ANALYSIS Vol. 4, January, 2018

ISSN 2347–3819 EISSN 2347–386X

DISCOVERY Agriculture

Substitution of chemical fertilizers with organic manure and biofertilizers in Chickpea (*Cicer arietinum* L.) on Calcareous Clayey soil

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Article History
Received: 29 November 2017
Accepted: 05 January 2018
Published: January 2018

Citation
Mathukia RK, Savaliya NV, Vekariya SJ, Rupareliya VV, Talavia BP. Substitution of chemical fertilizers with organic manure and biofertilizers in Chickpea (*Cicer arietinum* L.) on Calcareous Clayey soil. *Discovery Agriculture*, 2018, 4, 9-13

ABSTRACT

A field experiment was conducted on calcareous clayey soil at Junagadh (Gujarat) during *rabi*2016-17 to study the possibility of organic farming in chickpea (*Cicer arietinum* L.) by replacing chemical fertilizers with organic manure and biofertilizers. The experiment comprising 10 treatments of various combinations of farmyard manure (FYM) and biofertilizers like Rhizobium, phosphate solubilizing bacteria (PSB) and potash mobilizing bacteria (KMB) were replicated thrice in a randomized block design. The experimental results revealed that application of FYM 4 t/ha + Rhizobium 30 g/kg seed+ PSB 3 L/ha + KMB3 L/hasignificantly promoted growth and yield attributes *viz*., plant height, plant spread, number of branches/plant and number of pods/plant.This treatment ultimately recorded significantly the highest seed yield (16.98q/ha),stalk yield (25.31q/ha), net return (`38787/ha) and B:C(2.28),followed by application of chemical fertilizers (20-40-40 kg N-P_2O_5-K_2O/ha). The results clearly indicated that chemical fertilizers could absolutely be replaced by integrated use of FYM, Rhizobium, PSB and KMB for organic cultivation of chickpea under South Saurashtra Agro-climatic Zone of Gujarat.

Keywords: Chickpea, Farmyard manure (FYM), Rhizobium, Phosphate Solubilizing Bacteria (PSB), Potash Mobilizing Bacteria (KMB)

Abbreviations: FYM (Farmyard Manure), PSB (Phosphate Solubilizing Bacteria), KMB (Potash Mobilizing Bacteria), GJG-4 (Gujarat Junagadh Gram-4), IW: CPE (Irrigation Water: Cumulative Pan Evaporation)

1. INTRODUCTION

Chickpea is the third most important food legume and second most important pulse crop of the world. It is traditionally grown in many parts of the world in a wide range of agro-climatic environments.Chickpea is known as “King of Pulses” in India. Chickpea occupies an important position due to its nutritious value (17-23% protein) in large vegetarian population of the country.

India is the largest producer of chickpea in the world. It accounts for 61% of the total area and 66% of total production in the world. In India chickpea represents 32% (6.42 million hectares) of total pulse area and 49% (5.47 million tonnes) of total pulse production. In India, it occupies about 9.18 million hectares area with production of 8.22 million tonnes and an average productivity of 900 kg/ha. The major chickpea production areas are situated in Madhya Pradesh, Rajasthan, Uttar Pradesh, Haryana, Maharashtra and Punjab. In Gujarat, it contributes about 1,61,000 hectares area with production of 1,67,200 tonnes and an average productivity of 1035 kg/ha. The major gram growing areas in Gujarat are Panch Mahal district, Ghed area of Junagadh district and Bhal area of Ahmedabad, Surendranagar and Bhavnagar districts (Anon. 2017). In spite of the importance of this crop in our daily diet and in agricultural production, productivity of this crop is very low in India. The indeterminate growth habit, prolonged flowering, flower drop and pod shattering responsible for decreasing yield.

Indiscriminate use of chemical fertilizers and chemical pesticides contributed in loss of soil productivity along with addition of salts to the soil (Aggani, 2013). Reliance on chemical fertilizers for upcoming agricultural growth would mean further loss in soil quality, likelihoods of water contamination and unmanageable burden on agricultural system (Rajasekaran et al., 2012).

Maintenance of organic matter in soil is essential for sustaining soil health and productivity of crop. Organic manures, valued by-products of farming and allied industries, contribute to plant growth through their positive effects on the physical, chemical and biological properties of soil (Singh and Ekhlaq, 2008; Rajkumara et al., 2009).

