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# Effect of Intercropping and INM Practices on Growth and Yield of Chilli (*Capsicum annuum* L.)

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**A B S T R A C T**

The present investigation was carried out to study the impact of intercropping and integrated nutrient management on growth, yield of chilli during *late kharif* 2015 and 2016 at College of Horticulture, Venkataramannagudem. The experiment was laid out in split plot design with five main plot treatments *i.e.* sole chilli ($M_0$), four intercrops onion ($M_1$), coriander ($M_2$), fenugreek ($M_3$) and marigold ($M_4$) combined with five sub plot treatments *viz.*, 100% RDN through urea ($S_0$), 25% RDN through FYM + 75% RDN through urea ($S_1$), 25% RDN through vermicompost + 75% RDN through urea ($S_2$), 25% RDN through poultry manure + 75% RDN through urea ($S_3$) and 25% RDN through neem cake + 75% RDN through urea ($S_4$), consisting of 25 treatment combinations, replicated thrice. All the intercrops, except marigold, positively influenced the growth and yield of chilli over chilli sole cropping. Chilli + fenugreek ($M_3$) treatment recorded maximum values for growth and yield parameters whereas, marigold as intercrop recorded the minimum values for plant growth and yield, of chilli. Among the INM treatments, maximum number of green fruits per plant, green fruit weight, 100 green fruit weight, green and ripe chilli yield per plant and, green and dry chilli yield per plot, dry chilli yield per ha were recorded with application of 25% RDN through neem cake + 75% RDN through urea ($S_4$) treatment, over application of 100 % RDN through urea ($S_0$). Among the interactions, chilli intercropped with fenugreek and applied with 25% RDN through neem cake + 75% RDN through urea was found superior in terms of growth and yield.

## Introduction

In India, chillies are grown in almost all the states. Andhra Pradesh is the third largest producer of green chilli with an area of 0.221 million hectares and a production of 0.530 million tonnes. Area under dry chilli cultivation is 0.206 million hectares with a

production of 0.883 million tonnes and productivity of 4.29 MT/ha (Horticultural Statistics 2016-17). Andhra Pradesh is the largest producer of dry chilli in India and contributes about 26% to the total area under chilli.

Chilli is the favoured cash crop for most of the farmers. It is a good choice for generating higher income among the farming sector as the potential returns per unit area are high which can be achieved in one season. At present, farmers are solely dependent on chemical fertilizers for enhancing the productivity. Application of chemical fertilizers not only increased the production but also deteriorated the ecosystem.

Organic manures are one of the alternative renewable sources of nutrient supply. Organic manures not only supply macro, micro and secondary nutrients regularly but also improve physical, chemical and biological properties of soil. Organic manures are slow releasing, hence are less prone to loss than inorganic fertilizers, hence soil, water and air pollution can be reduced (Bade *et al.,* 2017). Organic forms of nutrients through crop residues, dung, and city compost constitute a potential renewable source of nutrient supply to the crops under all situations (Motsara, 1999).

Intercropping is an age old practice in India, especially under rainfed conditions, which aims to insure against seasonal vagaries, severe damage due to pests and diseases to increase total productivity per unit area and to equitably and judiciously utilize land resources and farming inputs, including labour. Thus, the objective of intercropping is now more towards augmenting the total productivity per unit area per unit time by growing more than one crop in the same field (Rajat and Singh, 1979). It is not only a potential system of crop production for income generation to the farmers but also serves as an alternative approach for controlling different pest complex. Intercropping with coriander, methi, onion, marigold *etc.,* was proved to reduce the sucking pests in chilli (Sridhar *et al.,* 2014).

In Andhra Pradesh, chilli is being grown as a sole crop and it is more prone to number of pests and viral diseases. Increased cost of cultivation, frequent aberrations in climate, inconsistent yields and plummeting market prices are the current problems encountered by the farmers causing distress to them. In addition to this, the farmers are accustomed to apply huge quantities of inorganic fertilizers which deteriorate soil health to a great extent and also result in micronutrient deficiencies. Keeping the above problems in view, the present study was proposed to find out a suitable intercrop and INM treatment combination to enhance the yield of chilli crop.

