Research Article

Growth and Yield Maximization of Chickpea (*Cicer arietinum*) Through Integrated Nutrient Management Applied to Rice-Chickpea Cropping System

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Abstract | The chickpea is a major legume crop of Pakistan cultivated under rice-chickpea cropping system. Integrated nutrient management is important for higher crop yields and sustainable agriculture. A field experiment was conducted to study the residual effect of integrated nutrient management on growth and yield of chickpea crop. The treatments included control (no organic or inorganic fertilizer), NPK (36-72-0 kg ha^{-1}), NPK (36-72-20 kg ha^{-1}), Farmyard Manure (20 t ha^{-1}), Poultry Manure (20 t ha^{-1}), NPK (18-36-10 kg ha^{-1}) + FYM (20 t ha^{-1}), NPK (18-36-10 kg ha^{-1}) + P.M (20 t ha^{-1}), NPK (36-72-20 kg ha^{-1}) + FYM (20 t ha^{-1}), NPK (36-72-20 kg ha^{-1}) + P.M (20 t ha^{-1}), NPK (18-36-10 kg ha^{-1}) + FYM (10 t ha^{-1}), and NPK (18-36-10 kg ha^{-1}) + P.M (10 t ha^{-1}). All the relevant agronomic observations and chemical analysis of the soil and plant samples were recorded. The application of organic sources of farmyard manure and poultry manure in combination with inorganic NPK fertilizers had shown positive effect on chickpea plant height, number of branches plant^{-1}, number of pods plant^{-1} and seed index. The growth and yield of chickpea significantly increased with the collective application of chemical fertilizers and organic manures. It is concluded that the application of half of recommended dose of NKP (18-36-10 kg ha^{-1}) in combination with poultry manure or farmyard manure at the rate of 20 t ha^{-1} was found best combination for higher chickpea crop yields in compare to other levels of fertilizers.

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Introduction

The pulses in Pakistan are cultivated on an area of 1.492 million hectares, with a production of 983,000 tons. Gram is an important winter pulse crop of Pakistan and during the year 2011-12, the gram was cultivated on an area of 1055 thousand hectares with a production of 291 thousand tons indicating 41.3 percent decrease in production against last year crop due to unfavourable weather conditions. For the years 2010-11, and during the year 2009-2010, the chick pea production was 5 M t against 5.6 M t of previous year, viewing a fall of 6.9 % for the period of 2010-11 largely due to unfavorable climate (GOP, 2012). The balanced nutrient application for crop production is essential because their imbalanced use reduced crop yields (Naruka et al., 2000). Silberbush (2002) stated that all sources of nutrients may be applied to crops and recommended that foliar fertilization may extensively be applied to overcome nutritional shortage in plants happened by inappropriate application of nutrients to roots (Tumbare et al., 1999). Thus, the integration of nutrients on the basis of soil texture, fertility level and ecological conditions is of great economic importance.

Exhaustive agriculture with incredibly elevated nutrient revenue in soil plant environment attached to small and imbalanced fertilization resulted in worsening of indigenous soil fertility and posed a stern hazard to extended sustainability of crop production. Studies on various cropping systems had noticeably showed that sole application of organic or synthetic fertilizers could not maintain towering yield of crops in intensive cropping systems. The integrated use of organic and inorganic fertilizers could help to uphold crop yield strength through alleviation of deficiencies of nutrients, increasing the applied nutrients efficiency and offering the favorable soil atmosphere (Muddukumar, 2007). The use of organic manures which were traditionally important nutrient resources declined substantially. Added to this, excessive and continuous use of a few inorganic fertilizers in unbalanced proportion resulted in the deficiency of micronutrients besides diminishing soil fertility and resulting in unsustainable crop yield. Among the various organic manures, the compost produced by earthworms (vermicompost) and FYM are main sources of macro and micronutrients.

Despite the fact that the chemical inputs in farming is unavoidable to congregate the mounting demand for foodstuff in planet, there are chances in chosen crops and niche areas where organic production can be supported to tape the domestic export market (Karmakar et al., 2007). Sumathi and Rao (2007) found that application of bio fertilizers along with FYM and inorganic nitrogen resulted in significant increase in the values of all the growth and yield components in sunflower; while Sumathi et al. (2007) indicated that replacement of 25% N by bio fertilizers and FYM resulted in improved crop growth and production. Baradhan et al. (2006) applied bio fertilizers and N in various sources and obtained higher sunflower yield and oil content as compared to straight NPK fertilizers.