Biofertilizers most commonly referred to as the fertilizer that contains living soil micro-organisms to increase the availability and uptake of mineral nutrients for plants. When biofertilizers are applied as seed or soil inoculants, they multiply and participate in nutrient cycling and benefit crop productivity (Vessey, 2003). Biofertilizers provide most of the macro- and micro-nutrients through biological nitrogen fixation, phosphate solubilization and potassium mobilization or mineralization, secretion of plant growth promoting substances, production of antibiotics and decomposition of organic waste materials in the soil (Sinha et al., 2014) and thereby enhancing nutrient uptake and augmenting tolerance against moisture deficit stress.

Recognizing the adverse impact of excessive use of chemicals on soil health, human health and environment, Government of India promoting organic farming through various projects and schemes. Organic farming has been included as special category of farming in the National Agriculture Policy approved by the Government of India during 2000. Recently the Government of Gujarat declared “Gujarat Organic Farming Policy-2015” to support scientifically evolved organic farming practices for sustainable farming system along with the trustworthy marketing and supply chain of the produce. It is aimed to promote technically sound, economically viable, environmentally non-degrading, and socially acceptable use of natural resources in favour of organic agriculture. The policy seeks to actualize the area and crop potential for organic farming, sustaining soil fertility, conserving bio-resources, strengthening rural economy, promoting value addition, accelerating the growth of agro-business and securing a fair standard of living for the farmers and agricultural workers and their families. For effective implementation of the policy, there is an urgent need to develop a composite package of practices for major crops of the region.

Taking note of the facts highlighted above, it was felt worthwhile to integrate organic manure and biofertilizers to replace chemical fertilizers for organic cultivation of chickpea.

2. MATERIALS AND METHODS

A field experiment was conducted on a clayey soil at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) in *rabi* 2016-17. Geographically, Junagadh is situated at 21.5^0 N latitude and 70.5^0 E longitude with an altitude of 60 m above the mean sea level. The experimental soil was clayey in texture having gentle slope. It was slightly alkaline in reaction with pH 7.9 and EC 0.33 dS/m, medium in available nitrogen (254-269 kg/ha), available phosphorus (28.4-30.7 kg/ha) and available potash (183-185- kg/ha). The experiment comprise of 10 treatments viz., T_1: Control, T_2: 20-40-40 kg N-P_2O_5-K_2O/ha, T_3: Farmyard manure (FYM) 4 t/ha, T_4: FYM 4 t/ha + Rhizobium, T_5: FYM 4 t/ha + Phosphate solubilizing bacteria (PSB), T_6: FYM 4 t/ha + Potash mobilizing bacteria (KMB), T_7: FYM 4 t/ha + Rhizobium + PSB, T_8: FYM 4 t/ha + Rhizobium + KMB, T_9: FYM 4 t/ha + PSB + KMB, and T_{10}: FYM 4 t/ha + Rhizobium + PSB + KMB. These treatments were replicated thrice in a randomized block design. The chickpea variety 'GJG-4' was sown at row spacing of 45 cm x 10 cm using seed rate of 60 kg/ha. Farmyard manure (FYM) was applied at the time of land preparation as per treatment. Entire dose of nitrogen, phosphorus and potash as per treatments was applied in form of Urea, Diammonium Phosphate and Muriate of Potash, respectively at sowing. Liquid formulation of Rhizobium (*Bradyrhizobium ciceri*) was used as seed treatment @ 30 mL/kg seed), while PSB (*Bacillus coagulans*) and KMB (*Frateuriaaurantia*) were used as soil application (3000 mL/ha). For seed treatment, seeds were spreaded and Rhizobium culture (10^8 viable cells/g) @ 30 mL/kg of seed was sprinkled on the seeds and then dried in shade. For soil application, PSB/KMB culture (10^8 viable cells/g) @ 3000 mL/ha was applied in furrows just after sowing before irrigation. Liquid formulations of Rhizobium and PSB culture were obtained from Department of Plant Pathology, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India while liquid KMB culture was obtained from Department of Plant Pathology, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India. The experiment was laid out in the organic plot (maintained since 10 years) and the treatment of chemical fertilizers was kept outside the organic plot. Six irrigations each of 5 cm depth were applied at 0.8 IW: CPE and plant protection measures were taken as per need using bio-pesticides. The growth and yield attributes were recorded from the five tagged plants in each plot. Seed and stalk yield were recorded from the net plot area and converted into quintal per hectare base.The gross realization in terms of rupees per hectare was worked out taking into consideration the seed and stalk yields from each treatment and local market prices. The expenses incurred for all the cultivation operations from preparatory tillage to harvesting including the cost of inputs *viz*., seeds, fertilizers, pesticides, *etc*. applied to each treatments along with the treatment cost were calculated on the basis of prevailing local charges.Net return of each treatment was calculated by deducting the total cost of cultivation from the gross returns. The Benefit: Cost (B:C) ratio was calculated with the help of the following formula.