## Materials and Methods

The experiment was carried out at College of Horticulture, Venkataramannagudem, West Godavari District, Andhra Pradesh, during *late kharif,* 2015-2016 and 2016-2017. Chilli variety, LCA 655 was selected for the experiment. LCA 655 is a pre released dual purpose variety developed at Horticultural Research Station, Lam, Guntur. Four intercrops (Onion, Coriander, Fenugreek and Marigold) in combination with four INM treatments (25% RDN through FYM, vermicompost, poultry manures and neem cake + 75 % RDN through urea) were implemented along with two control treatments (Sole chilli and 100% RDN through urea). Recommended dose of fertilizers for chilli is 300:60:120 Kg NPK $ha^{-1}$ in Andhra Pradesh. As per the treatments, 25% recommended dose of nitrogen was applied by manures and 75% of recommended nitrogen was applied in the form of urea.

Phosphorous in the form of SSP and potassium as Muriate of Potash were applied uniformly to all the plots as per the recommendation. Quantity of organic manure equivalent to 25 % recommended N was calculated based on the nutrient analysis of manures done at Soil Science laboratory at College of Horticulture, VR Gudem. Onion seedlings were transplanted in two rows with spacing of 15×10 cm, coriander and fenugreek seeds are sown in three lines, and marigold seedlings were transplanted in one row at spacing of 20×20 cm in between two rows of chilli. Recommended package of practices were followed during the cropping period. Green chilli fruits were harvested for two pickings and remaining five pickings were taken up for dry chilli. All the intercrops except marigold were harvested at a single harvest and marigold flowers were harvested in multiple pickings. Data were recorded on growth and yield parameters of chilli and the results were discussed hereunder.

## Results and Discussion

### Effect of intercrops and INM practices on growth and yield of chilli

The pooled mean data of two years indicated that most of the growth and yield attributes of chilli were significantly influenced by intercropping, INM treatments and their interaction.

Intercrops had significant influence on chilli growth parameters like plant height, plant spread, leaf chlorophyll content and number of primary branches. Intercrops like onion, coriander and fenugreek showed positive influence on growth parameters of chilli.

All the intercrops except marigold recorded the maximum values for growth attributes over sole chilli treatment. Chilli + coriander ($M_2$) treatment recorded the maximum plant height (72.92 cm) and leaf chlorophyll content (60.48 SPAD in pooled data at final harvest over sole chilli ($M_0$) (63.41 cm, and 57.03 SPAD respectively). The plant spread and number of branches were maximum in chilli + fenugreek ($M_3$) treatment (134.23 cm and 8.34 respectively).

Intercropping facilitates both productivity and nutrient acquisition, compared with the corresponding monocrops. As a consequence, intercropping significantly removes more nutrients from the soil than monocultures (Wang *et al.,* 2014). This might be the reason for increase in the plant growth in intercropping when compared to sole crop. Similar results were obtained by Sujay and Giraddi (2015) in chilli + onion and chilli + coriander cropping systems.

On the contrary, marigold as intercrop had shown negative influence on chilli plant growth parameters like plant height (47.06 cm), plant spread (110.30 cm), leaf chlorophyll content (55.01 SPAD) and number of primary branches (6.31) at final harvest, compared to sole chilli (Table 1).

The reduction in plant growth in marigold ($M_4$) plots might be due to the rapid growth habit of marigold at early stages and chilli being a slow growing plant at the initial growth stages might not absorb the nutrients as efficiently as marigold. The competition between marigold and chilli for moisture, light and nutrients might be the reason for reduction in all growth parameters in $M_4$ plots. Similar results were reported by Suresha *et al., (*2007) in chilli + cluster bean combination when compared to chilli + carrot, chilli + radish, chilli + dolichos bean combination.

Among the intercrop treatments, intercropping with coriander ($M_2$) recorded the lowest number of days (45.37) for 50% flowering and the highest number of days (52.17) was

observed in chilli intercropped with marigold ($M_4$) treatment (Table 1).