Integrated nutrient management (INM) is very important in crop production. Many of our production problems (increasing cost, declining yield) can be traced to improper and inefficient use of nutrients. The INM takes into consideration the nutrient cycle involving soils, crops and livestock, nutrient deficiencies, organic recycling, conjunctive use of organic manures and mineral fertilizers and biological nitrogen fixing potential (Kumar and Sreenivasulu, 2004). The INM looks for to augment agricultural production and preserve the atmosphere for upcoming generation. It is an approach through which organic and inorganic nutrient elements are applied jointly to soil for superior crop production, soil deprivation prevention, and to meet future food supply requirements (Gruhn et al., 2000). Proper fertilization and application methods like incorporation in splits at phenological phases of crop is important. Slow released and coated fertilizers as well as combined application of organic and inorganic fertilizers are also important for enhanced crop production. Use of indigenous sources such as press mud, granulated compost material and mixing urea with neem cake in ratio of 5:1 could result in higher nitrogen use efficiency. Long-term fertilizer experiments have revealed that the efficiency of P and K increased appreciably when both were applied in conjunction, suggesting their positive interactions (Mahajan et al., 2003; Kumar and Sreenivasulu, 2004).

Combined application of 50, 100 and 150% of the recommended rates of inorganic nitrogen, phosphorus and potassium with farmyard manure and in some cases zinc, improved crop yield compared to straight fertilizers (Roy et al., 2001). The INM system aims at achieving efficient use of chemical fertilizers in conjunction with organic manures. Long term fertilizer experiments involving intensive cereal based cropping systems revealed a declining trend in productivity even with the application of recommended levels of N, P and K fertilizers (Mahajan et al., 2002; Mahajan and Sharma, 2005). The crop productivity increases from the combined application of chemical fertilizers and organic manures. Such combination contributed to the improvement of physical, chemical and biological properties and soil organic matter and nutrient status. Looking in to the above facts a study was designed to explore chickpea response under INM.

Materials and Methods

Field experiment was conducted in a four replicated randomized complete block design (RCBD) at Quaid-e-Awam Agriculture Research Institute (QAARI) Larkana, Sindh Pakistan. These plots were previously under rice crop cultivation. The first season rice crop was transplanted in third week of June 2012 and crop duration was 110 days. The second season chickpea crop was sown in first week of November 2012 after the interval period of 30 days, during this time gap between first and second season crop soil was fallow. During the chickpea growing period rainfall was 25 mm and average temperature was 22^0C. Commercial chickpea variety DG-92 was used. The crop was sown by seed drill at a row spacing of 30 cm. The seed rate was 80 kg ha^{-1}. Organic (Farmyard manure and Poultry manure) and inorganic fertilizers were applied at the time of rice transplanting and the residual effects of these fertilizers were studied on second season chickpea crop. Farmyard manure used in study contains 0.5 per cent N, 0.2 per cent P_2O_5 and 0.5 per cent K_2O, and the poultry manure nutrient content was 8 kg N /ton- 10 kg P_2O_5/ton and 7 kg K_2O/ton.

The fertilizers dozes were applied at the rates of control (no organic or inorganic fertilizer), NPK (36-72-0 kg ha^{-1}), NPK (36-72-20 kg ha^{-1}), Farmyard Manure (20 t ha^{-1}), Poultry Manure (20 t ha^{-1}), NPK (18-36-10 kg ha^{-1}) + FYM (20 t ha^{-1}), NPK (18-36-10 kg ha^{-1}) + P.M (20 t ha^{-1}), NPK (36-72-20 kg ha^{-1}) + FYM (20 t ha^{-1}), NPK (36-72-20 kg ha^{-1}) + P.M (20 t ha^{-1}), NPK (18-36-10 kg ha^{-1}) + FYM (10 t ha^{-1}), and NPK (18-36-10 kg ha^{-1}) + P.M (10 t ha^{-1}). Sources of fertilizers were urea, Di-ammonium phosphate (DAP) and sulphate of potash (SOP).

