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Effect of integrated nutrient management on seed yield and quality in cowpea

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ABSTRACT

A study was carried out to assess effect of inorganic fertilizers, vermicompost, Vesicular Arbuscular Mycorhizae (VAM) and biofertilizers [*Rhizobium* and Phosphate solubilizing bacteria (PSB)] inoculation on seed yield and quality of cowpea (*Vigna unguiculata*). The experiment was conducted in a split plot design for two consecutive cropping season, *kharif* 2012 and 2013, with two main plot treatments of inorganic fertilizers i.e. 100% and 75% recommended dose of fertilizers (RDF) and nine sub plot integrated nutrient management (INM) treatments including control (No organic fertilizer). Main plot treatments were at par but sub plot INM treatments differed significantly for plant height, seed yield, number of pods/plant, pod length, number of seeds/pod, 1000-seed weight, seed germination and vigour indices. Integrated use of inorganic fertilizers + Vermicompost 2.5 t ha^{-1} (4.76, 4.16 q ha^{-1}) performed significantly better than the control (3.32, 2.79 q ha^{-1}) for seed yield and its attributes as well as seed quality parameters during *Kharif* 2012 and 2013, respectively. It was at par with combined use of inorganic fertilizers + biofertilizer inoculation (*Rhizobium* + PSB) + VAM 10 Kg ha^{-1} Also, the mean cost benefit ratios (2.04, 1.90) were highest for combination of biofertilizer inoculation (*Rhizobium* + PSB) + VAM 10 Kg ha^{-1} +inorganic fertilizers 100% and 75% RDF, respectively.

Key words: Biofertilizers, Cowpea, Seed quality, Seed yield, Vermicompost.

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.]` is one of the important *kharif* pulses grown in India. It is a warm season crop, well adapted to many areas of the humid tropics and sub tropical zones. It is grown throughout India for its long, green vegetable pods, seeds and foliage for fodder. There is worldwide consensus that sole dependence on chemical input based agriculture is not suitable in long run and only integrated plant nutrient system (IPNS) involving a combination of fertilizer, organic manures and bio-fertilizers are essential to sustain crop production, preserve soil health and biodiversity. In addition to this, the organic manures help in improving the use efficiency of inorganic fertilizers (Singh and Biswas 2000). The basic concept of integrated nutrient management system is the maintenance of plant nutrients supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients in an integrated manner, appropriate to each cropping system and farming system (Mahajan and Sharma 2005). The advantage of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately (Palaniappan and Annadurai 2007).Seed production is an area of interest in vegetable cowpea, as availability of quality seed is a felt need among vegetable growers. Quality seed production in cowpea is very difficult due to poor seed setting, biotic and abiotic stresses and labour intensiveness. The present investigation was undertaken with a view to study the effect of integrated nutrient management on seed yield and seed quality of cowpea.

MATERIALS AND METHODS

Field experiments were undertaken during the *Kharif* seasons of 2012 and 2013 in the experimental research farm of Indian Agricultural Research Institute Regional Station, Karnal, India. The location stands at 29.1-29.5° N and 76.3-77.1° E, at an elevation of 243m above mean sea level. The climate is sub-tropical with mean maximum temperature ranging between 34-39° C in summer and mean minimum temperature ranging between 6-7°C in winter. The mean annual rainfall is around 744mm. The soil on site was clay to clay loam, deep, well drained and productive for growing a large variety of different crop. The soil was neutral to alkaline in reaction (pH - 7.6), electrical conductivity of 0.45 ds/m. with deficient (0.27%) soil organic carbon, medium (28.63 Kg ha^{-1}) phosphorus, medium (190 Kg ha^{-1}) potash and sufficient (14.57 ppm) sulphur. It has sufficient amount (3.46, 6.58, 3.25 ppm) of micronutrients *viz.*, Zn, Fe and Mn, respectively. Vermicompost used in experiments was neutral to alkaline in reaction (pH 7.4) and having nitrogen 1.75%, phosphorus 1.25%, potassium 1.95%, sulphur 120ppm, zinc 1.06ppm, iron 14.78ppm and manganese 8.74ppm. Experiment

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Table 1: Details of experimental treatments.

