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Research Article

# EFFECT OF DIFFERENT INM COMBINATIONS ON THE GROWTH AND YIELD OF CLUSTERBEAN [*Cyamopsis tetragonoloba* L. TAUB]

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**Abstract-** Clusterbean [*Cyamopsis tetragonoloba* L. Taub] commonly known as guar is a drought and high temperature tolerant, deep rooted, it's a good source of carbohydrates, protein, fibre and minerals like calcium, phosphorus and iron as well as contains appreciable amount of vitamin C, and it has become an important industrial crop with a great potential for foreign exchange. The present experiment was laid out in RBD design with three replications. Total ten numbers of different INM combinations were tested in the experiment. It can be concluded that application of 75% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha and 75% RDF + vermicompost 5 t/ha are the best combination of organic and inorganic fertilizer for increasing growth and yield of clusterbean. These treatments are also helpful to improving soil nutrient status.

**Key words-** Clusterbean, INM, Vermicompost, PSB and Rhizobium.

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## Introduction

Clusterbean [*Cyamopsis tetragonoloba* L. Taub] commonly known as guar is a drought and high temperature tolerant, deep rooted, Clusterbean grow on marginal lands mainly for food, animal feed fodder and various industrial uses. Seed of clusterbean contain 22-33% gum [1]. It's a good source of carbohydrates, protein, fibre and minerals like calcium, phosphorus and iron as well as contains appreciable amount of vitamin C, and it has become an important industrial crop with a great potential for foreign exchange [2].

India contributes 82% of total guar production in the word. It is grown an area of 2.96 million hectare with the production of 1.69 million tones and the productivity is 491 kg/ha [3]. In Madhya Pradesh, guar is cultivated as pure crops an area of 70622 hectare and productivity is 705 kg/has. Cultivated as mixed crop an area of 54782 hectare and productivity is 316 kg/ha.

The productivity is far low from its potential yield in many of the state's due to improper nutrient management under limited moisture [4]. Therefore, it has considered as major limiting factor for achieving higher productivity of clusterbean in semi-arid region. In INM, it combines the objective of production with ecological and environment, that is optimum nutrition, optimum functioning of the soil heath and minimum nutrient losses or other adverse effect on the environment [5].

Organic manure (FYM) and vermicompost are the important constituents of the integrated plant nutrient management system. Singh *et al.* (2007) found that when manure was applied in conjunction with chemical fertilizers for efficient growth of crop, the decline in organic carbon was arrested and the gap between potential yield and actual yield was bridged to a large extent [6]. According to Roy and Singh (2006), the use of vermicompost is being advocated for sustaining soil fertility in various field crops [7]. Biofertilizers do not directly supply nutrients to the crop plant, but have capacity to fix atmospheric nitrogen and convert insoluble phosphate into soluble form. Biofertilizer mainly *Rhizobium* and PSB and which are commonly used, have an enormous potential to increase the nutrient use efficiency [8].

Present investigation was designed with a view in mind to find out the effect of fertility levels on growth attributes and yields of clusterbean in semi-arid conditions.

## Material and Method

The investigation reported here was carried out at the Research Farm of the Department of Agronomy, College of Agriculture, Gwalior (M.P.) during the *Kharif* season of 2014. The weather condition was normal during the crop season with an average maximum and minimum temperature during growing period remained as 39.5$^0$C and 15.8$^0$C, respectively. The total rainfall received during the rainy season from July to November 2014 was 654 mm. Drought is the common feature due to the scanty and uneven distribution of rainfall. The soil of the experimental field was sandy clay loam. The soil of the experimental field was rich in potash content, but low in organic carbon, available nitrogen and medium in available phosphorus contents. It is slightly alkaline in reaction and had moderate cation exchange capacity. The experiment was laid out in RBD design with three replications. Total ten numbers of different INM combinations were tested in the experiment. Seed was sown 20 kg /ha by manually with a uniform distance of forty-five centimeters between rows and ten centimeters distance between plant to plant. The sowing was done on 24 July, 2014.

