) during *rabi* season were laid out in randomized block design (gross plot: 11.0 m × 3.6 m and net plot: 10.0 m × 2.7 m) and eighteen treatment combinations comprising residual effect of preceding six integrated nitrogen management treatments of wheat followed by three levels of RDN *viz*. 50, 75 and 100% RDN to greengram in spilt plot design (gross plot: 3.0 m × 3.6 m, net plot: 2.0 m × 2.7 m and RDF of greengram: 20-40-00 kg N-P-K/ha) with four replications. There are non-significant interaction effect was found between treatments and years. The half dose of nitrogen in form of urea was manually applied before sowing of wheat crop as per treatments. The remaining half dose of nitrogen was applied in the form of urea at CRI stage after 1st irrigation to each plot as per treatment. In greengram crop full dose of nitrogen in form of urea was manually applied before sowing as per treatments. The phosphorus was applied common to all treatments as per recommended dose of fertilizer in both the crop. Nutrients composition of FYM (0.43, 0.17, 0.44% and 0.45, 0.18 and 0.45% NPK), vermicompost (1.20, 0.89, 1.13% and 1.40, 0.87, 1.12% NPK), cator cake (6.10, 2.40, 1.00% and 6.30, 2.50, 1.10% NPK) and *Panchgavya* (0.021, 0.019, 0.022% and 0.023, 0.020, 0.023% NPK) during 2020-21 and 2021-22, respectively. According to content of nutrient, different organic manures were applied to wheat crop as per treatments at least 10 days before of sowing and uniformly mixed with soil. Before sowing seeds were treated with *Azotobacter* biofertilizer @ 10 ml/kg seed during both the years. Crop was sown at 22.5 cm spacing by using uniform seed rate of 125 kg/ha. Before sowing seeds were treated with *Azotobacter* biofertilizer @ 10 ml/kg seed during both the years for wheat var. GW-451 (Gujrat Wheat), whereas greengram seeds var. GM-4 (Gujarat Mungbean) were treated with *Rhizobium* biofertilizer @ 10 ml/kg seed during both the years. Wheat crop was sown at 22.5 cm (row to row) spacing by using uniform seed rate of 125 kg/ha and greengram crop was sown at 45 cm (row to row) spacing by using uniform seed rate of 17.5 kg/ha.

**The relative growth rate (RGR) and crop growth rate (CGR) was computed as**

$$RGR = \frac{LnW_2 - LnW_1}{t_2 - t_1}$$

Where,
Ln is natural logarithm
$W_1$ and $W_2$ are dry weights of plants at time $t_1$ and $t_2$, respectively.
$t_2 - t_1$ is the interval of time in days

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

Where,
$W_1$ and $W_2$ are dry weights of plants at time $t_1$ and $t_2$, respectively.
$t_2 - t_1$ is the interval of time in days
S is land area ($m^2$) occupied by plants

The data on various variables were analyzed by using statistical procedures as described by Panse and Sukhatme (1967) [7]. The simple technique of analysis of variance may not be valid under two different seasonal conditions as the error variances in the seasons and the treatment x season interaction may be significant. Hence, pooled analysis of the preceding wheat and succeeding fodder cowpea crop analyzed for two years was worked out as per the method described by Panse and Sukhatme (1967) [7].

## Results and Discussion

### Wheat

### Growth attributes

According to pooled results of 2 years (Table 1) integrated nitrogen management treatments exhibited significant effect on plant height, dry matter accumulation per plant, relative growth rate (RGR) and crop growth rate (CGR). Application of 100% RDN through inorganic source ($N_3$) recorded significantly higher plant height and dry matter accumulation per plant at 60, 90 DAS and at harvest, which were remained at par with treatment 75% RDN through inorganic source + 25% RDN through organic source ($N_4$) and 50% RDN through inorganic source + 50% RDN through organic source ($N_5$). Significantly higher relative growth rate (RGR at 30-60 DAS, 60-90 DAS and 90 DAS- at harvest) in pooled analysis with the application of 100% RDN through inorganic source ($N_3$), which was remained at par with treatment $N_4$: 75% RDN

through inorganic source + 25% RDN through organic source and $N_5$: 50% RDN through inorganic source + 50% RDN through organic source in case of RGR at 60-90 DAS and RGR at 90 DAS- at harvest. Application of 100% RDN through inorganic source ($N_3$) recorded significantly higher crop growth rate (CGR at 30-60 DAS, 60-90 DAS and 90 DAS- at harvest) in pooled results, which was at par with treatment $N_4$ and $N_5$ in case of CGR at 30-60 DAS and CGR at 60-90 DAS, while in case of CGR at 90 DAS-at harvest it was at par with treatment $N_4$. Significantly lower values of all growth parameters were recorded with the application of 100% RDN through organic source ($N_1$).

