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**B Vibhajam Sagal Kiran**

Department of Agronomy,  
Agricultural Chemistry, College  
of Agriculture, Latur, VNMKV,  
Parbhani, Maharashtra, India

**NK Kalegore**

Department of Agronomy,  
Agricultural Chemistry, College  
of Agriculture, Latur, VNMKV,  
Parbhani, Maharashtra, India

**VP Suryavanshi**

Department of Agronomy,  
Agricultural Chemistry, College  
of Agriculture, Latur, VNMKV,  
Parbhani, Maharashtra, India

**AK Ghotmukale**

Department of Agronomy,  
Agricultural Chemistry, College  
of Agriculture, Latur, VNMKV,  
Parbhani, Maharashtra, India

**PH Vaidya**

Department of Soil Science and  
Agricultural Chemistry, College  
of Agriculture, Latur, VNMKV,  
Parbhani, Maharashtra, India

**Corresponding Author:****B Vibhajam Sagal Kiran**

Department of Agronomy,  
Agricultural Chemistry, College  
of Agriculture, Latur, VNMKV,  
Parbhani, Maharashtra, India

## Integrated nutrient management and relationship studies in Cowpea (*Vigna unguiculata* L. Walp) under rainfed conditions

**B Vibhajam Sagal Kiran, NK Kalegore, VP Suryavanshi, AK Ghotmukale and PH Vaidya**

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### Abstract

Field experiment was conducted on clay soil during *kharif* season of 2014-15 at College farm, Latur, VNMKV, Parbhani, Maharashtra to study the effect of various sources of nutrients *viz.*, organic manures, inorganic, biofertilizers and their combinations on growth parameters and yield attributes of cowpea (*Vigna unguiculata* L. Walp) cv. 'Konkan Sadhabahar'. The experiment was conducted in a randomized block design (RBD) and replicated thrice. The results revealed that significantly the maximum plant height (30.0 cm), drymatter production (17.5 g per plant), branches per plant (5.9), functional leaves per plant (14.0) and leaf area per plant (12.1 dm<sup>2</sup>) were recorded with the application of 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> as compared to other treatments. In respect of yield per hectare and over all yield contributing factors *viz.*, pods per plant (6.6), pod yield per plant (7.7 g), seed yield (1066 kg ha<sup>-1</sup>) and straw yield (2707 kg ha<sup>-1</sup>) recorded significantly higher in 75 per cent RDF+Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup>. The increased supply of N and P through organic manures, inorganic fertilizers and Biofertilizers like *Rhizobium* and Phosphorous Solubilising Bacteria (PSB) and higher uptake by plants contributed to increased rate of physiological processes in plant and led to higher growth and yield attributes. Correlation coefficients resulted significant positive relationships between growth, yield contributing traits and seed yield.

**Keywords:** Cowpea, vermicompost, farm yard manure (FYM), biofertilizers, recommended dose of fertilizers (RDF) and correlation

### Introduction

Cowpea (*Vigna unguiculata* L. Walp) is one of the annual herbaceous legume belongs to the family leguminosae and native of Central Africa. Due to its tolerance under moisture stress conditions, it is important crop in the semi arid regions across Africa and Asia. The largest producer is Africa, Brazil, Haiti, India, Myanmar, Srilanka, Australia, Bosnia and Herzegovina also have significant production. Globally cowpea crop was cultivated in approximate 8 million hectares. The global production is estimated about 3.3 million tonnes of dry grain. In India cowpea is mostly grown for green vegetable pods, grain, forage and green manure purpose. In India the area under cowpea 3.9 million hectares with a production of 2.21 million tonnes with the national productivity of 683 kg ha<sup>-1</sup> (Singh *et al.*, 2012) [16]. Major states grown cowpea are Maharashtra, Karnataka, Tamilnadu, Madhya Pradesh, Rajasthan and Andhra Pradesh. In Maharashtra, cowpea occupies an acreage of 11, 800 ha with an average productivity of 400 kg ha<sup>-1</sup> (Anonymous, 2012) [1].

Pulses are the main source of dietary protein and has a characteristic feature of fixing atmospheric nitrogen (Biological Nitrogen Fixation) which maintains and restores the soil fertility furthermore adding small amount of residues to the soil (Bisikwa *et al.*, 2014) [3]. There is a vast scope for increasing productivity of cowpea by adopting agro-techniques. For achieving the potential crop yield per unit area, high yielding varieties should be coupled with proper agronomic practices. Among the various factors known to augment the crop productivity, fertilizers added with suitable agronomic practices can boost up the crop yield. Presently, 40 to 50 per cent increase in agricultural production can be credited to fertilizers alone (Tondon, 1994) [18]. Integrated Nutrient Management approach of chemical, organic and biological sources can maintain and sustain soil fertility and achieve sustainable production.