Plot	Notations	Treatments
Main plot treatments	M_1	100% RDF or NPK, Recommended dose of fertilizer; N -20, P_2O_5 -60, K_2O -50 Kg ha^{-1}
	M_2	75% RDF or NPK
Sub plot treatments	S_1	Rhizobium (Rz) as seed innoculant
	S_2	Phosphate solubilizing bacteria (PSB) as seed innoculant
	S_3	VAM @ 10 Kg ha^{-1} applied as band application in the soil
	S_4	Rz+PSB
	S_5	PSB+VAM (Vesicular Arbuscular Mycorhizae)
	S_6	VAM+Rz
	S_7	Rz+PSB+VAM
	S_8	Vermicompost @ 2.5 t ha^{-1} applied as band application in the soil
	S_9	Control (No organic fertilizer)

Only N and P_2O_5 (basal dose) doses were reduced to 75%.

was conducted to evaluate the performance of cowpea variety, Pusa Sukomal under different nutrient management practices to recommend the best suited management package. Seeds were planted on August 07, 2012 and August 27, 2013 in the experimental field. Plot sizes of 3m × 3m with 60cm row to row and 20cm plant to plant spacing were laid out in Split plot design with two main and nine sub plot treatments in two replications. The treatment details are given in Table 1.

Yield and yield attributing characteristics: Plant stand, plant height (cm) and number of pods of ten randomly selected plants, pod length (cm) and number of seeds of twenty five randomly selected pods of each treatment and replication were recorded at maturity. Mean of five samples of 1000 randomly selected seeds of each treatment and replication were recorded and expressed as 1000-seed weight (g). Weight of total quantity of harvested seeds per plot for each treatment and replication was recorded and the yield per hectare was calculated and expressed in q ha^{-1}.

Seed quality parameters: For seed quality assessment germination test was conducted using the paper towel method as prescribed in ISTA rules (1996), by providing the optimum conditions. The germination counts was made on normal seedlings and expressed in per cent. Vigour indices were computed by adopting the following formula as suggested by Abdul Baki and Anderson (1973) and expressed in number.

Vigour Index I = Germination (%) X Seedling length (cm)

Vigour Index II = Germination (%) X Seedling dry weight (g)

Economics of cowpea seed production: Cost of cultivation was calculated on the basis of prevailing market prices and inputs used in cultivation of cowpea. The produce obtained from different treatments was converted into gross return (Rs. ha^{-1}) by multiplying the produce with the National Seed Corporation sale price of cowpea seed. Net return from the produce was calculated by deducting the cost of cultivation from the gross return. The benefit cost ratio, which implies the return per rupee invested, was worked out for different treatments by dividing the gross return with the corresponding cost of cultivation.

Statistical analysis: Analysis of observation taken on different variable was carried out to know the degree of variation among all the treatments. The results were obtained through analysis of variance (ANOVA) and SPSS software. Means were separated by Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