All other agronomic practices were kept normal and uniform for all treatments. Three plants were selected at random from each plot for individual plant observations like plant height, number of branches $plant^{-1}$, and number of pods $plant^{-1}$. Two samples of 1000 grains were taken at random from each plot for recording 1000-grain weight. Total plants of each plot were harvested, sun-dried, threshed with sticks on the cloth sheet for recording seed yield $plot^{-1}$ and converted into seed yield per hectare.

Soil sampling and analysis

The soil belongs to great group fluvaquents with parent material recent alluvium. The soil sampling was done with the help of stainless steel auger and samples were collected in plastic bags. The soil samples were collected from two depths: 0-15 cm and 16-30 cm. After properly labelling all the samples were brought to the departmental laboratory. Samples were air-dried ground and passed through 2 mm sieve and stored in plastic bags. Necessary care was taken to avoid contamination during sample preparation. All prepared samples were analysed for the determinations before sowing and after harvest of the crop. Electrical conductivity was determined with the help of portable conductivity meter (Hana Model-8733, Germany) and pH of soil water extract was determined by portable pH meter (Orion (ISE) Model-SA-720 USA) using buffers of pH 4.0 and pH 9.0 (Rowel, 1994). Bouyoucos Hydrometer method was adopted for the determination of soil texture (Kanwar and Chopra, 1959), and Walkley-Black method was adopted for the determinations of organic matter (%) in soil (Jackson, 1958). Total N in soil was measured through Kjeldahl's method (Jackson, 1958). Available P was determined using Spectrophotometer (Model Specord-200 PC. Analytik Jen, Germany) (Soltanpour and Schwab, 1977) whereas, extractable K was determined with the help of Flame photometer- Jenway UK Model No. PFP-7 (Soltanpour and Schwab, 1977) (Table 1).

Table 1: *Physico-chemical properties of soil before sowing of chickpea*

S. No.	Properties		Values	
			0-15 cm	16-30 cm
1.	Texture	Sand (%)	34.3	36
		Silt (%)	33.4	36.5
		Clay (%)	32.3	35.5
	Textural Class		**Clay Loam**	**Clay Loam**
2.	EC (dS m^{-1})		0.81	0.62
3.	pH(1:5 soil- water extract)		7.75	7.80
4.	Organic matter (%)		0.97	0.59
5.	Calcium carbonate (%)		9.44	7.81
6.	Total N (%)		0.049	0.030
7.	Available P (mg kg^{-1})		3.68	2.69
8.	Extractable K (mg kg^{-1})		203.4	175.9

Plant analysis

At harvest five randomly plants were selected from each treatment and processed for the determination of NPK content. Total N was analysed using the micro kjeldahl digestion method (Bremner, 1960). Phosphorus in plant was determined spectrophotometerically from the digested material by per chloric nitric acid mixture (Jackson, 1958). AB-DTPA extractable potassium was measured by acid wet digestion method ($HCLO_3/HNO_3$) using flame photometer (Soltanpour and Schwab, 1977).

Statistical analysis

The data collected were analysed with one way ANO-

VA by MSTATC. For treatment mean discrimination, Duncan's Multiple Range Test (DMRT) was applied at 0.05 alpha levels (Gomez and Gomez, 1984).

Results and Discussion

Effect of integrated plant nutrient management on agronomic traits of chickpea

Plant height (cm)

Statistical analysis of the data showed that integrated plant nutrient management has a significant ($p< 0.05$) influence on plant height. The results of the experiment showed that integrated use of FYM or poultry manure with in-organic fertilizers significantly recorded higher plant height (Table 2). The highest mean plant height (57.5 and 56.5 cm) was recorded in plots where half of the recommended dose of NPK (18-36-10 kg) + 20 t ha^{-1} poultry manure (PM) and full recommended dose of NPK (36-72-20 kg ha^{-1}) was applied. Both the treatments were statistically non-significant with each other. The lowest plant height (28.8 cm) was observed in control plots.