It is important to exploit the potential of organic manures, composts, Biofertilizers and their synergistic effect with chemical fertilizers for increasing balanced nutrient supply (Singh *et al.*, 2012) [16].

### Materials and Methods

The experiment entitled effect of Integrated nutrient management on growth and yield of cowpea (*Vigna unguiculata* L. Walp) was conducted during *kharif* 2014-15 at College farm, College of Agriculture, Latur, VNMKV, Parbhani (Maharashtra). The experiment comprised of 10 treatments *viz.*, RDF (25:50:00 NPK kg ha<sup>-1</sup>)(T<sub>1</sub>), 75 per cent RDF + Bio-fertilizers (*Rhizobium*+PSB) (T<sub>2</sub>), 75 per cent RDF + FYM @ 2.5 t ha<sup>-1</sup>(T<sub>3</sub>), 75 per cent RDF + vermicompost @ 1.25 t ha<sup>-1</sup>(T<sub>4</sub>), 75 per cent RDF + Bio-fertilizers + FYM @ 2.5 t ha<sup>-1</sup>(T<sub>5</sub>), 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup>(T<sub>6</sub>), 50 per cent RDF + Bio-fertilizers + FYM @ 5 t ha<sup>-1</sup>(T<sub>7</sub>), 50 per cent RDF + Bio-fertilizers + vermicompost @ 2.5 t ha<sup>-1</sup> (T<sub>8</sub>), 50 per cent RDF + FYM @ 5 t ha<sup>-1</sup>(T<sub>9</sub>) and 50 per cent RDF + vermicompost @ 2.5 t ha<sup>-1</sup>(T<sub>10</sub>). Sowing of seed was done in *kharif* season with variety Konkan Sadhabahar. Quantity of organic manures (FYM and vermicompost) and inorganic fertilizers, nitrogen added through urea, phosphorus added through single super phosphate and biofertilizers (*Rhizobium* and PSB) @ 250 g per kg of seed to be applied to the cowpea was calculated as per the treatments. Five plants per treatment was randomly selected to record observations. In the yield parameters harvest index indicates the efficiency of plant material to convert the photosynthates in to the economic yield and it is worked out as

$$\text{Harvest index (\%)} = \frac{\text{Total seed yield (kg ha}^{-1}\text{)}}{\text{Total biological yield (kg ha}^{-1}\text{)}} \times 100$$

### Statistical analysis

Data obtained on various variables were analyzed by "analysis of variance method" (Panse and Sukhatme, 1967) [10]. The total variance (S<sup>2</sup>) and degrees of freedom (n-1) divided into different possible sources. The variance due to replication and treatment effects were calculated and compared with error variance for finding out 'F' values and ultimately for testing the significance at P = 0.05 wherever the results were found significant. Critical difference was calculated for comparison of treatment mean at 5 per cent level of significance where results are significant.

### Pearson correlation

Correlation studies were taken up between seed yield per plant in relation to various important growth and yield attributes. Pearson correlation co-efficient (r) was worked out between seed yield per plant (Y) and plant characters (X<sub>n</sub>) as mentioned below *viz.*,

X<sub>1</sub> = Height of plant (cm)

X<sub>2</sub> = Branches per plant

X<sub>3</sub> = Functional leaves per plant

X<sub>4</sub> = Leaf area (dm<sup>2</sup>) per plant

X<sub>5</sub> = Nodules per plant

X<sub>6</sub> = Total drymatter per plant (g)

X<sub>7</sub> = Pods per plant

X<sub>8</sub> = Pod yield (g) per plant

X<sub>9</sub> = Seed index (g)

Y = Seed yield (g) per plant

The procedure and formula described by Snedecor and Cochran (1968) [17] were adopted and significance was tested.

$$r = \frac{\sum XY}{\sqrt{(\sum X)(\sum Y)}}$$

Where, r = Correlation coefficient, X = Independent variable (attributes), Y = Dependent variable (yield)