The reason for better growth and development under treatment $N_3$, $N_4$ and $N_5$ might be due to increased availability of nitrogen to plant through inorganic fertilizer alone or in combinations with organic manures matching to the need of crop throughout the growing season. Being a cereal crop, wheat required nutrients throughout the growing season. Inadequate availability of nitrogen during initial growth period under treatment $N_1$ might be responsible for poor plant growth. Our results confirm the findings of Sudhagar *et al.* (2019) [10].

**Table 1:** Growth attributes of wheat as influenced by integrated nitrogen management (pooled data of 2020-21 and 2021-22)

| Treatments | Plant height (cm) | | | | Dry matter accumulation per plant (g) | | | | Relative growth rate (mg/g/day) | | | Crop growth rate (g/m$^2$/day) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest | 30 DAS | 60 DAS | 90 DAS | At harvest | 30-60 DAS | 60-90 DAS | 90 DAS-at harvest | 30-60 DAS | 60-90 DAS | 90 DAS-at harvest |
| $N_1$: 100% RDN through organic source | 29.80 | 46.03 | 64.55 | 67.25 | 1.54 | 5.58 | 11.52 | 11.95 | 42.74 | 24.05 | 1.23 | 0.598 | 0.881 | 0.062 |
| $N_2$: 75% RDN through organic source + two spray of *panchgavya* @ 2% at 30 and 60 DAS | 31.48 | 48.60 | 70.20 | 72.95 | 1.57 | 5.85 | 12.78 | 13.33 | 44.16 | 25.88 | 1.41 | 0.635 | 1.027 | 0.081 |
| $N_3$:100% RDN through inorganic source | 31.68 | 56.58 | 83.58 | 86.68 | 1.33 | 6.60 | 16.43 | 17.75 | 53.30 | 30.44 | 2.59 | 0.780 | 1.457 | 0.196 |
| $N_4$: 75% RDN through inorganic source + 25% RDN through organic source | 30.38 | 53.23 | 79.75 | 82.65 | 1.46 | 6.49 | 16.02 | 17.22 | 49.74 | 30.11 | 2.43 | 0.745 | 1.412 | 0.179 |
| $N_5$: 50% RDN through inorganic source + 50% RDN through organic source | 31.75 | 52.93 | 78.13 | 81.03 | 1.54 | 6.43 | 15.82 | 16.97 | 47.90 | 30.02 | 2.35 | 0.725 | 1.391 | 0.171 |
| $N_6$: 25% RDN through inorganic source + 75% RDN through organic source | 31.40 | 50.73 | 71.55 | 74.38 | 1.52 | 6.01 | 13.60 | 14.25 | 45.94 | 27.20 | 1.54 | 0.666 | 1.124 | 0.096 |
| S.Em.± | 0.90 | 1.31 | 2.45 | 2.43 | 0.05 | 0.17 | 0.43 | 0.44 | 1.21 | 1.08 | 0.12 | 0.023 | 0.057 | 0.007 |
| C.D. (P=0.05) | NS | 3.77 | 7.07 | 7.03 | NS | 0.48 | 1.25 | 1.27 | 3.49 | 3.12 | 0.34 | 0.065 | 0.165 | 0.022 |
| Interaction (Y × N) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| C.V.% | 8.17 | 7.20 | 9.27 | 8.88 | 10.37 | 7.61 | 8.50 | 8.13 | 7.23 | 10.92 | 17.47 | 9.25 | 13.33 | 16.17 |