Table 2: *Plant height (cm) of chickpea under integrated plant nutrient management applied to rice-chickpea cropping system*

Treatments	Plant height(cm)
NPK 0-0-0 kg ha^{-1}	28.8g
NPK 36-72-0 kg ha^{-1}	50.0d
NPK 36-72-20 kg ha^{-1}	56.5ab
FYM 20 t ha^{-1}	31.8f
PM 20 t ha^{-1}	33.0f
NPK 18-36-10 kg ha^{-1} +FYM @ 20 t ha^{-1}	55.0b
NPK 18-36-10 kg ha^{-1} +PM @ 20 t ha^{-1}	57.5a
NPK 36-72-20 kg ha^{-1} +FYM @ 20 t ha^{-1}	50.0d
NPK 36-72-20 kg ha^{-1} +PM @ 20 t ha^{-1}	52.5c
NPK 8-36-10 kg ha^{-1} +FYM @ 10 t ha^{-1}	44.5e
NPK 18-36-10 kg ha^{-1} +PM @ 10 t ha^{-1}	46.5e
SE	0.797
LSD 5%	2.301

Means with the same letter (s) are not significantly different at P= 0.05 level (Duncan's multiple range test); **NPK**: *Nitrogen, Phosphorus, Potassium;* **FYM**: *Farm Yard Manure;* **PM**: *Poultry Manure*

Number of branches plant^{-1}

The results regarding number of branches plant^{-1} as affected by integrated plant nutrient management on the chickpea revealed that highest mean number of branches palnt^{-1} (4.18, 4.17 and 4.15) was noted in plots which were treated with half of the recommended NPK (18-36-10 kg ha^{-1}) +20 t ha^{-1} PM, recommended NPK (36-72-20 kg ha^{-1}) and half of the recommended NPK + FYM (20 t ha^{-1}), respectively (Table 3). All these three treatments were statistically similar with each other. The second highest number of branches plant^{-1} (3.67 and 3.65) was recorded in treatments where full dose of NPK (36-72-20 kg ha^{-1}) + P.M @ 20 t ha^{-1} and NPK (36-72-20 kg ha^{-1}) + FYM @ 20 t ha^{-1} was applied, respectively. The lowest number of branches plant^{-1} (2.01) was observed in control plots.

Table 3: *Number of branches plant^{-1} of chickpea under integrated plant nutrient management applied to rice-chickpea cropping system*

Treatments	No. of Branches Plant^{-1}
NPK 0-0-0 kg ha^{-1}	2.01e
NPK 36-72-0 kg ha^{-1}	3.66b
NPK 36-72-20 kg ha^{-1}	4.17a
FYM 20 t ha^{-1}	2.10d
PM 20 t ha^{-1}	2.14d
NPK 18-36-10 kg ha^{-1} + FYM @ 20 t ha^{-1}	4.15a
NPK 18-36-10 kg ha^{-1} + PM @ 20 t ha^{-1}	4.18a
NPK 36-72-20 kg ha^{-1} + FYM @ 20 t ha^{-1}	3.65b
NPK 36-72-20 kg ha^{-1} + PM @ 20 t ha^{-1}	3.67b
NPK 8-36-10 kg ha^{-1} + FYM @ 10 t ha^{-1}	2.70c
NPK 18-36-10 kg ha^{-1} + PM @ 10 t ha^{-1}	2.73c
SE	0.01581
LSD 5%	0.04567

Means with the same letter (s) are not significantly different at P= 0.05 level (Duncan's multiple range test); **NPK**: *Nitrogen, Phosphorus, Potassium;* **FYM**: *Farm Yard Manure;* **PM**: *Poultry Manure*

Number of pods plant^{-1}

The results of the study revealed that the integrated use of organic manure with inorganic fertilizer had significant effect on number of pods plant^{-1}. According to the results the integrated use of the FYM or P.M with inorganic fertilizer recorded higher number of pods plant^{-1} (Table 4). The highest mean number of pods plant^{-1} (66.0) was observed in plots where half dose of NPK (18-36-10 kg) was added along with P.M @ 20 t ha^{-1}. The lowest number (23.7) of pods plant^{-1} was observed in control plots.

Seed index (g)

According to the research conducted on chickpea plant, the integrated use of the poultry manure in combination with inorganic fertilizer significantly recorded higher values of seed index (Table 5). The highest mean seed index (240.0 and 247.0) was recorded in plots where half dose of NPK (18-36-10 kg ha-^{1}) along with P.M @ 20 t ha^{-1} was applied. The results indicate that half dose of NPK with P.M @ 20 t ha^{-1} was right combination for increasing the seed index of the plant, where as the full dose of NPK with FYM or P.M at 20 t ha^{-1} significantly reduced seed index of the plant. The lowest seed index of the plants (112.7 g) was recorded in control plot.