### Results

Significant differences were recorded with the treatment combination of organic manures, inorganic fertilizers and biofertilizers on growth characteristics of cowpea. The maximum plant height (30.0 cm) was recorded significantly with the application of 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> (T<sub>6</sub>) and was statistically comparable with T<sub>1</sub>, T<sub>4</sub> and T<sub>5</sub> (Table 1). Number of branches (5.9) per plant was found to be significant and highest with 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> (T<sub>6</sub>). Maximum number of functional leaves (14.0) and leaf area (12.1 dm<sup>2</sup>) per plant was observed at 60 days after sowing (DAS) with 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> (T<sub>6</sub>) and reduced at subsequent stages of plant growth. Whereas, the lowest functional leaves (9.5) and leaf area (7.9 dm<sup>2</sup>) per plant was recorded significantly with T<sub>9</sub>. Similarly, drymatter production showed significant among the treatments and obtained maximum of 17.5 g per plant with T<sub>6</sub> and minimum of 12.0 g per plant with T<sub>9</sub>. The highest number of nodules per plant (27.8) at 45 DAS was observed with the application of 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> (T<sub>6</sub>) which was at par with T<sub>4</sub> and T<sub>5</sub> and found significantly superior over rest of the treatments.

Data pertaining to Table 2 revealed that, 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> (T<sub>6</sub>) recorded significantly higher yield attributes and yield of cowpea. Maximum number of pods per plant (6.6), pod yield per plant (7.7 g), seed yield per plant (4.6 g) and higher number of seeds per plant (58.2) of cowpea was obtained in T<sub>6</sub> and least was observed with T<sub>9</sub>. Seed index (g) was not significantly influenced by the various treatments but observed highest (7.7 g) in T<sub>6</sub>. Application of 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> treatment (T<sub>6</sub>) recorded significantly the highest seed yield (1066 kg ha<sup>-1</sup>) and straw yield (2707 kg ha<sup>-1</sup>). The maximum harvest index (28.3 %) was obtained in T<sub>6</sub> and least in T<sub>9</sub>.

Data on simple pearson correlation between seed yield per plant as dependent variable and plant height (cm), branches per plant, functional leaves per plant, mean leaf area per plant, nodules per plant, total dry matter per plant (g), pods per plant, pod yield per plant and seed index (g) as independent variables were established (Table 3) and resultant data revealed that positive and highly significant correlation was observed between seed yield per plant and plant height (0.988\*\*), branches per plant (0.968\*\*), functional leaves per plant (0.969\*\*), leaf area per plant (0.951\*\*), nodules per plant (0.964\*\*), total drymatter per plant (0.984\*\*), pods per plant (0.976\*\*), pod yield per plant (0.989\*\*) and seed index (0.826\*\*).

### Discussion

The present study results revealed that the maximum plant height and number of branches per plant were with the

application of 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> (T<sub>6</sub>) might be due to increased availability of nutrients. Similar results were reported by Menon *et al.*, (2010) [8] and Minchin *et al.*, (1981) [9]. The higher bacterial growth under easy availability of organic matter through vermicompost resulted in releasing the nutrients to the soil solution which are readily available to crop plant (Rajput, 1994) [11] and helped to increase the height which differed significantly at all growth stages. The results are in accordance with Kher *et al.*, (1994) [5]. The number of functional leaves and leaf area per plant were gradually increased up to 60 DAS and recorded highest in T<sub>6</sub> and then decreased till to harvest due to leaf senescence. The results of the present study were in conformity with those earlier findings of Hala and Wafaa (2001) [4] and Madukwe *et al.*, (2001) [6] who reported that addition of organic manure in the soil where cowpea crop was grown enhanced the symbiotic relationship between microorganisms. Phosphorus enhances the elongation and expansion of leaf which helps in cell elongation and contributed to maximum leaf area.

The drymatter accumulation per plant was found to be increased continuously with the advancement in age of crop. The rate of drymatter production was slow at the beginning, fast during 30 to 45 days and gradually increased up to harvest in the treatment 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> (T<sub>6</sub>). Highest drymatter was recorded due to readily available nitrogen for rapid initial growth and cumulative improvement in most of the growth parameters as a result of sustained availability of macro and micronutrients. Similar results were reported by Yadav and Malik (2005) [21]. Moreover, beneficial bacteria such as *Rhizobium* and Phosphobacteria colonizing in the rhizosphere region and has the ability to fix nitrogen, solubilize phosphorous and stimulate plant growth. These findings are in agreement with Magdi *et al.*, (2011) [7]. The higher number of nodules per plant was observed in T<sub>6</sub> at 45 days after sowing. The rate of increase in number of nodules per plant was fast in first 15 days and gradually increased up to 45 days and then decreased at subsequent stages. Improved nodulation due to *Rhizobium* inoculation may be ascribed to stimulatory effect of bacterioids on root curling, bulging infection thread and ultimately the production of more infection in nodules. The results are in concurrence with the findings of Yadav and Malik (2005) [21]. Inoculation of seed with symbiotic nitrogen fixers might have increased the concentration of an efficient and healthy strain of *Rhizobium* in rhizosphere which resulted

in greater fixation of atmospheric nitrogen in soil for use by plants and consequently resulted in higher nodules (Rohit *et al.*, 2013) [13].