Among the intercrops, chilli + fenugreek combination ($M_3$) recorded the maximum pooled values for number of green chilli fruits per plant (28.69), fruit weight (3.89 g), 100 fruit weight (383.23 g), green chilli yield per plant (from two pickings) (112.30g) and yield per plot (4.04 kg) followed by chilli + coriander treatment. Further, it was observed from the data, that $M_3$ treatment (chilli + fenugreek) recorded the highest number of ripe chilli fruits per plant (192.20) and ripe chilli yield per plant (968.58g), dry chilli yield per plant (6.76 kg) and dry chilli yield per ha (52.1 q). However, the dry chilli yield per plant and yield per ha were on par with the yields obtained in chilli + onion ($M_1$), chilli + coriander treatments ($M_2$) respectively (Table 2). Similar results were obtained by Anitha *et al.,* (2001) in chilli + french bean, Hussain (2003) in pea + coriander system, Suresha *et al.,* (2007) in chilli + radish system, Tavaprakash and Velayudhan (2007) in baby corn intercropped with green gram and amaranthus, Sujay and Giraddi (2015) in chilli + onion and chilli + coriander systems.

In intercropping systems, the land use efficacy, water use efficiency, radiation use efficiency are at maximum and hence the productivity. Fenugreek, being a legume and short duration crop might have helped in more nitrogen fixation and hence increased the nitrogen availability to the main crop. This might be the reason for obtaining high green and dry chilli yield in chilli intercropped with fenugreek treatment. Similar results were obtained by Mao *et al.,* (2012) and Palzer *et al.,* (2012) in maize intercropped with pea. Nitrogen is a major element in plant growth and development. Intercropping with legumes increase the nitrogen availability to the main crop not only as a companion crop but also as post crop (Dane and Laugale, 2014).

Among all the intercrop treatments, chilli + marigold ($M_4$) treatment recorded the lowest values for all the yield and yield attributing characters of green and red chilli (Table 1 and 2). Similar results were observed by Choudhary *et al.,* (2014) in maize + radish intercropping system. This may be due to vigorous stature and long duration of marigold crop. The harmful effect of inter crop on chilli was probably due to irreconcilable association with the root on one hand and on the other hand the aggressive nature of marigold compared to other intercrops, which might have resulted in less availability of nutrients and environmental resources *viz.* solar radiation, light, moisture and space to grow freely for the chilli plant. In the intercropping system, where both plants are coalescent, there can be a problem with shading and competition and by virtue of such competition, the growth attributes will also vary significantly (Dane and Laugale, 2014).

Integrated Nutrient Management (INM) practices significantly influenced the growth and yield of chilli. The pooled data collected on growth parameters clearly indicated that all the INM treatments were found superior over 100% RDN through urea ($S_0$) in terms of growth and yield. Among the INM practices, chilli applied with 25% RDN through neem cake + 75% RDN through urea ($S_4$) recorded the maximum pooled values for plant height (74.81 cm) and spread (144.53 cm), over all the treatments and it was found on par with 25% RDN through FYM + 75% RDN through urea ($S_1$) in leaf chlorophyll content (59.32 SPAD and 59.09 SPAD respectively) and number of primary branches (7.88 and 7.47 respectively) at harvest (Table). The 100% RDN through urea ($S_0$) treatment recorded significantly the lowest values for all the growth attributes (plant height 57.58 cm, spread 115.19 cm, leaf chlorophyll content 54.35 SPAD and number of primary branches 7.00) (Table 1).

**Table.1** Effect of intercropping, integrated nutrient management practices and their interaction on plant growth and green fruit parameters of chilli