Table 4: *Number of pods plant^{-1} of chickpea under integrated plant nutrient management applied to rice-chickpea cropping system*

Treatments	No. of pods plant^{-1}
NPK 0-0-0 kg ha^{-1}	23.75f
NPK 36-72-0 kg ha^{-1}	57.0 bc
NPK 36-72-20 kg ha^{-1}	65.0 ab
FYM 20 t ha^{-1}	46.00e
PM 20 t ha^{-1}	47.00de
NPK 18-36-10 kg ha^{-1}+FYM @ 20 t ha^{-1}	64.00ab
NPK 18-36-10 kg ha^{-1} +PM @ 20 t ha^{-1}	66.00a
NPK 36-72-20 kg ha^{-1}+FYM @ 20 t ha^{-1}	58.30abc
NPK 36-72-20 kg ha^{-1} +PM @ 20 t ha^{-1}	59.00abc
NPK 8-36-10 kg ha^{-1} +FYM @ 10 t ha^{-1}	54.00d
NPK 18-36-10 kg ha^{-1}+PM @ 10 t ha^{-1}	55.00c
SE	2.612
LSD 5%	7.545

Means with the same letter (s) are not significantly different at P= 0.05 level (Duncan's multiple range test); **NPK**: *Nitrogen, Phosphorus, Potassium;* **FYM**: *Farm Yard Manure;* **PM**: *Poultry Manure*

Seed yield (kg ha^{-1})

The integrated use of organic manure with inorganic fertilizer increased the seed yield of the crop (Table 6). The highest mean seed yield (1582 kg ha^{-1}) was recorded in plots where half dose of NPK (18-36-20 kg ha^{-1}) was applied along with PM. The results of the study further indicated that plants treated with full dose of NPK (36-27-20 kg) in combination with FYM or P.M @ 20 t ha^{-1} had lower seed yield (1321 and 1346 kg ha^{-1}). However, the lowest crop seed yield (501.0 kg ha^{-1}) was recorded in control plots.

Effect of integrated plant nutrient management on nutrient contents of soil

The results of the study presented in Table 7 showed that maximum contents of N were observed in plots treated with NP (36-72-0 kg ha^{-1}), NPK (36-72-20 kg ha^{-1}), NPK (36-72-20 kg ha^{-1}) + FYM (20 t ha^{-1}), and NPK (36-72-20 kg ha^{-1}) + PM (20 t ha^{-1}). The highest soil P and K were observed in plots treated with NPK (36-72-20 kg ha^{-1}) + PM (20 t ha^{-1}). The highest organic matter contents were recorded in plots fertilized with full dose of organic manures. However, minimum N (0.12%), P (2.04 mg kg^{-1}) and K (100.9

Table 5: *Seed index (1000- seed weight (g)) of chickpea under integrated plant nutrient management applied to rice-chickpea cropping system*

Treatments	Seed index (g)
NPK 0-0-0 kg ha^{-1}	112.7 j
NPK 36-72-0 kg ha^{-1}	233.0e
NPK 36-72-20 kg ha^{-1}	242.0b
FYM 20 t ha^{-1}	172.5 i
PM 20 t ha^{-1}	180.8h
NPK 18-36-10 kg ha^{-1} + FYM @ 20 t ha^{-1}	240.0c
NPK 18-36-10 kg ha^{-1} + PM @ 20 t ha^{-1}	247.0a
NPK 36-72-20 kg ha^{-1} + FYM @ 20 t ha^{-1}	234.0e
NPK 36-72-20 kg ha^{-1} + PM @ 20 t ha^{-1}	237.4d
NPK 8-36-10 kg ha^{-1} + FYM @ 10 t ha^{-1}	210.9g
NPK 18-36-10 kg ha^{-1} + PM @ 10 t ha^{-1}	214.0f
SE	0.584
LSD 5%	1.687

Means with the same letter (s) are not significantly different at P= 0.05 level (Duncan's multiple range test); **NPK**: *Nitrogen, Phosphorus, Potassium;* **FYM**: *Farm Yard Manure;* **PM**: *Poultry Manure*