## Result

The result obtained with respect to different treatments were statistically analysed and presented in tabular form for ready references.

### Plant height (cm)

The plant height increased with the advancement in crop age, irrespective of the treatment and reached maximum at maturity stage. The rate of increase in plant

height was more during 30 to 60 DAS as compared to 60 DAS to maturity stage. The effect of various treatments with respect to plant height was found significant at all the stages of crop growth.

**Number of Branch per plant**

The formation of branches per plant was augmented steadily in all the treatments with the advancement of plant growth upto 90 days stage. The branches were increased by more than two-fold upto the 90 DAS, there after constant till maturity stage in all the nutrient management treatments. The nutrient management practices exerted significant impact upon this parameter at all the growth stages. The significantly higher number of branches (3.20, 6.20, 7.83 and 7.83 /plant at 30, 60, 90 DAS and maturity stage, respectively) were recorded under the application of 75% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha ($T_6$), followed by 75% RDF + VC 5 t/ha ($T_4$), and 50% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha ($T_{10}$) and all these treatments were statistically at par with each other at all the growth stages.

**Dry Weight per plant (g)**

At 30 DAS, the significantly higher dry weight per plant was registered with treatment $T_6$ (75% RDF + FYM 5 t/ha + PSB 2kg/ha + *Rhizobium* culture 3 kg/ha) and $T_4$ (75% RDF + VC 5 t/ha) and both these treatments were at par with each other and resulted dry weight 2.57 and 2.53 g/plant, respectively. At 60, 90 DAS and maturity stage, all the integrated nutrient management treatments produced significantly higher dry weight per plant over control. The maximum dry weight (11.94, 32.01 and 43.80 g/plant, at 60, 90 DAS and maturity, respectively) was recorded under the application of 75% + FYM 5 t/ha + PSB 2kg/ha + *Rhizobium* culture 3 kg/ha, and 75% RDF + VC 5 t/ha and then were statistically at par with each other and significantly superior over rest of the treatments.

**Crop growth rate (g/m²/day)**

The scrutiny of data in [Table-2] revealed that in general, CGR was increased with the increase in plant growth from 30 DAS to 90 DAS stage. Thereafter it tended to decline up to maturity stage under the various treatments. At 30 DAS stage, CGR ranged from 1.16 to 1.90, at 60 DAS 3.12 to 6.95, whereas at 90 DAS stage, 5.55 to 14.86 and then at maturity stage reduced CGR ranged from 2.67 to 10.48 in various treatments.

**Table-1** *Effect of Different INM treatments on Plant height (cm), Number of branches and Dry weight (g/plant) at different crop growth stages of cluster bean*