| Treatment<br>Main plot | Plant height (cm) | Plant spread (cm) | Leaf chlorophyll (SPAD) | Number of primary branches | Days taken for 50% flowering | Green chilli fruit number per plant* | Green chilli fruit length (cm) | Green chilli fruit girth (cm) | Green chilli fruit weight (g) | 100 green chilli fruit weight (g) | Green chilli fruit yield per plant (g)* | Green chilli fruit yield per plot (kg)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$M_0$** | 63.41 | 132.37 | 57.03 | 7.52 | 46.13 | 23.94 | 8.06 | 4.38 | 3.69 | 357.60 | 89.60 | 3.74 |
| **$M_1$** | 69.44 | 127.53 | 55.29 | 7.79 | 49.90 | 28.11 | 8.30 | 4.20 | 3.61 | 357.17 | 102.68 | 2.91 |
| **$M_2$** | 72.92 | 126.83 | 60.48 | 6.99 | 45.37 | 22.31 | 8.32 | 4.18 | 3.82 | 379.77 | 85.69 | 3.61 |
| **$M_3$** | 68.78 | 134.23 | 56.55 | 8.34 | 45.87 | 28.69 | 8.27 | 4.25 | 3.89 | 383.23 | 112.30 | 4.04 |
| **$M_4$** | 47.06 | 110.30 | 55.01 | 6.31 | 52.17 | 18.02 | 6.95 | 4.06 | 3.05 | 287.10 | 55.19 | 1.74 |
| **S.Em.±** | 1.928 | 1.227 | 0.647 | 0.185 | 0.735 | 1.108 | 0.152 | 0.121 | 0.076 | 7.142 | 4.802 | 0.140 |
| **CD (P = 0.05)** | 6.386 | 4.064 | 2.143 | 0.611 | 2.434 | 3.67 | 0.504 | NS | 0.252 | 23.652 | 15.904 | 0.463 |
| **Sub plot** | | | | | | | | | | | | |
| **$S_0$** | 57.98 | 115.19 | 54.35 | 7.00 | 45.97 | 26.06 | 7.37 | 3.79 | 3.14 | 311.17 | 71.36 | 2.71 |
| **$S_1$** | 61.97 | 131.00 | 59.32 | 7.47 | 47.17 | 22.38 | 8.22 | 4.06 | 3.62 | 356.63 | 81.83 | 2.92 |
| **$S_2$** | 58.84 | 119.50 | 55.92 | 7.25 | 47.57 | 20.78 | 7.73 | 4.08 | 3.33 | 331.77 | 85.18 | 3.16 |
| **$S_3$** | 68.02 | 121.05 | 55.68 | 7.35 | 49.43 | 23.05 | 8.40 | 4.64 | 3.87 | 369.80 | 88.82 | 3.15 |
| **$S_4$** | 74.81 | 144.53 | 59.09 | 7.88 | 49.30 | 28.81 | 8.17 | 4.50 | 4.10 | 395.50 | 118.26 | 4.11 |
| **S.Em.±** | 2.208 | 1.209 | 0.693 | 0.170 | 0.702 | 0.601 | 0.142 | 0.124 | 0.072 | 7.132 | 3.174 | 0.118 |
| **CD (P = 0.05)** | 6.334 | 3.468 | 1.987 | 0.488 | 2.015 | 1.723 | 0.409 | 0.355 | 0.206 | 20.461 | 9.106 | 0.338 |

| | |
|---|---|
| **$M_0$ : Sole chilli** | **$S_0$: 100% RDN through urea** |
| **$M_1$ : Chilli + Onion** | $S_1$ : 25% RDN through FYM + 75% RDN through urea |
| **$M_2$ : Chilli + Coriander** | $S_2$: 25% RDN through vermicompost+ 75% RDN through urea |
| **$M_3$ : Chilli + Fenugreek** | $S_3$ : 25% RDN through poultry manure + 75% RDN through urea |
| **$M_4$ : Chilli + Marigold** | $S_4$: 25% RDN through neem cake + 75% RDN through urea |

*Green chilli number, yield per plant and yield per plot were recorded from two pickings only.