**Yield and yield attributes**

The pooled data pertaining to number of tillers per plant, number of effective tillers per plant, spike length, number of grains per spike, grain yield and straw yield significantly by the various integrated nitrogen management treatments (Table 2). The number of tillers per plant at 60 DAS, 90 DAS and effective tillers per plant at harvest were significantly higher under the application of 100% RDN through inorganic source ($N_3$) in pooled results, which were remain statistically at par with treatment 75% RDN through inorganic source + 25% RDN through organic source ($N_4$) in case of number of total tillers at 60 and 90 DAS. The higher number of tillers per plant may be due to sufficient availability of nitrogen to the root of the crop when crop was fertilized with inorganic fertilizer alone or in combinations with organic manures, which may increase the nutrition to active growing part of plant, which have the ability to multi shooting with sufficient availability of nutrients and that's why ultimately leads to higher shooting of the tillers to the base of the plant. The results are in close conformity with Sudhagar *et al*, (2019) [10].

Application of 100% RDN through inorganic source ($N_3$) recorded significantly higher spike length and number of grains per spike in pooled results and was at par with treatment 75% RDN through inorganic source + 25% RDN through organic source ($N_4$) and 50% RDN through inorganic source + 50% RDN through organic source ($N_5$). Plants remained green for longer time with the application of nitrogen through integrated nitrogen management contributed in production of carbohydrates from current photosynthates for increased number of filled grains coinciding with more sunshine hours for increased photosynthetic products to fill better sink resulting in higher length of spike and number of grains per spike. Our results confirm the findings of Shekhar *et al.* (2021) [9]. A critical analysis of pooled data (Table 2) revealed that the application of 100% RDN through inorganic source ($N_3$) recorded significantly higher grain and straw yield over treatments $N_1$, $N_2$ and $N_6$, while it was at par with 75% RDN through inorganic source + 25% RDN through organic source ($N_4$) and 50% RDN through inorganic source + 50% RDN through organic source ($N_5$). The percent increase in grain yield under $N_3$, $N_4$ and $N_5$ were 27.23, 25.82 and 25.20 in pooled results over $N_1$, respectively, whereas extent of increase in straw yield under $N_3$, $N_4$ and $N_5$ were 25.73, 22.55 and 21.75% in pooled results over $N_1$, respectively. Significantly lower values of all yield parameters were recorded with the application of 100% RDN through organic source ($N_1$). This may be mainly attributed due to improvement in growth and yield parameters and the beneficial effects of nitrogen on cell division and elongation, formation of nucleotides and co-enzymes which resulted in increased meristematic activity and photosynthetic area and hence more production and accumulation of photosynthates, yielding higher grain and straw yield. These results are in conformity with the findings of Kumar *et al*. (2017$^b$).

**Table 2:** Yield and yield attributes of wheat as influenced by integrated nitrogen management (pooled data of 2020-21 and 2021-22)

| Treatments | No. of tillers per plant | | No. of effective tillers per plant at harvest | Spike length (cm) | No. of grains per spike | Grain yield (kg/ha) | Straw yield (kg/ha) |
|---|---|---|---|---|---|---|---|
| | 60 DAS | 90 DAS | | | | | |
| $N_1$: 100% RDN through organic source | 2.78 | 3.93 | 1.53 | 6.33 | 34.63 | 3357 | 4197 |
| $N_2$: 75% RDN through organic source + two spray of *panchgavya* @ 2% at 30 and 60 DAS | 3.15 | 4.35 | 2.10 | 6.93 | 37.73 | 3549 | 4480 |
| $N_3$: 100% RDN through inorganic source | 4.23 | 5.75 | 3.15 | 9.23 | 49.50 | 4613 | 5651 |
| $N_4$: 75% RDN through inorganic source + 25% RDN through organic source | 3.98 | 5.43 | 2.78 | 8.75 | 47.58 | 4525 | 5419 |
| $N_5$: 50% RDN through inorganic source + 50% RDN through organic source | 3.78 | 5.08 | 2.63 | 8.38 | 45.60 | 4488 | 5364 |
| $N_6$: 25% RDN through inorganic source + 75% RDN through organic source | 3.23 | 4.58 | 2.18 | 7.45 | 40.30 | 3749 | 4638 |
| S.Em.± | 0.15 | 0.22 | 0.11 | 0.38 | 2.02 | 148.5 | 213.2 |
| C.D. (P=0.05) | 0.42 | 0.63 | 0.33 | 1.10 | 5.83 | 429 | 616 |
| Interaction (Y × N) | NS | NS | NS | NS | NS | NS | NS |
| C.V.% | 11.80 | 12.78 | 13.46 | 13.74 | 13.41 | 10.38 | 12.16 |