| | Plant height (cm) at | | | | Number of branches /plant at | | | | Dry weight (g/plant) at | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | Maturity | 30 DAS | 60 DAS | 90 DAS | Maturity | 30 DAS | 60 DAS | 90 DAS | Maturity |
| No fertilizer (control) | 14.17 | 65.83 | 74.77 | 75.43 | 2.13 | 3.90 | 4.80 | 4.80 | 1.57 | 5.78 | 13.27 | 16.27 |
| 100% RDF | 19.87 | 78.97 | 86.60 | 87.53 | 2.87 | 5.57 | 7.00 | 7.00 | 2.10 | 8.59 | 21.35 | 29.09 |
| 75% RDF + FYM 5t/ha | 18.97 | 82.73 | 90.63 | 91.20 | 2.70 | 5.57 | 7.07 | 7.07 | 2.22 | 9.22 | 23.07 | 31.27 |
| 75% RDF + VC 5 t/ha | 20.20 | 87.23 | 98.50 | 100.37 | 3.10 | 6.07 | 7.77 | 7.77 | 2.53 | 11.68 | 30.87 | 42.47 |
| 75% RDF + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 18.97 | 74.90 | 83.07 | 83.27 | 2.43 | 5.20 | 6.43 | 6.43 | 1.93 | 7.73 | 19.12 | 25.17 |
| 75% RDF + FYM 5t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 21.03 | 87.70 | 99.23 | 100.23 | 3.20 | 6.20 | 7.83 | 7.83 | 2.57 | 11.94 | 32.01 | 43.80 |
| 50% RDF + FYM 5t/ha | 18.90 | 78.10 | 86.17 | 87.03 | 2.43 | 5.27 | 6.73 | 6.73 | 1.94 | 7.87 | 19.65 | 26.05 |
| 50% RDF + VC 5t/ha | 19.43 | 80.67 | 90.70 | 91.37 | 2.90 | 5.67 | 7.20 | 7.20 | 2.20 | 9.18 | 23.57 | 31.93 |
| 50% RDF + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 17.20 | 72.47 | 81.10 | 81.77 | 2.37 | 5.17 | 6.33 | 6.33 | 1.85 | 7.37 | 17.85 | 23.23 |
| 50% RDF + FYM 5t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 20.17 | 83.60 | 94.27 | 95.00 | 2.99 | 5.97 | 7.60 | 7.60 | 2.30 | 9.76 | 25.13 | 34.33 |
| **S.E.(m)±** | 0.62 | 1.49 | 1.42 | 1.53 | 0.08 | 0.08 | 0.10 | 0.10 | 0.07 | 0.19 | 0.38 | 0.49 |
| **C.D. (at 5%)** | 1.83 | 4.43 | 4.21 | 4.56 | 0.22 | 0.25 | 0.29 | 0.29 | 0.20 | 0.58 | 1.14 | 1.44 |

**Table-2** *Effect of INM treatment of CGR (g/m²/day), RGR (mg/g/day) and AGR (g/day) in Clusterbean on successive crop growth stages*

| Treatments | CGR (g/m²/day) at | | | | RGR (mg/g/day) at | | | | AGR (g/day) at | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | Maturity | 30 DAS | 60 DAS | 90 DAS | Maturity | 30 DAS | 60 DAS | 90 DAS | Maturity |
| No fertilizer (control) | 1.16 | 3.12 | 5.55 | 2.67 | 14.91 | 43.54 | 27.73 | 8.15 | 0.0522 | 0.1404 | 0.2497 | 0.1201 |
| 100% RDF | 1.55 | 4.81 | 9.46 | 6.87 | 24.63 | 47.03 | 30.37 | 12.35 | 0.0699 | 0.2163 | 0.4256 | 0.3093 |
| 75% RDF + FYM 5t/ha | 1.64 | 5.19 | 10.26 | 7.29 | 26.51 | 47.53 | 30.55 | 12.17 | 0.0739 | 0.2334 | 0.4616 | 0.3280 |
| 75% RDF + VC 5 t/ha | 1.88 | 6.78 | 14.21 | 10.31 | 30.97 | 50.94 | 32.39 | 12.77 | 0.0844 | 0.3050 | 0.6397 | 0.4640 |
| 75% RDF + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 1.43 | 4.30 | 8.43 | 5.38 | 21.93 | 46.23 | 30.19 | 10.99 | 0.0644 | 0.1933 | 0.3794 | 0.2420 |
| 75% RDF + FYM 5t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 1.90 | 6.95 | 14.86 | 10.48 | 31.40 | 51.26 | 32.87 | 12.54 | 0.0856 | 0.3126 | 0.6688 | 0.4716 |
| 50% RDF + FYM 5t/ha | 1.43 | 4.40 | 8.73 | 5.69 | 22.02 | 46.76 | 30.48 | 11.27 | 0.0646 | 0.1979 | 0.3927 | 0.2559 |
| 50% RDF + VC 5t/ha | 1.63 | 5.17 | 10.66 | 7.44 | 26.23 | 47.64 | 31.46 | 12.15 | 0.0733 | 0.2326 | 0.4797 | 0.3347 |
| 50% RDF + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 1.37 | 4.08 | 7.77 | 4.79 | 20.53 | 45.99 | 29.55 | 10.54 | 0.0618 | 0.1838 | 0.3494 | 0.2153 |
| 50% RDF + FYM 5t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 1.70 | 5.53 | 11.38 | 8.18 | 27.74 | 48.20 | 31.52 | 12.49 | 0.0767 | 0.2487 | 0.5122 | 0.3683 |
| **S.E.(m)±** | 0.05 | 0.12 | 0.26 | 0.26 | 1.06 | 0.79 | 0.77 | 0.46 | 0.0021 | 0.0056 | 0.0119 | 0.0119 |
| **C.D. (at 5%)** | 0.14 | 0.37 | 0.79 | 0.78 | 3.14 | 2.34 | 2.28 | 1.37 | 0.0064 | 0.0165 | 0.0354 | 0.0353 |