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| Interaction (MXS) | Plant height (cm) | Plant spread (cm) | Leaf chlorophyll (SPAD) | Number of primary branches | Days taken for 50% flowering | Green chilli fruit number per plant* | Green chilli fruit length (cm) | Green chilli fruit girth (cm) | Green chilli fruit weight (g) | 100 green chilli fruit weight (g) | Green chilli fruit yield per plant (g)* | Green chilli fruit yield per plot (kg)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $M_0S_0$ | 55.14 | 121.93 | 56.25 | 7.28 | 46.67 | 20.37 | 7.28 | 3.92 | 3.23 | 311.67 | 62.79 | 3.40 |
| $M_0S_1$ | 66.05 | 137.50 | 62.34 | 7.47 | 44.50 | 24.02 | 8.75 | 4.17 | 4.02 | 403.83 | 96.72 | 3.56 |
| $M_0S_2$ | 48.32 | 128.00 | 50.47 | 6.89 | 45.50 | 19.22 | 7.75 | 4.13 | 3.27 | 329.83 | 65.83 | 3.16 |
| $M_0S_3$ | 63.09 | 130.43 | 54.18 | 8.03 | 46.33 | 19.06 | 8.50 | 4.95 | 3.83 | 338.50 | 72.61 | 3.64 |
| $M_0S_4$ | 84.44 | 144.00 | 61.92 | 7.92 | 47.67 | 37.04 | 8.00 | 4.74 | 4.08 | 404.17 | 150.05 | 4.95 |
| $M_1S_0$ | 54.37 | 114.83 | 48.70 | 7.09 | 44.50 | 26.45 | 7.63 | 3.95 | 2.94 | 294.00 | 82.87 | 2.84 |
| $M_1S_1$ | 69.27 | 134.50 | 54.84 | 7.61 | 50.33 | 26.65 | 8.67 | 4.08 | 3.77 | 372.00 | 100.43 | 2.33 |
| $M_1S_2$ | 64.49 | 118.50 | 53.97 | 7.85 | 52.83 | 21.28 | 7.75 | 4.00 | 3.87 | 383.50 | 81.52 | 2.41 |
| $M_1S_3$ | 80.32 | 123.33 | 58.42 | 8.19 | 50.67 | 31.89 | 9.08 | 4.82 | 3.50 | 352.17 | 112.62 | 3.02 |
| $M_1S_4$ | 78.74 | 146.50 | 60.49 | 8.18 | 51.17 | 34.31 | 8.33 | 4.17 | 3.97 | 384.17 | 135.94 | 3.96 |
| $M_2S_0$ | 83.18 | 114.00 | 61.71 | 6.70 | 45.50 | 31.00 | 7.75 | 3.65 | 4.09 | 407.00 | 68.81 | 3.01 |
| $M_2S_1$ | 65.54 | 136.50 | 63.15 | 7.64 | 47.83 | 22.67 | 8.85 | 4.33 | 3.57 | 356.50 | 81.37 | 3.11 |
| $M_2S_2$ | 70.41 | 116.17 | 59.55 | 7.02 | 40.83 | 20.28 | 7.58 | 4.14 | 3.38 | 337.83 | 126.80 | 5.00 |
| $M_2S_3$ | 73.60 | 116.67 | 57.70 | 6.41 | 46.83 | 20.05 | 8.83 | 4.50 | 3.98 | 396.17 | 79.84 | 2.78 |
| $M_2S_4$ | 71.85 | 150.83 | 60.29 | 7.18 | 45.83 | 17.56 | 8.58 | 4.25 | 4.09 | 401.33 | 71.59 | 4.15 |
| $M_3S_0$ | 53.95 | 123.50 | 57.22 | 7.88 | 45.67 | 33.39 | 7.75 | 3.73 | 3.28 | 327.67 | 107.39 | 2.82 |
| $M_3S_1$ | 62.06 | 134.67 | 54.88 | 8.25 | 40.67 | 20.48 | 8.00 | 3.69 | 3.64 | 341.83 | 74.59 | 4.32 |
| $M_3S_2$ | 67.09 | 124.17 | 49.32 | 8.40 | 45.33 | 26.02 | 8.08 | 3.79 | 4.08 | 405.17 | 109.41 | 3.75 |
| $M_3S_3$ | 72.83 | 124.17 | 56.84 | 8.02 | 49.17 | 26.55 | 8.83 | 5.02 | 4.10 | 409.83 | 109.02 | 4.25 |
| $M_3S_4$ | 87.97 | 164.67 | 64.47 | 9.14 | 48.50 | 37.00 | 8.67 | 5.00 | 4.36 | 431.67 | 161.08 | 5.05 |
| $M_4S_0$ | 43.25 | 101.67 | 47.85 | 6.04 | 47.50 | 19.11 | 6.42 | 3.70 | 2.16 | 215.50 | 34.93 | 1.29 |
| $M_4S_1$ | 46.89 | 111.83 | 61.37 | 6.37 | 52.50 | 18.08 | 6.83 | 4.00 | 3.09 | 309.00 | 56.04 | 1.48 |
| $M_4S_2$ | 43.88 | 110.67 | 66.29 | 6.07 | 53.33 | 17.11 | 7.50 | 4.33 | 2.03 | 202.50 | 42.34 | 1.48 |
| $M_4S_3$ | 50.27 | 110.67 | 51.26 | 6.10 | 54.17 | 17.69 | 6.75 | 3.92 | 3.96 | 352.33 | 69.98 | 2.03 |
| $M_4S_4$ | 51.03 | 116.67 | 48.27 | 6.96 | 53.33 | 18.11 | 7.25 | 4.33 | 4.01 | 356.17 | 72.65 | 2.41 |
| **Main with Sub** | | | | | | | | | | | | |
| S.Em.± | 4.312 | 2.744 | 1.447 | 0.413 | 1.643 | 2.478 | 0.341 | 0.270 | 0.170 | 15.970 | 10.738 | 0.313 |
| CD (P = 0.05) | 14.513 | 8.000 | 4.565 | NS | 4.656 | 4.127 | NS | NS | 0.476 | 47.168 | 21.506 | 0.787 |
| **Sub with Main** | | | | | | | | | | | | |
| S.Em.± | 4.818 | 2.711 | 1.529 | 0.387 | 1.586 | 1.634 | 0.323 | 0.276 | 0.162 | 15.953 | 7.960 | 0.274 |
| CD (P = 0.05) | 14.164 | 8.024 | 4.507 | NS | 4.699 | 5.022 | NS | NS | 0.481 | 47.181 | 24.119 | 0.818 |