In general, mean performance for plant stand per plot, plant height (cm), seed yield (q/ha) and yield attributing traits viz., number of pods/plant, pod length (cm), number of seeds/pod, 1000-seed weight was higher in *Kharif* 2012 than 2013 (Table 2). Main plot treatments of inorganic fertilizers M_1 (100% RDF) and M_2 (75% RDF) were at par for all the traits studied during *Kharif* 2012 and 2013, though the numerical superiority was observed under M_1. Similar findings of 25 per cent saving of inorganic fertilizers when used in combination with organic fertilizers were observed by Das *et al.* (2011) in cowpea and Singh *et al.* (2006) in pea. Sub plot integrated nutrient management treatments of biofertilizer seed inoculation alone (S_1, S_2, S_3), in combination with other biofertilizers (S_4, S_5, S_6, S_7) and vermicompost (S_8) differed significantly for plant height, seed yield, number of pods/ plant, length of pod, number of seeds/pod and 1000-seed weight during both years. Treatment S_8 (vermicompost 2.5 t ha^{-1}) gave the significantly higher seed yield (4.76, 4.16 q ha^{-1}) than control (No organic fertilizer) *i.e.* S_9 (3.32, 2.79 q ha^{-1}) and at par with S_7 (4.73, 3.75 q ha^{-1}) followed by S_6 (4.29, 3. 57 q ha^{-1}), S_4 (4.4.29, 3.47 q ha^{-1}), S_5 (4.28, 3.33 q ha^{-1}) and S_1 (3.97, 3.45 q ha^{-1}) in *Kharif* 2012, 2013, respectively. There are number of reports stating that vermicompost is rich in NPK, micronutrients, beneficial soil microbes and also contain 'plant growth hormones and enzymes'. It is scientifically proving as 'miracle growth promoter and also plant protector' from pests and diseases. Vermicompost retains nutrients for long time and while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NKP to plants in shorter time, the vermicompost does (Sinha *et al.* 2009). Das *et al.* (2011) in cowpea and Singh *et al.* (2006) in pea

Table 2: Effect of INM treatments on seed yield and its attributes in Cowpea cv. Pusa Sukomal.

Treatments	Plant Stand/plot		Pl. height (cm)		No. of pods/plant		Pod length (cm)		No. of seeds/pod		1000 Seed Weight (g)		Seed Yield (q/ha)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
100%RDF	68	67	55.6	54.7	12.7	12.3	23.1	22.0	12.0	11.8	100.0	98.7	4.28	3.50
75%RDF	66	65	54.0	52.9	11.7	11.5	22.1	20.6	11.4	11.4	97.6	96.9	3.92	3.34
CD 0.05	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
RZ	67	65	53.9bc	52.3c	12.3b	12.0b	23.1ab	21.9ab	11.5b	11.3b	99.5ab	98.5ab	3.97bc	3.45bc
PSB	66	67	53.2c	51.7c	12.0bc	11.7bc	22.2b	20.7bc	11.4b	11.3b	100.5ab	99.5ab	3.63c	3.26bc
VAM	65	66	52.4c	51.6c	11.7bc	11.5bc	22.5b	20.9bc	11.3b	11.2b	98.3ab	96.7b	3.60c	3.04c
RZ+PSB	66	65	55.3bc	54.5bc	12.3b	12.1ab	23.0ab	21.5b	11.8ab	11.6b	97.7b	97.2b	4.29b	3.47bc
PSB+VAM	67	66	54.1bc	53.9bc	11.9bc	11.7bc	21.7b	20.7bc	11.8ab	11.8ab	100.7a	98.8ab	4.28b	3.33bc
VAM+RZ	68	67	55.8b	54.9b	12.3b	12.1ab	22.9ab	21.6b	12.0ab	11.7ab	97.9b	96.6b	4.29b	3.57b
RZ+PSB+VAM	69	68	57.5ab	56.3ab	12.7ab	12.3ab	23.3ab	21.9ab	12.1ab	11.9ab	98.3ab	98.5ab	4.73a	3.75ab
Vermicompost	68	67	59.8a	58.6a	13.3a	12.7a	23.9a	22.7a	12.5a	12.3a	102.7a	102.0a	4.76a	4.16a
Control	67	66	51.2c	50.8c	11.3c	11.1c	21.1b	20.2c	11.0b	11.0b	93.7b	92.2c	3.32c	2.79c
CD 0.05	**NS**	**NS**	**2.5**	**2.4**	**0.9**	**0.7**	**1.1**	**1.0**	**0.7**	**0.6**	**4.4**	**4.3**	**0.41**	**0.45**

Values in a column followed by the same letter are not significantly different, DMRT, P≤0.05.