$$B:C = \frac{\text{Gross returns (`/ha)}}{\text{Total cost of cultivation (`/ha)}}$$

The data were subjected to statistical analysis by adopting appropriate analysis of variance (Gomez and Gomez, 1984). Wherever the F values found significant at 5 per cent level of probability, the critical difference (CD) values were computed for making comparison among the treatment means.

3. RESULTS AND DISCUSSION

3.1. Growth and yield attributes

The results (Table 1) revealed that different treatments comprising integration of FYM and biofertilizers did cause significant variation in growth and yield attributes of chickpea *viz*., plant height, plant spread, number of branches/plant and number of pods/plant.

Application of FYM 4 t/ha + Rhizobium 30 g/kg seed + PSB 3 L/ha + KMB 3 L/ha(T_{10}), being statistically at par with application of 20-40-40 kg N-P_2O_5-K_2O/ha (T_2), FYM 4 t/ha + Rhizobium + PSB (T_7), FYM 4 t/ha + PSB + KMB (T_9) and FYM 4 t/ha + Rhizobium + KMB (T_8) significantly enhanced plant height over the control (T_1).

Significantly the highest plant spread was noticed under the treatment of FYM 4 t/ha + Rhizobium 30 g/kg seed + PSB 3 L/ha + KMB 3 L/ha(T_{10}), which however, remained statistically at par with the treatments T_2 (20-40-40 kg N-P_2O_5-K_2O/ha) and T_7 (FYM 4 t/ha + Rhizobium + PSB).

The treatment comprising application of FYM 4 t/ha + Rhizobium 30 g/kg seed + PSB 3 L/ha + KMB 3 L/ha(T_{10}) recorded significantly the highest number of branches/plant, but found statistically equivalent to the treatment of chemical fertilizers (T_2).

Significantly the highest number of pods/plant was recorded with application of FYM 4 t/ha + Rhizobium 30 g/kg seed + PSB 3 L/ha + KMB 3 L/ha(T_{10}), which was statistically comparable to the treatments T_2 (20-40-40 kg N-P_2O_5-K_2O/ha), T_7 (FYM 4 t/ha + Rhizobium + PSB) and T_9 (FYM 4 t/ha + PSB + KMB).

The improvement in growth and yield parameters of chickpea with integrated use of FYM and biofertilizers might have been attributed to the production of higher quantities of nutrients and growth promoting substances and enhanced nitrogen fixation, phosphate solubilization and potash mobilization for their utilization by plants. The results are in conformity with those reported by Singh et al. (2012), Singh et al. (2015), Yadav et al. (2014) and Savaliya et al. (2017).

Table 1

Growth, yield and economics of chickpea under different treatments

Treatment	Plant height (cm)	Plant spread (cm)	No. of branches/ plant	No. of pods/ plant	Seed yield (q/ha)	Stalk yield (q/ha)	Gross returns (`/ha)	Cost of cultivation (`/ha)	Net returns (`/ha)	B:C
T_1 : Control	27.3	22.7	3.8	18.6	7.84	14.69	32,095	26,775	5,320	1.20
T_2 : RDF	37.2	33.6	5.9	35.2	16.30	24.83	66,442	29,907	36,535	2.22
T_3 : FYM	31.2	26.4	4.7	28.8	10.78	17.57	43,999	29,887	14,112	1.47
T_4 : FYM + Rhizobium	33.5	30.7	5.4	31.7	13.88	22.45	56,643	30,101	26,542	1.88
T_5 : FYM + PSB	32.8	30.6	5.3	30.7	13.78	21.24	56,182	30,125	26,057	1.86
T_6 : FYM + KMB	32.7	29.3	4.9	29.2	12.91	20.50	52,665	30,125	22,540	1.75
T_7 : FYM + Rhizobium + PSB	36.8	32.4	5.7	34.8	15.72	23.73	64,067	30,339	33,728	2.11
T_8 : FYM + Rhizobium + KMB	34.9	31.3	5.4	32.9	14.23	22.94	58,067	30,339	27,728	1.91
T_9 : FYM + PSB + KMB	35.4	31.8	5.5	33.4	14.78	23.47	60,294	30,363	29,931	1.99
T_{10}: FYM + Rhizobium + PSB + KMB	37.5	34.0	6.0	35.5	16.98	25.31	69,186	30,399	38,787	2.28
CD (P=0.05)	2.9	1.7	0.2	2.6	0.73	1.23				