*Green chilli number, yield per plant and yield per plot were recorded from two pickings only.

**Table.2** Effect of intercropping, integrated nutrient management practices and their interaction on ripe and dry chilli parameters

| Treatment<br>Main plot | Ripe chilli number per plant* | Ripe chilli yield per plant *(g) | Dry chilli yield per plot *(kg) | Dry chilli yield per ha (qt) |
|---|---|---|---|---|
| $M_0$ | 179.50 | 841.05 | 6.35 | 49.00 |
| $M_1$ | 157.77 | 767.00 | 6.42 | 49.50 |
| $M_2$ | 167.73 | 747.43 | 6.68 | 51.50 |
| $M_3$ | 192.20 | 968.65 | 6.76 | 52.10 |
| $M_4$ | 97.13 | 480.43 | 3.27 | 25.20 |
| S.Em.± | 8.256 | 49.484 | 0.184 | 0.142 |
| CD (P = 0.05) | 27.341 | 163.879 | 0.609 | 0.470 |
| Sub plot | | | | |
| $S_0$ | 145.07 | 662.92 | 4.79 | 36.90 |
| $S_1$ | 159.28 | 773.46 | 6.29 | 48.50 |
| $S_2$ | 154.80 | 764.08 | 6.02 | 46.40 |
| $S_3$ | 164.97 | 743.08 | 5.65 | 43.50 |
| $S_4$ | 170.23 | 861.00 | 6.75 | 52.00 |
| S.Em.± | 6.92 | 39.719 | 0.156 | 0.120 |
| CD (P = 0.05) | NS | NS | 0.449 | 0.345 |

| | |
|---|---|
| $M_0$ : Sole chilli | $S_0$: 100% RDN through urea |
| $M_1$ : Chilli + Onion | $S_1$ : 25% RDN through FYM + 75% RDN through urea |
| $M_2$ : Chilli + Coriander | $S_2$: 25% RDN through vermicompost+ 75% RDN through urea |
| $M_3$ : Chilli + Fenugreek | $S_3$ : 25% RDN through poultry manure + 75% RDN through urea |
| $M_4$ : Chilli + Marigold | $S_4$: 25% RDN through neem cake + 75% RDN through urea |

*Ripe chilli number, yield per plant and dry chilli yield per plot were recorded from five pickings.