reported that for seed yield and its attributes combined use of 75 per cent RDF + Vermicompost + *Rhizobium* + PSB was found significant over control and RDF alone. Number of pods per plant were highest in S_8 (13.3, 12.7) and statistically superior than control (11.3, 11.1) in 2012 and 2013, respectively; and at par with S_7 (12.7) in 2012 and S_7, S_6, S_4 (12.3, 12.1, 12.1, respectively) in 2013. This might be due to integrated application of inorganic fertilizers (100% RDF or 75% RDF) along with vermicompost and biofertilizers which increased the availability and uptake of nutrients for a longer duration. Both vermicompost and biofertilizer are involved in the various endogenous hormonal functions in the plant tissues and responsible for enhanced pollen germination and pollen tube growth and ultimately increased the fruit set as well as increased numbers of fruits per plant (Mal *et al*. 2014). Senthilkumar and Sivagurunathan (2012) observed higher number of pods in cowpea by combined inoculation of *Rhizobium*, Phosphobacteria and *Azospirillum*. Patil *et al*. (2012), Menon *et al*. (2010), Subbarayappa *et al*. (2009) in cowpea, Gorade *et al*. (2014) in green gram and Rajput *et al*. (2009) in French bean reported that combination of organic and inorganic nutrient sources gave significantly better results than when either was used alone with regard to the growth of cowpea plants. Pod length (23.9, 22.7cm), number of seeds per pod (12.5, 12.3), 1000-seed weight (102.7, 102g) and plant height (59.8, 58.6cm) were found maximum under treatment S_8 (vermicompost 2.5 t ha^{-1}) and significantly higher than control, S_9 (21.1, 20.2cm; 11.0, 11.0; 93.7, 92.2g; 51.2, 50.8cm, respectively) and at par with combined use of Rz+PSB+VAM *i.e*. S_7 (23.3,21.9cm; 12.1, 11.9; 98.3, 98.5g; 57.5, 76.3cm, respectively) during *Kharif* 2012 and 2013, respectively. Das *et al*. (2011) also reported that growth parameters the plant height, number of leaves and branches per plant were significantly increased to a greater extent by the treatment 75 per cent RDF + Vermicompost + *Rhizobium* + PSB as compared to RDF alone in cowpea. It is quite evident from the results that dose of inorganic fertilizers could be reduced to 75 per cent under integrated nutrient management practices of using vermicompost (2.5 tha^{-1} as band application in soil) or combination of biofertilizers (Rz+PSB) seed inoculation and Vesicular Arbuscular Mycorhizae (VAM 10 Kg ha^{-1} as band application in soil).

In general, mean performance for seed germination (%) was higher in *Kharif* 2013 than 2012 but the trend is reversed for other seed quality parameters viz., seedling length (cm) and seedling dry weight (g) (Table 3). There was non-significant differences for main plot treatments of inorganic fertilizers M_1 (100% RDF) and M_2 (75% RDF) for all the seed quality parameters studied during *Kharif* 2012 and 2013. Sub plot INM treatments including control (No organic fertilizer) differed significantly for the seed quality parameters *viz.*, seed germination (%), seedling length (cm), seedling dry weight (g), seed vigour index I and seed vigour index II during both the years. Application of 2.5 tha^{-1} vermicompost, treatment S_8, gave significantly higher seed germination percentage (89.8, 93.8), vigour index I (2272, 2392) and II (33.70, 34.31) than control, S_9 (83.8, 85.3; 1835, 1621; 26.25, 24.51, respectively) during *Kharif* 2012, 2013, respectively. S_8 was at par with S_7 (Rz+PSB+VAM), S_6 (Rz+VAM) S_4 (Rz+PSB) and S_5 (PSB+VAM) in 2012 and S_7 in 2013 for seed germination; and at par with S_7, S_6, S_4 and S_1 (Rz) in 2012 and S_7 in 2013for seed vigour index I. The enhanced seed germination and seed vigour indices may be due to the favourable C/N ratio and better availability of nutrients. Similar findings regarding integrated use of different chemical and biofertilizers and vermicompost showed significant increase in per cent germination, root-shoot length of seedlings and SVI compared to non-treated plants. It has already been reported by Senthilkumar and Sivagurunathan (2012) in cowpea, Dar *et al*. (2010) in okra, Mishra and Jain (2013) in *Andrographis paniculata* (Kalmegh), Assiouty and Sedera (2005) in spinach; Shashidhara (2000) in chilli; Firuzsalari *et al*. (2012) in corn. It is evident from the results

Table 3: Effect of INM treatments on seed quality parameters in cowpea.