**Relative growth rate (mg/g/day)**

Amongst all treatments, application of 75% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha accounted for maximum RGR (31.40, 51.26 and 32.87 mg/g/day) at 30, 60 and 90 DAS, respectively. While at maturity, application of 75% RDF + VC 5 t/ha gave highest RGR value (12.77 mg/g/day) and both these treatments were at par with each other and significantly superior over rest of the other treatments at all the stages of crop growth. However, treatment $T_{10}$ (50% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha, being statistically at par with all remaining treatments at all the stages of crop growth except at 30 DAS in case of $T_7$, $T_5$, $T_9$ and $T_1$; and at maturity stage in respect of $T_5$, $T_9$ and $T_1$. The significantly lowest value of RGR was recorded with treatment $T_1$ (no fertilizer).

**Absolute growth rate (g/day):**
Soil application of biofertilizer (PSB 2 kg/ha and *Rhizobium* culture 3 kg/ha) with 75% RDF + FYM 5 t/ha recorded significantly higher AGR over rest of other treatments except 75 % RDF + VC 5 t/ha at all the stages. Further, treatment $T_{10}$ (50% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha) was also gave significantly higher AGR over $T_5$, $T_9$, $T_7$ and $T_2$ at all the stages. However, it was statistically at par with $T_8$ treatments at all stages. The lowest AGR was obtained under no fertilizer application treatments at all the stages.

**Seed yield (kg/ha)**
Seed yield per plant was significantly affected due to different treatments. The maximum seed yield per plant (2052.48 kg/ha) was recorded under the application of 75% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha ($T_6$), which was significantly higher over the remaining treatments except $T_4$ (75% RDF + VC 5 t/ha). The treatment $T_1$ (no fertilizer) produced the lowest seed yield per plant (987.66 kg/ha) which was significantly lower than remaining treatments.

**Table-1** *Effect of different INM treatments on seed yield (kg/ha), Stover yield (kg/ha) and Harvest index (%) of cluster bean*

| Treatments | Seed yield (kg/ha) | Stover yield (kg/ha) | Harvest index (%) |
|---|---|---|---|
| No fertilizer (control) | 987.66 | 2888.11 | 25.48 |
| 100% RDF | 1604.95 | 4086.81 | 28.20 |
| 75% RDF + FYM 5t/ha | 1651.24 | 4136.44 | 28.53 |
| 75% RDF + VC 5 t/ha | 2006.18 | 4828.54 | 29.36 |
| 75% RDF + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 1496.92 | 3901.48 | 27.74 |
| 75% RDF + FYM 5t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 2052.48 | 4930.76 | 29.40 |
| 50% RDF + FYM 5t/ha | 1591.37 | 4071.25 | 28.12 |
| 50% RDF + VC 5t/ha | 1666.67 | 4141.68 | 28.70 |
| 50% RDF + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 1435.19 | 3751.76 | 27.67 |
| 50% RDF + FYM 5t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha | 1712.97 | 4220.77 | 28.86 |
| **S.E.(m)±** | 35.28 | 102.35 | 0.28 |
| **C.D. (at 5%)** | 104.83 | 304.12 | 0.83 |

**Stover Yield (kg/ha)**
it was observed that significantly higher stover yield (4930.76 kg/ha) recorded in $T_6$ (75% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha but at par with treatment $T_4$ (75 % RDF + VC 5 t/ha). Further, application of 50% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha was also significantly superior as compared to $T_5$, $T_9$ and $T_1$ and gave statistically equal stover yield with rest of remaining treatments. The minimum stover yield (2888.11 kg/ha) was recorded under control ($T_1$) treatment, which was significantly inferior to rest of the treatments.