**Contd…**

| Interaction (MXS) | Ripe chilli number per plant* | Ripe chilli yield per plant (g)* | Dry chilli yield per plot (kg)* | Dry chilli yield per ha (qt) |
|---|---|---|---|---|
| $M_0S_0$ | 169.33 | 731.52 | 5.24 | 40.40 |
| $M_0S_1$ | 180.33 | 932.32 | 6.59 | 50.80 |
| $M_0S_2$ | 153.50 | 707.81 | 6.33 | 48.70 |
| $M_0S_3$ | 196.67 | 802.94 | 6.11 | 47.10 |
| $M_0S_4$ | 197.67 | 1030.66 | 7.50 | 57.70 |
| $M_1S_0$ | 143.00 | 794.13 | 5.11 | 39.40 |
| $M_1S_1$ | 143.50 | 729.54 | 6.82 | 52.60 |
| $M_1S_2$ | 172.00 | 688.68 | 6.53 | 50.30 |
| $M_1S_3$ | 163.33 | 807.76 | 6.24 | 48.10 |
| $M_1S_4$ | 166.67 | 814.88 | 7.40 | 57.10 |
| $M_2S_0$ | 115.50 | 1008.37 | 5.50 | 42.40 |
| $M_2S_1$ | 186.33 | 775.08 | 7.29 | 56.20 |
| $M_2S_2$ | 195.33 | 532.98 | 7.18 | 55.30 |
| $M_2S_3$ | 169.83 | 653.03 | 6.18 | 47.70 |
| $M_2S_4$ | 171.67 | 767.67 | 7.23 | 55.80 |
| $M_3S_0$ | 193.33 | 997.20 | 5.77 | 44.40 |
| $M_3S_1$ | 181.67 | 906.90 | 6.85 | 52.80 |
| $M_3S_2$ | 195.67 | 857.77 | 6.84 | 52.70 |
| $M_3S_3$ | 171.50 | 885.50 | 6.40 | 49.40 |
| $M_3S_4$ | 218.83 | 1195.86 | 7.93 | 61.10 |
| $M_4S_0$ | 104.17 | 289.20 | 2.31 | 17.80 |
| $M_4S_1$ | 104.50 | 523.47 | 3.88 | 29.90 |
| $M_4S_2$ | 57.17 | 527.36 | 3.22 | 24.80 |
| $M_4S_3$ | 123.50 | 566.17 | 3.29 | 25.40 |
| $M_4S_4$ | 96.33 | 495.94 | 3.67 | 28.30 |
| **Main with Sub** | | | | |
| **S.Em.±** | 18.461 | 110.650 | 0.411 | 0.317 |
| **CD (P = 0.05)** | 46.175 | NS | NS | NS |
| **Sub with Main** | | | | |
| **S.Em.±** | 16.111 | 93.590 | 0.363 | 0.279 |
| **CD (P = 0.05)** | 48.094 | NS | NS | NS |

*Ripe chilli number, yield per plant and dry chilli yield per plot were recorded from five pickings.

These results are in agreement with Adilaxmi *et al.,* (2008) in okra, Kashyap *et al.,* (2014) and Veena *et al.,* (2017 in chilli. Combined application of organic manures and inorganic fertilizers might have ensured all round nutrient availability to the crop, the inorganic components were readily available and hence absorbed for early crop growth and development (Patil *et al.,* 2012).

The organic compounds might have improved the soil physical condition for the plant growth along with increased availability of N and K at the early stage of crop growth which might be the reason for increase in plant growth in INM plots. Neem cake especially when added to the soil, not only improves the soil with organic matter, but also lowers nitrogen losses by inhibiting nitrification (Lokanadhan *et al.,* 2012). After perusal of the pooled data on yield and yield attributes of green and ripe chilli, it was clear that all the INM treatments exhibited superiority over 100% RDN through urea ($S_0$). The lowest number of days (45.97) to 50% flowering was observed with $S_0$ and the maximum number of days (49.43) was recorded with 25% RDN through poultry manure + 75% RDN through urea ($S_3$). Among all INM treatments, $S_3$ recorded the maximum green fruit length and girth (8.40 cm, 4.64 cm respectively).

Maximum number of green fruits per plant (28.81), green and ripe fruit weights (4.10 g and 5.02 g respectively), 100 green fruit weight (395.50 g), green and ripe chilli yields per plant (118.26 g and 895.12 g respectively), green and dry chilli yields per plot (4.11 kg and 6.75 kg respectively), and dry chilli yield per ha (52 q) were recorded with chilli applied with 25% RDN through neem cake + 75% RDN through urea ($S_4$), whereas, the lowest values for all the parameters were recorded in chilli applied with 100% RDN through urea ($S_0$) Table 1 and 2.