**Summer greengram**

**Growth attributes**

Residual effect of integrated nitrogen management treatments applied to wheat was found significant influence on growth of greengram (Table 3). Among the various integrated nitrogen management treatments applied to wheat crop, application of 100% RDN through organic source to wheat ($N_1$) recorded significantly higher plant height at harvest, number of branches per plant at harvest, number of root nodules per plant, weight of fresh and dry root nodules per plant in pooled study. Treatment $N_2$, $N_5$ and $N_6$ were found statistically at par with $N_1$. Significantly lower values of growth parameters in pooled study were observed under treatment $N_3$. This might be due to residual effect of organic manures applied in the preceding crop. As the rate of release of nutrients from organic sources is comparatively slower than inorganic ones, the nutrients are available to the crops for a longer period of time and favorable effect of soil properties might be supplied the plant nutrients in adequate amount throughout the growth period of greengram crop, which improved the plant growth. These results are in conformity with Kumar *et al.* (2017a) [2] and Kumar *et al.* (2018) [3].

Direct application of various levels of nitrogen to greengram was also found significant influence on growth parameters of greengram (Table 3). Significantly higher plant height at harvest, number of branches per plant at harvest, number of root nodules per plant, weight of fresh and dry root nodules per plant were found with the application of 100% RDN ($L_3$), which remain at par with treatment 75% RDN ($L_2$) in pooled results. Lower values of growth parameters were found with treatment 50% RDN ($L_1$). The increase in plant growth with increase in successive level of nitrogen might be due to more supply of nitrogen to crop resulting in rapid synthesis of carbohydrates and consequently converted into protoplasm and thereby smaller portion available for cell wall formation. This has served consequences of increase in size of cell, which is expressed morphologically through increase in plant growth parameters. Our results confirm the findings of Gudadhe *et al.* (2020) [1].

**Yield and yield attributes**

Pooled data pertaining to yield parameters *viz.* number of pods per plant, pod length, number of seeds per pod, seed yield and stover yield of greengram are presented in Table 3. It was observed that, the yield parameters were significantly influenced by residual effect of integrated nitrogen management treatments applied to preceding wheat. Application of 100% RDN through organic source ($N_1$) to preceding wheat crop recorded significantly higher number of pods per plant, pod length, number of seeds per pod, seed yield and stover yield and was at par with treatment $N_2$, $N_5$ and $N_6$. Significantly the lower values of yield parameters were recorded with the application of 100% RDN through inorganic source ($N_3$) in pooled study. The percent increase in seed yield under $N_1$, $N_2$, $N_5$ and $N_6$ were 18.27, 17.27, 16 and 16.91% in pooled results over $N_3$, respectively, whereas percent increase in stover yield under $N_1$, $N_2$, $N_5$ and $N_6$ were 20.78, 17.97, 16.38 and 17.5% over $N_3$, respectively. This might be due to application of organic manures to wheat crop improved the available nutrients status of soil, which might increase the availability of plant nutrients during crop growth period ultimately improved growth and yield attributes. Thus, overall improvement in growth and yield attributes reflected in to higher seed and stover yield. The results are in line with those reported by Mahunta *et al.* (2017) [5], Patel *et al.*, (2018) [8] and Sudhagar *et al.*, (2019) [10].

Yield and yield attributes of greengram also significantly influenced by direct application of varying levels of nitrogen (Table 3). In general, all yield parameters of greengram increased with increase in level of nitrogen. Application of 100% RDN ($L_3$) recorded the significantly higher number of pods per plant, pod length, number of seeds per pod, seed yield and stover yield and was at par with treatment 75% RDN ($L_2$) in pooled study. Significantly lower values of yield parameters were recorded with treatment 50% RDN ($L_1$). The percent increase in seed yield under $L_3$ and $L_2$ were 15.35 and 14.83% in pooled results over $L_1$, respectively, whereas percent increase in stover yield under $L_3$ and $L_2$ were 13.99 and 13.64% over $L_1$, respectively. This might be due to application of adequate amount of nitrogen to crop increased vegetative growth of greengram, which resulted in more production of photosynthetes supplied to sink site and ultimately reflected in to increased values of yield and yield attributes. Results are supported by Gudadhe *et al.* (2020) [1].