Treatments	Seed Germination (%)		Seedling length (cm)		Seedling dry weight (g)		Seed Vigour Index I		Seed Vigour Index II	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
100%RDF	87.4	90.0	24.3	22.6	0.342	0.325	2124	2034	29.91	29.24
75%RDF	85.1	88.6	23.1	21.2	0.330	0.314	1966	1878	28.08	27.85
CD 0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
RZ	85.5b	89.0bc	24.2b	21.1d	0.351b	0.323c	2069ab	1878bc	29.97c	28.73c
PSB	83.3b	88.0bc	23.6b	20.1e	0.326c	0.301d	1966b	1769c	27.14cd	26.47d
VAM	82.9b	87.5c	23.6b	19.9e	0.322cd	0.300d	1956b	1741c	26.65d	26.28d
RZ+PSB	87.9ab	90.0bc	23.7b	22.9c	0.320cd	0.320c	2083ab	2061b	28.08c	28.78c
PSB+VAM	87.0ab	88.5bc	22.7c	21.5d	0.302d	0.307d	1975b	1903bc	26.30d	27.13d
VAM+RZ	88.0ab	90.3b	24.1b	22.9c	0.353b	0.329c	2121ab	2068b	31.06bc	29.74c
RZ+PSB+VAM	88.3ab	91.3ab	24.0b	24.4b	0.364ab	0.344b	2119ab	2228ab	32.14b	31.43b
Vermicompost	89.8a	93.8a	25.3a	25.5a	0.375a	0.366a	2272a	2392a	33.70a	34.31a
Control	83.8b	85.3c	21.9d	19.0f	0.313d	0.287e	1835b	1621c	26.25d	24.51e
CD 0.05	3.0	2.5	0.7	0.5	0.012	0.012	271	254	1.2	1.18

Values in a column followed by the same letter are not significantly different, DMRT, P≤0.05.

that application of vermicompost @ 2.5 t ha^{-1} and inoculation with biofertilizers (Rz+PSB) + VAM application showed positive effect on seed quality.

There is a great variation in economics of cowpea cultivation due to application of different levels of chemical fertilizers in combination with vermicompost, biofertilizers and VAM was observed (Table 4). The average total cost of cultivation in cowpea cv. Pusa Sukomal varied between Rs. 32,750 to Rs. 40,175 ha^{-1} under different INM treatments. Combined use of 100% RDF or NPK as inorganic fertilizers with vermicompost 2.5 t ha^{-1} recorded the highest mean gross return (Rs. 72,960 ha^{-1}) against control, 100% RDF (Rs. 50080 ha^{-1}) followed by combination of 100% RDF, bio-inoculants (Rz+PSB) and VAM 10 Kg ha^{-1} (Rs. 70,960 ha^{-1}), 75% RDF and vermicompost 2.5 t ha^{-1} (Rs. 69,840 ha^{-1}), 100% RDF, bio-inoculants (Rz+PSB) and VAM 10 Kg ha^{-1} (Rs. 64,800 ha^{-1}); while the lowest (Rs. 47,520 ha^{-1}) where only 75% NPK was applied. The highest mean net returns (Rs. 36,110 ha^{-1}) was obtained with conjunctive use of inorganic fertilizer (100% NPK as chemical fertilizers), bio-inoculants and VAM against control (Rs. 16,555 ha^{-1}), followed by 100% NPK plus vermicompost treatment (Rs. 32,875 ha^{-1}). However, the lowest mean net return of Rs. 14,770 ha^{-1} was obtained with 75% RDF treatment. Similar findings of enhanced profitability by use of INM treatments was reported by Subbarayappa *et al.* (2009) in cowpea and Rajput *et al.* (2009) in French bean. Maximum mean benefit cost ratio of 2.04 was obtained by combined application 100% RDF, biofertilizers inoculation (Rz+PSB) and VAM @ 10 Kg ha^{-1} against 1.49 of control. Among the various combinations of biofertilizers with 75% RDF, biofertilizers inoculation (Rz+PSB) and VAM @ 10 Kg ha^{-1} gave the best

Table 4: Economics of cowpea seed production as influenced by INM treatments.