Application of 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> (T<sub>6</sub>) recorded significantly higher yield attributing characters. Singh *et al.*, (2011) [15] reported that phosphorus is essential for higher nodulation in cowpea and contributed to more fixing of atmospheric nitrogen which enhances photosynthesis, pod development and eventually more number of yield attributing characters of cowpea *viz.*, pods per plant, pod yield per plant (g), seed yield per plant (g) and number of seeds per plant. This might be also due to in treatment T<sub>6</sub> higher vegetative growth contributed to higher interception of light increased assimilated production thereby enhanced pod yields. These results are in conformity with the results of Babaji *et al.*, (2011) [2]. The seed and straw yield obtained maximum in T<sub>6</sub> probably might be due to enhanced microbial activity in vermicompost resulted in an increase in the concentration of nutrients in vermicompost. Beneficial microbes like phosphorous solubilisers and nitrogen fixers, vermicompost induced solubilisation of phosphate and helped in nitrogen fixation. Same results were reported by Sailaja Kumari and Ushakumari (2002) [14]. Compost application might have played a major role in improvement of physical, chemical and biological properties of soil, improvement in the water holding capacity of soil (Venkateswarlu, 1987) [20] and improved soil health by reducing the soil hardening. This collectively resulted in increased yield of cowpea under rainfed conditions. These results are in conformity with the results of Ramesh and Devasenapathy (2008) [12].

Present study reveals that positive and highly significant correlation was observed between seed yield per plant and plant height, branches per plant, functional leaves per plant, leaf area per plant, nodules per plant, total drymatter per plant, pods per plant, pod yield per plant and seed index. More nodulation increases biological nitrogen fixation with maximum vegetative growth with broader leaves, the more leaf area that will be exposed to photosynthetic activity and more pods that will be produced which might affect the pod yield and ultimately seed yield. Thus integrated nutrient management approach contributes significantly to the final yield of cowpea by improving the soil properties and soil fertility making sustainable production (Udensi *et al.*, 2012) [19].

**Table 1:** Effect of integrated nutrient management on growth parameters of cowpea

Treatment	Plant height (cm)	Branches per plant (No.)	Functional leaves per plant (No.)	Drymatter production (g) per plant	Leaf area per plant (dm <sup>2</sup> )	Nodules per plant (No.)
T <sub>1</sub> : RDF (25:50:0 NPK kg ha <sup>-1</sup> )	29.1	5.9	13.2	17.1	11.3	23.4
T <sub>2</sub> : 75% RDF + Bio-fertilizers ( <i>Rhizobium</i> +PSB)	25.5	5.3	12.2	14.9	10.3	22.6
T <sub>3</sub> : 75% RDF + FYM @ 2.5 t ha <sup>-1</sup>	24.3	5.0	11.7	14.2	9.9	21.8
T <sub>4</sub> : 75% RDF + vermicompost @ 1.25 t ha <sup>-1</sup>	27.1	5.7	12.6	15.9	10.9	24.8
T <sub>5</sub> : 75% RDF + Bio-fertilizers + FYM @ 2.5 t ha <sup>-1</sup>	28.5	5.8	13.0	16.3	11.0	24.6
T <sub>6</sub> : 75% RDF + Bio-fertilizers + vermicompost @ 1.25 t ha <sup>-1</sup>	30.0	5.9	14.0	17.5	12.1	27.8
T <sub>7</sub> : 50% RDF + Bio-fertilizers + FYM @ 5 t ha <sup>-1</sup>	23.1	4.4	10.9	12.8	9.6	17.9
T <sub>8</sub> : 50% RDF + Bio-fertilizers + vermicompost @ 2.5 t ha <sup>-1</sup>	23.5	4.9	11.5	13.9	9.7	18.6
T <sub>9</sub> : 50% RDF + FYM @ 5 t ha <sup>-1</sup>	21.1	4.0	9.5	12.0	7.9	16.5
T <sub>10</sub> : 50% RDF + vermicompost @ 2.5 t ha <sup>-1</sup>	21.4	4.1	10.4	12.3	8.6	17.5

ha <sup>-1</sup>						
S. Em <sub>±</sub>	1.2	0.3	0.6	0.7	0.4	1.1
C.D. at 5%	3.6	0.8	1.9	2.2	1.3	3.2
General Mean	25.4	5.1	11.9	14.7	10.1	21.5