Table 6: *Seed yield (kg ha^{-1}) of chickpea under integrated plant nutrient management applied to rice-chickpea cropping system*

Treatments	Seed Yield (kg ha^{-1})
NPK 0-0-0 kg ha^{-1}	501.0i
NPK 36-72-0 kg ha^{-1}	1323.0 d
NPK 36-72-20 kg ha^{-1}	1531.0b
FYM 20 t ha^{-1}	901.5h
PM 20 t ha^{-1}	915.0g
NPK 18-36-10 kg ha^{-1} + FYM @ 20 t ha^{-1}	1529.0 b
NPK 18-36-10 kg ha^{-1} + PM @ 20 t ha^{-1}	1582.0a
NPK 36-72-20 kg ha^{-1} + FYM @ 20 t ha^{-1}	1321.0d
NPK 36-72-20 kg ha^{-1} + PM @ 20 t ha^{-1}	1346.0c
NPK 8-36-10 kg ha^{-1} + FYM @ 10 t ha^{-1}	1101.0f
NPK 18-36-10 kg ha^{-1} + PM @ 10 t ha^{-1}	1113.0e
SE	1.645
LSD5%	4.751

Means with the same letter (s) are not significantly different at P= 0.05 level (Duncan's multiple range test); **NPK**: *Nitrogen, Phosphorus, Potassium;* **FYM**: *Farm Yard Manure;* **PM**: *Poultry Manure*

Table 7: *Nutrient content of soil after harvest of chickpea under integrated plant nutrient management applied to rice-chickpea cropping system*

Treatments	Soil N	Soil P	Soil K	Soil OM
	%	mg kg-1	mg kg-1	%
NPK 0-0-0 kg ha-1	0.120e	2.04i	100.9g	0.48c
NPK 36-72-0 kg ha-1	0.463a	9.11c	102.3g	0.48c
NPK 36-72-20 kg ha-1	0.470a	9.12c	189.0b	0.46c
FYM 20 t ha-1	0.250d	5.39h	132.1f	1.24a
PM 20 t ha-1	0.250d	5.41h	134.6e	1.192a
NPK 18-36-10 kg ha-1 + FYM @ 20 t ha-1	0.350b	8.41e	168.3c	1.29a
NPK 18-36-10 kg ha-1 + PM @ 20 t ha-1	0.360bc	8.501	169.4c	1.19a
NPK 36-72-20 kg ha-1 + FYM @ 20 t ha-1	0.468a	10.9b	188.6b	1.27a
NPK 36-72-20 kg ha-1 + PM @ 20 t ha-1	0.470a	11.21a	190.5a	1.23a
NPK 8-36-10 kg ha-1 + FYM @ 10 t ha-1	0.340c	8.20g	165.1d	0.96b
NPK 18-36-10 kg ha-1 + PM @ 10 t ha-1	0.340c	8.31f	166.3d	0.84b
SE	0.0050	0.0158	0.497	0.0445
LSD 5%	0.0144	0.0457	1.435	0.129

Means with the same letter (s) are not significantly different at P= 0.05 level (Duncan's multiple range test); **NPK***: Nitrogen, Phosphorus, Potassium;* **FYM***: Farm Yard Manure;* **PM***: Poultry Manure*

Table 8: *Nutrient concentration in chickpea plant under integrated plant nutrient management applied to rice-chickpea cropping system*

Treatments	(%) Plant N	(%) Plant P	(%) Plant K
NPK 0-0-0 kg ha-1	1.120d	0.1225f	1.38j
NPK 36-72-0 kg ha-1	4.330a	0.4600b	1.400i
NPK 36-72-20 kg ha-1	4.350a	0.4700ab	3.300b
FYM 20 t ha-1	2.900c	0.2450e	2.050h
PM 20 t ha-1	2.920c	0.2550e	2.080g
NPK 18-36-10 kg ha-1 + FYM @ 20 t ha-1	3.930b	0.3600c	2.940d
NPK 18-36-10 kg ha-1 + PM @ 20 t ha-1	3.950b	0.3600c	2.980c
NPK 36-72-20 kg ha-1 + FYM @ 20 t ha-1	4.360a	0.4700ab	3.310b
NPK 36-72-20 kg ha-1 + PM @ 20 t ha-1	4.380a	0.4800a	3.350a
NPK 8-36-10 kg ha-1 + FYM @ 10 t ha-1	3.880b	0.3400d	2.900f
NPK 18-36-10 kg ha-1 + PM @ 10 t ha-1	3.900b	0.3425d	2.920 e
SE	0.0224	0.005	0.005
LSD 5%	0.0646	0.014	0.014