**Table 3:** Growth attributes and yield attributes of greengram as influenced by integrated nitrogen management (pooled data of 2021 and 2022)

| Treatments | Plant height at harvest (cm) | No. of branches per plant at harvest | No. of root nodules per plant at flowering | Weight of fresh root nodules per plant (mg) | Weight of dry root nodules per plant (mg) | No. of pods per plant | Pod length (cm) | No. of seeds per pod | Seed yield (kg/ha) | Stover yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Main plot: Nitrogen management in wheat** | | | | | | | | | | |
| $N_1$: 100% RDN through organic source | 53.30 | 7.23 | 35.78 | 494 | 81 | 25.98 | 6.92 | 9.15 | 861 | 2003 |
| $N_2$: 75% RDN through organic source + two spray of *panchgavya* @ 2% at 30 and 60 DAS | 52.78 | 7.13 | 35.02 | 484 | 79 | 25.50 | 6.88 | 9.09 | 850 | 1935 |
| $N_3$:100% RDN through inorganic source | 43.32 | 6.08 | 30.77 | 440 | 66 | 22.93 | 5.38 | 7.13 | 703 | 1587 |
| $N_4$: 75% RDN through inorganic source + 25% RDN through organic source | 46.61 | 6.24 | 31.55 | 450 | 68 | 23.19 | 5.58 | 7.35 | 731 | 1616 |
| $N_5$: 50% RDN through inorganic source + 50% RDN through organic source | 51.58 | 6.98 | 33.76 | 472 | 75 | 25.07 | 6.63 | 8.70 | 837 | 1898 |
| $N_6$: 25% RDN through inorganic source + 75% RDN through organic source | 52.46 | 7.07 | 34.63 | 480 | 78 | 25.15 | 6.72 | 8.93 | 847 | 1924 |
| S.Em.± | 1.08 | 0.17 | 0.73 | 7.81 | 2.23 | 0.44 | 0.14 | 0.18 | 18.0 | 37.3 |
| C.D. (P=0.05) | 3.12 | 0.48 | 2.10 | 22.55 | 6.43 | 1.26 | 0.41 | 0.53 | 52.03 | 107.80 |
| C.V.% | 10.58 | 12.04 | 10.60 | 8.13 | 14.62 | 8.67 | 10.89 | 10.63 | 10.96 | 10.01 |
| **Sub plot: Levels of nitrogen in summer greengram** | | | | | | | | | | |
| $L_1$: 50% RDN | 46.52 | 6.17 | 32.03 | 455 | 70 | 23.77 | 5.65 | 7.45 | 720 | 1651 |
| $L_2$: 75% RDN | 51.26 | 7.03 | 33.89 | 473 | 75 | 24.78 | 6.63 | 8.75 | 845 | 1911 |
| $L_3$: 100% RDN | 52.25 | 7.17 | 34.83 | 482 | 78 | 25.36 | 6.78 | 8.96 | 850 | 1919 |
| S.Em.± | 0.55 | 0.07 | 0.40 | 4.11 | 1.22 | 0.23 | 0.07 | 0.09 | 7.3 | 16.6 |
| C.D. (P=0.05) | 1.54 | 0.20 | 1.13 | 11.54 | 3.42 | 0.65 | 0.19 | 0.26 | 20.60 | 46.50 |
| **Interaction (N × L)** | | | | | | | | | | |
| S.Em.± | 0.24 | 0.18 | 0.84 | 0.12 | 0.82 | 0.57 | 0.17 | 0.52 | 18.0 | 40.5 |
| C.D. (P=0.05) | NS | NS | NS | NS | NS | 1.60 | NS | NS | 51 | 114 |
| C.V.% | 7.61 | 7.14 | 8.31 | 6.05 | 11.32 | 6.53 | 7.38 | 7.71 | 6.31 | 6.28 |