**Harvest Index (%)**
The data revealed that all INM treatments significantly increased harvest index over control. The significantly higher value of harvest index (29.40%) was recorded with treatment $T_6$ (75% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha), followed by $T_4$ (29.36%), $T_{10}$ (28.86%) and $T_8$ (28.70%) and all these treatments were at par with each other and they were significantly superior over rest of the treatments. The lowest harvest index registered with $T_1$ (control).
Each plant passes through the vegetative as well as reproductive phases of growth to complete its life cycle. Yield can be considered to be the final expression of the physiological and metabolic activities of plants and is governed by various factors. These yield-attributing factors have direct bearing on plant productivity and for increasing the yield that means seed as well as stover yield /plant, *etc*., play an important role.

**Discussion**
Fertility levels caused a marked variation in growth parameters of clusterbean at all of the crop growth stages. The growth parameter *viz*., Plant height, number of branches per plant, dry weight per plant, CGR, RGR and AGR had a direct relationship with fertility levels. All integrated nutrient management treatments significantly increased all growth parameters over control. The maximum values of all these growth parameters were recorded with application of 75% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha followed by 75% RDF + vermicompost 5 t/ha and both treatments were found significantly superior over other INM treatments including 100% RDF. The order of significance was followed by 50% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg /ha as soil application, 50% RDF + vermicompost 5 t/ha and 75% RDF + FYM 5 t/ha and 100% RDF.
Application of FYM or biofertilizer (PSB 2 kg/ha + *Rizobium* 3 kg /ha) with 50% RDF or biofertilizer with 75% RDF also gave significantly higher plant height, number of branches per plant, dry weight per plant, CGR, RGR and AGR compared to control plot. These results in line with Singh *et al.,* (2007) who reported that sole or dual inoculation of soybean with biofertilizers, application of FYM and recommended dose of fertilizer (RDF) significantly increased the plant growth over the control. Patel *et al.* (2010) also observed that the integrated use of inorganic fertilizer, bio-fertilizer and organic manure enhanced the growth of clusterbean [9].
This may be owing to increased supply of multi-nutrients, plant growth regulators and beneficial microflora released from FYM and vermicompost in addition to most favourable conditions improved with respect to physico-chemical and biological properties of the soil. The boosted vegetative growth (height and branches per plant) due to increased multi-nutrients which promoted plant growth by ensuring higher number of greener leaves with increased photosynthesis as a result of increased metabolism of the plant.
The overall improvement in the growth of clusterbean at higher level of fertility could be ascribed to their pivotal role in several physiological and biochemical processes, *viz*., root development, photosynthesis, energy transfer reaction and symbiotic biological N-fixation process. These observations are in line with the findings of Rathore *et al*. (2007) who reported that N and $P_2O_5$ combination had significant favourable effect on plant growth of clusterbean [10]. Arya and Singh (1996) also reported that major plant nutrients mainly nitrogen and phosphorus had a positive effect on plant height in horse gram [11].
The trend of increases in seed and straw yields obtained due to these treatments was exactly in accordance with the similar increases in the vegetative growth. The increases in yield-attributing characters and consequently the seed yield of clusterbean and other pulses as a result of integrated nutrient management have also been reported by many research workers [12-17].

**Conclusion**
It can be concluded that application of 75% RDF + FYM 5 t/ha + PSB 2 kg/ha + *Rhizobium* culture 3 kg/ha and 75% RDF + vermicompost 5 t/ha are the best combination of organic and inorganic fertilizer for increasing growth and yield of clusterbean.

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**Abbreviations:**
RDF: Recommended Dose of Fertilizer
CGR: Crop Growth Rate
RGR: Relative Growth Rate
AGR: Absolute Growth Rate

**Application of research:** These treatments are also helpful to improving soil nutrient status.

**Conflict of Interest:** None declared

**Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.

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