Treatments	Total Expenditure (Rs/ha)			Gross Return (Rs/ha)			Net Return (Rs/ha)			Benefit Cost Ratio		
	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
100% RDF+RZ	32850	34500	33675	64480	56960	60720	31630	22460	27045	1.96	1.65	1.80
100% RDF+PSB	32850	34500	33675	60960	52960	56960	28110	18460	23285	1.86	1.54	1.69
100% RDF+VAM	33700	35400	34550	54880	48960	51920	21180	13560	17370	1.63	1.38	1.50
100% RDF+RZ+PSB	33000	34650	33825	76000	55360	65680	43000	20710	31855	2.30	1.60	1.94
100% RDF+PSB+VAM	33850	35550	34700	74400	54720	64560	40550	19170	29860	2.20	1.54	1.86
100% RDF+VAM+RZ	33850	35550	34700	72960	59200	66080	39110	23650	31380	2.16	1.67	1.90
100% RDF+RZ+PSB+VAM	34000	35700	34850	79200	62720	70960	45200	27020	36110	2.33	1.76	2.04
100% RDF+Vermicompost	39200	41150	40175	78560	67360	72960	39360	26210	32785	2.00	1.64	1.82
100% RDF (Control)	32700	34350	33525	54560	45600	50080	21860	11250	16555	1.67	1.33	1.49
75% RDF+RZ	32100	33700	32900	62560	53440	58000	30460	19740	25100	1.95	1.59	1.76
75% RDF+PSB	32100	33700	32900	55040	51520	53280	22940	17820	20380	1.71	1.53	1.62
75% RDF+VAM	32950	34600	33775	60320	48320	54320	27370	13720	20545	1.83	1.40	1.61
75% RDF+RZ+PSB	32250	33850	33050	61280	55680	58480	29030	21830	25430	1.90	1.64	1.77
75% RDF+PSB+VAM	33100	34750	33925	62560	51840	57200	29460	17090	23275	1.89	1.49	1.69
75% RDF+VAM+RZ	33100	34750	33925	64480	54880	59680	31380	20130	25755	1.95	1.58	1.76
75% RDF+RZ+PSB+VAM	33250	34900	34075	72160	57440	64800	38910	22540	30725	2.17	1.65	1.90
75% RDF+Vermicompost	38450	40375	39413	73760	65920	69840	35310	25545	30428	1.92	1.63	1.77
75%RDF	31950	33550	32750	51520	43520	47520	19570	9970	14770	1.61	1.30	1.45

B:C ratio of 1.90. B:C ratio of combination treatments of 100% RDF and 75% RDF with vermicompost (1.82 and 1.77, respectively) were lower due to significant extra cost of the vermicompost and its application in the field.

From the above results, it is concluded that use of inorganic fertilizers can be reduced to 75% without significant effect on seed yield. Integrated use of inorganic fertilizers and vermicompost 2.5 t ha^{-1} proved to be the best combination during both years of experiment as it gave higher seed yield (43%, 49%), germination (6.0%, 8.5%), vigour index I (24%, 48%), vigour index II (28%, 40%) as compare to the control (100% RDF) during *Kharif* 2012 and 2013, respectively. It was at par with treatment combination of inorganic fertilizers with biofertilizers inoculation (Rz+PSB) and VAM @ 10 Kg ha^{-1} for seed yield and quality parameters. This treatment was found to be the most remunerative with average net return of Rs. 36,110 and Rs. 30725 ha^{-1} with 100% and 75% RDF, respectively.

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