**Table 2:** Effect of integrated nutrient management on yield attributes and yield of cowpea

Treatment	Pods per plant (No.)	Pod yield per plant (g)	Seed yield per plant (g)	Seeds per plant (No.)	Seed index (g)	Seed yield (kg ha <sup>-1</sup> )	Straw yield (kg ha <sup>-1</sup> )	Harvest index (%)
T <sub>1</sub> : RDF (25:50:0 NPK kg ha <sup>-1</sup> )	6.1	7.6	4.4	57.7	7.6	1002	2603	27.8
T <sub>2</sub> : 75% RDF + Bio-fertilizers ( <i>Rhizobium</i> +PSB)	5.4	6.1	3.8	51.6	7.5	879	2322	27.5
T <sub>3</sub> : 75% RDF + FYM @ 2.5 t ha <sup>-1</sup>	5.2	5.9	3.7	48.6	7.5	829	2210	27.3
T <sub>4</sub> : 75% RDF + vermicompost @ 1.25 t ha <sup>-1</sup>	5.8	6.4	4.1	54.3	7.5	938	2460	27.6
T <sub>5</sub> : 75% RDF + Bio-fertilizers + FYM @ 2.5 t ha <sup>-1</sup>	5.9	7.0	4.3	57.2	7.6	992	2593	27.7
T <sub>6</sub> : 75% RDF + Bio-fertilizers + vermicompost @ 1.25 t ha <sup>-1</sup>	6.6	7.7	4.6	58.2	7.7	1066	2707	28.3
T <sub>7</sub> : 50% RDF + Bio-fertilizers + FYM @ 5 t ha <sup>-1</sup>	5.0	5.2	3.1	44.5	7.4	704	1920	26.8
T <sub>8</sub> : 50% RDF + Bio-fertilizers + vermicompost @ 2.5 t ha <sup>-1</sup>	5.1	5.3	3.3	45.8	7.4	725	1967	26.9
T <sub>9</sub> : 50% RDF + FYM @ 5 t ha <sup>-1</sup>	4.7	4.7	2.9	42.7	7.0	626	1737	26.5
T <sub>10</sub> : 50% RDF + vermicompost @ 2.5 t ha <sup>-1</sup>	4.9	5.1	3.1	43.3	7.4	665	1842	26.5
S.Em <sub>±</sub>	0.3	0.3	0.2	2.8	0.2	47	109	-
C.D. at 5%	0.9	0.9	0.7	8.3	NS	140	325	-
General Mean	5.5	6.1	3.7	50.4	7.5	842	2236	27.3

NS = Non-significant

**Table 3:** Simple pearson correlation on growth and yield related characters of cowpea (*Vigna unguiculata* L. Walp)

Particulars	Plant height	Bran-ches plant <sup>-1</sup>	Functional leaves plant <sup>-1</sup>	Leaf area plant <sup>-1</sup>	Nodules plant <sup>-1</sup>	Total dry matter plant <sup>-1</sup> (g)	Pods plant <sup>-1</sup>	Pod yield plant <sup>-1</sup> (g)	Seed index (g)	Seed yield plant <sup>-1</sup> (g)
Plant height	1	0.966**	0.975**	0.969**	0.945**	0.992**	0.981**	0.985**	0.829**	0.988**
No. of branches plant <sup>-1</sup>		1	0.972**	0.951**	0.941**	0.983**	0.927**	0.941**	0.836**	0.968**
No. of functional leaves plant <sup>-1</sup>			1	0.992**	0.953**	0.981**	0.962**	0.958**	0.912**	0.969**
Leaf area plant <sup>-1</sup>				1	0.939**	0.966**	0.955**	0.945**	0.919**	0.951**
No. of nodules plant <sup>-1</sup>					1	0.951**	0.948**	0.928**	0.808**	0.964**
Total dry matter plant <sup>-1</sup> (g)						1	0.977**	0.982**	0.833**	0.989**
No. of pods plant <sup>-1</sup>							1	0.981**	0.813**	0.976**
Pod yield plant <sup>-1</sup> (g)								1	0.820**	0.989**
Seed index (g)									1	0.826**
Seed yield plant <sup>-1</sup> (g)										1

\* Significance at 5 percent:0.443

\*\* Significance at 1 percent:0.564

## Conclusion

After the interpretation of results of present study, it can be concluded that the application of 75 per cent RDF + Bio-fertilizers + vermicompost @ 1.25 t ha<sup>-1</sup> can contribute to higher plant growth characteristics with better nodulation for biological nitrogen fixation and increased yield attributes and yield of cowpea. The correlation studies concluded that positive and highly significant correlation was observed between seed yield per plant and plant height, branches per plant, functional leaves per plant, leaf area per plant, nodules per plant, total dry matter per plant, pods per plant, pod yield per plant and seed index.

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