*Interactions Y × N, Y × L and Y × N × L: NS

**Interaction effect**

The interaction between integrated nitrogen management treatments applied to preceding wheat and levels of nitrogen to summer greengram was found significant in pooled data for number of pods per plant, seed and stover yield. The pooled data of 2 years on number of pods per plant, seed and stover yield of greengram as influenced by interaction effect are furnished in Table 4. Treatment combination of $N_1L_3$ (100% RDN through organic source to wheat with 100% RDN to greengram) secured the higher number of pods per plant in pooled analysis. Treatment combination $N_5L_3$ (50% RDN through inorganic source + 50% RDN through organic source to wheat and 100% RDN to greengram) recorded significantly higher seed yield in pooled study, while treatment combination $N_1L_2$ (100% RDN through organic source to wheat and 75% RDN to greengram) recorded significantly higher stover yield in pooled study. Significantly lower numbers of pods per plant, seed and stover yield were found under $N_3L_1$ (100% RDN through inorganic source to wheat + 50% RDN to greengram). This might be due to the increased supply of all the essential nutrients by organic manures and inorganic fertilizer resulted in higher manufacture of food and its subsequent partitioning towards sink, which leads to higher number of pods per plant in greengram. These findings are in close conformity with Patil *et al.* (2018) [8]. The improvement in growth attributes might have resulted in greater synthesis of photosynthates contributing to increase into pods per plant and ultimately seed and stover yield of greengram. This could be attributed to balanced fertilization through combined application of organic manures to wheat and inorganic fertilizer to greengram. These findings are in agreement with those of Patil *et al.* (2018) [8] and Mangaraj *et al*. (2021) [6].

Based on the findings of two years of experimentation, it is concluded that for securing the higher yield from wheat crop, apply 100% RDN (120 kg nitrogen/ha) through inorganic source, whereas residual effect of 100% RDN (20 kg nitrogen/ha) through organic source applied to preceding wheat crop found significantly higher yield of succeeding summer greengram, which reduce the 25% nitrogen requirement in succeeding summer greengram.

**Table 4:** Interaction effect of nitrogen management (N) and levels of RDN (L) on number of pods per plant, seed yield and stover yield of summer greengram (pooled data of 2021 and 2022)

| N × L | No. of pods per plant | | | |
|---|---|---|---|---|
| | **$L_1$** | **$L_2$** | **$L_3$** | **Mean** |
| $N_1$ | 24.43 | 25.60 | 27.93 | 25.98 |
| $N_2$ | 24.03 | 25.95 | 26.53 | 25.50 |
| $N_3$ | 20.20 | 24.45 | 24.15 | 22.93 |
| $N_4$ | 23.78 | 22.95 | 22.85 | 23.19 |
| $N_5$ | 26.20 | 24.38 | 24.63 | 25.07 |
| $N_6$ | 24.00 | 25.38 | 26.08 | 25.15 |
| Mean | 23.77 | 24.78 | 25.36 | |
| S.Em.± | 0.57 | | | |
| C.D. (P=0.05) | 1.60 | | | |
| N × L | Seed yield (kg/ha) | | | |
| | $L_1$ | $L_2$ | $L_3$ | Mean |
| $N_1$ | 783 | 917 | 882 | 861 |
| $N_2$ | 846 | 819 | 886 | 850 |
| $N_3$ | 601 | 757 | 752 | 703 |
| $N_4$ | 652 | 789 | 752 | 731 |
| $N_5$ | 658 | 927 | 928 | 837 |
| $N_6$ | 779 | 860 | 901 | 847 |
| Mean | 720 | 845 | 850 | |
| S.Em.± | 18.0 | | | |
| C.D. (P=0.05) | 51 | | | |
| N × L | Stover yield (kg/ha) | | | |
| | $L_1$ | $L_2$ | $L_3$ | Mean |
| $N_1$ | 1831 | 2123 | 2057 | 2003 |
| $N_2$ | 1892 | 1934 | 1979 | 1935 |
| $N_3$ | 1363 | 1632 | 1767 | 1587 |
| $N_4$ | 1471 | 1725 | 1651 | 1616 |
| $N_5$ | 1516 | 2106 | 2072 | 1898 |
| $N_6$ | 1832 | 1949 | 1990 | 1924 |
| Mean | 1651 | 1911 | 1919 | |
| S.Em.± | 40.5 | | | |
| C.D. (P=0.05) | 114 | | | |

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