3.2. Cropyields

Data presented in Table 1 indicated that the highest grain yield and stalk yield were significantly influenced by different treatments. Significantly the highest seed yield (16.98 q/ha) was registered with application of FYM 4 t/ha + Rhizobium 30 g/kg seed + PSB 3 L/ha + KMB 3 L/ha(T_{10}), however it remained statistically at par with the fertilizer dose of 20-40-40 kg N-P_2O_5-K_2O/ha (T_2).These treatments increased seed yield by 117 and 108 per cent over the control (T_1), respectively.

Likewise, the treatment T_{10}(FYM 4 t/ha + Rhizobium 30 g/kg seed + PSB 3 L/ha + KMB 3 L/ha) registered significantly the highest stalk yield of 25.31 q/ha, but remained statistically analogues to T_2 (20-40-40 kg N-P_2O_5-K_2O/ha). These treatments increased stalk yield by 72 and 69 per cent over the control (T_1), respectively. Improved soil physical, chemical and biological properties under the integration of FYM and biofertilizers might have accelerated growth and yield attributes which ultimately increased yields. Similar observations were also recorded by Nandan et al. (2015), Singh et al. (2015), Singh et al. (2014) and Savaliya et al. (2017).

3.3. Economics

Application of FYM 4 t/ha + Rhizobium 30 g/kg seed + phosphate solubilizing bacteria (PSB) 3 L/ha + potash mobilizing bacteria (KMB) 3 L/ha (T_{10}) gave higher net returns (`38787/ha) and B:C (2.28). The next superior treatments were 20-40-40 kg N-$P_2O_5$-$K_2O$/ha ($T_2$) and FYM 4 t/ha + Rhizobium 30 g/kg seed + phosphate solubilizing bacteria (PSB) 3 L/ha ($T_7$) having net returns of ` 36535 and 33728/ha and B:C of 2.22 and 2.11, respectively. Similar results were also reported by Nandan et al. (2015), Singh et al. (2015) and Savaliya et al. (2017).

4. CONCLUSION

Based on the study, it could be concluded that application of FYM 4 t/ha + Rhizobium (*Bradyrhizobium ciceri*) 30 g/kg seed + phosphate solubilizing bacteria (*Bacillus coagulans*) 3 L/ha + potash mobilizing bacteria (*Frateuria aurantia*) 3 L/ha could enhance yield of chickpea and also substitute chemical fertilizers on clayey soil of South Saurashtra Agroclimatic Zone of Gujarat.

SUMMARY OF THE RESEARCH

1. A field experiment was conducted on calcareous clayey soil at Junagadh (Gujarat) during *rabi*2016-17 to study the possibility of organic farming in chickpea (*Cicer arietinum* L.) by replacing chemical fertilizers with organic manure and biofertilizers. The experiment comprising 10 treatments of various combinations of farmyard manure (FYM) and biofertilizers like Rhizobium, phosphate solubilizing bacteria (PSB) and potash mobilizing bacteria (KMB) were replicated thrice in a randomized block design.
2. The parameters including plant height, plant spread, number of branches per plant, number of pods per plant, seed yield, stalk yield gross returns, cost of cultivation, net returns and B:C were studied.
3. Integrated use of FYM 4 t/ha + Rhizobium (*Bradyrhizobium ciceri*) 30 g/kg seed + phosphate solubilizing bacteria (*Bacillus coagulans*) 3 L/ha + potash mobilizing bacteria (*Frateuriaaurantia*) 3 L/hacould enhance yield of chickpea and net returns.

FUTURE ISSUES

Farmers and scientists should consider the importance of organic farming for food safety, soil health and environment protection.

ACKNOWLEDGEMENT

The authors acknowledge Junagadh Agricultural University, Junagadh for providing funding for the experiment. We are also grateful to Director of Research and Head, Department of Agronomy for execution of the experiment. The help rendered by field staff of Department of Agronomy is highly appreciated.

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