Means with the same letter (s) are not significantly different at P= 0.05 level (Duncan's multiple range test); **NPK***: Nitrogen, Phosphorus, Potassium;* **FYM***: Farm Yard Manure;* **PM***: Poultry Manure*

mg kg-1), were observed in un-fertilized plots.

Soil organic matter

The results for SOM revealed similar trend as in case of NPK that addition of organic manures increased the contents of SOM and highest contents were found in soil with highest rate of organic manure application (Table 7). Maximum SOM content was recorded with the application of NPK along with PM or FYM @ 20 t ha-1. Minimum SOM contents (0.45%) were observed in unfertilized plots.

Effect of integrated plant nutrient management on nutrient contents of plant

Data regarding N concentration shown in Table 8 revealed that maximum N contents were N contents were obtained from the plots treated with NPK (36-72-0 kg ha-1), NPK (36-72-20 kg ha-1) + FYM (20 t ha-1) and NPK (36-72-20 kg ha-1) + PM (20 t ha-1). However, minimum N was observed in plots where no manure or fertilizer was added. Regarding P and K concentration in chickpea plants, maximum P (0.48%) and K (3.35%) were recorded with the application of 36-72-

20 kg NPK+ P.M @ 20 t ha^{-1}. Minimum P (0.12%) and K (1.38%) were recorded in control treatments.

In this study, recommended NPK (36-72-40 kg ha^{-1}), or half dose of NPK (18-36-10 kg ha^{-1}) + poultry manure (P.M) or farmyard manure (FYM) @ 20 t ha^{-1} increased plant height, number of branches and pods plant^{-1}, seed index and seed yield of chickpea. These findings are in conformity with those of Kumar et al. (2004) for French bean. The increase in growth and yield traits of chickpea due to the application of nutrients through organic sources might be due to higher availability of nitrogen and potassium to plants, besides increased water holding capacity and other physico-chemical and biological properties of soil. If only macronutrients are applied to the crop, the shortage of a number of additional secondary and micronutrients will emerge in different crops. Hence, those sources of nutrients are supposed to apply which possess various nutrients. This will definitely results towering crop yields and maintain soil health for longer period. Farmyard manure and poultry manure are good example of such nutrients (Singh et al., 2012). Other researchers (Devi and Singh, 2005; Prasad et al., 2005; Singh et al., 2010) also reported beneficial effect of FYM on chickpea productivity.

Nitrogen, phosphorus and potassium application influenced plant growth and yield attributes of chickpea, which were higher with higher dose of nutrients. Macronutrient nutrition is known to improve yield in chickpea (Devi and Singh, 2005). Mineral nitrogen increase water use efficiency in chickpea (Bahavar et al., 2009) and therefore, apart from supplying nutrition it could benefit the crop indirectly also. Increase in grain yield of chickpea with the application of various nutrients could be due to improvement in plant growth and yield attributes such as pods plant^{-1} (Khan and Qureshi, 2001; Mishra et al., 2002; Noor et al., 2003; Ciftci et al., 2004), seeds pod^{-1} and seed index. Apart from chemical nutrients the other sources such as farmyard manure and poultry manure should be used as these have beneficial residual effects on the succeeding crops that ensures sustainable crop production. Tolanur and Badanur (2003) studied the effect of integrated use of organic manure and fertilizer N on the productivity of chickpea in Vertisol of Bijapur. They concluded that integration of fertilizer N with different organic manure such as FYM, sustained the productivity of chick pea and significantly improved the organic carbon, available N, P and K status of Vertisol after harvest.

Conclusions

The application of half of the recommended dose of NPK in conjunction with poultry manure or farmyard manure @ 20 tons ha^{-1} was found best combination for higher crop yield. This combination of fertilizers has improved the studied agronomic traits, soil organic matter content and macronutrients status of the soil.

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