Higher yields in the superior treatments viz., neem cake, poultry manure, vermicompost and FYM in combination of inorganic fertilisers over 100% RDN through urea could be mainly attributed to better growth and yield parameters namely, plant height, spread, number of branches per plant, number of fruits per plant, fruit length, fruit girth and fruit weight as compared to control. Organic manures are rich in micronutrients. The integrated supply and use of plant nutrients from chemical fertilizers and organic manures has been shown to produce higher crop yields than when they are applied alone. The synergistic effect of this combination might have caused the increase in yield through better root proliferation, more uptake of nutrients and water, higher plant growth, more photosynthesis and enhanced food accumulation (Denisilin *et al.,* 2010). Organic manures are also rich in micronutrients. The neem seed cake has organic matter content, with an ability to improve the physical characteristics of the soil, leading to improved water and nutrient holding capacities of soil that aid crop growth and yield (Eifediyi *et al.,* 2017). The positive effect of neem cake and inorganic fertilizer combination on growth and yield of vegetables was demonstrated by the experiments conducted by Sable *et al.,* (2007), Naveen *et al.,* (2009) and Kashyap *et al.,* (2014) and the effect of neem cake and vermicompost by Veena *et al.,* (2017) in chilli.

## Interaction effect of intercrops and INM practices on growth and yield of chilli

Interaction effect of intercrops and INM treatments on chilli was found significant on growth and yield of chilli. Growth parameters like plant height (87.97 cm), plant spread (164.67 cm), green fruit weight (4.36 g), 100 green fruit weight (431.67 g) and green chilli yield per plant (161.08 g) were found maximum in treatment combination of chilli +

fenugreek and application of 25% RDN through neem cake + 75% RDN through urea ($M_3S_4$). The same treatment was on par with the superior treatments in parameters like number of green fruits per plant, green chilli yield per plot and per ha (37.00, 5.17 kg and 31.6 q respectively). The same treatment recorded the maximum ripe chilli number per plant (218.83), ripe chilli yield per plant (1195.86 g), dry chilli yield per ha (61.9 q),whereas, the lowest values for all the above parameters were recorded with the treatment combination of chilli with marigold irrespective of INM treatments.

Legumes are the best intercrops as they fix the atmospheric nitrogen, release high-quality organic matter into the soil as green manure crops and facilitate soil nutrients circulation and water retention. Based on these multiple functions, legume crops have high potential for conservation agriculture, being functional either as a growing crop or as crop residue (Fabio *et al.,* 2017). The advantages of intercropping with legumes have been demonstrated in numerous studies; tomato or okra with cowpea (Odedina *et al.,* 2014), amaranthus with cowpea (Susan and Mini, 2005), cucumber with cowpea (Susan and Mini, 2005), maize with cowpea (Akande *et al.,* 2006), chilli with coriander (Durgannavar *et al.,* 2013) and chilli intercropped with coriander and onion (Sujay and Giraddi, 2015). The organic source seems to act directly by increasing crop yield either by accelerating respiratory process by cell permeability or by hormonal growth action. Organic sources supply NPK in available form to the plants through biological decomposition. They are also rich in micronutrients besides having plant growth promoting substances and humus forming microbes. Indirectly it improves the physical properties of soil such as aggregation, aeration, permeability and water holding capacity (Hiraguli and Alloli, 2011). Application of neem seed cake might have improved the availability of nutrients to the crop by enhancing the mineralization and supply of readily available nutrients to the soil microbial community. Organic manure like oil seed cake supply macro and micronutrients beneficial to crop growth and productivity. The study revealed that in chilli, the row spacing can be exploited to raise the intercrops like onion, coriander and fenugreek with no additional fertilizer application. These intercrops were found to have positive influence on chilli growth and yield due to complimentary nature of these crops that favoured nutrient uptake of chilli. However, the intercrop marigold was found to have negative influence on chilli growth and yield due to its competitive nature, vigorous stature and long duration. All the INM treatments were found superior over 100% RDN in terms of growth and, yield of chilli. The combination of intercropping and INM treatments had significant effect on ripe and dry chilli yield and yield attributing parameters. The treatment combination of chilli + fenugreek and application of 25% RDN through neem cake + 75% RDN through urea recorded the highest dry chilli yield per ha whereas, the lowest values for all the above parameters were recorded with the treatment combination of marigold irrespective of INM treatments.

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