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Effect of Integrated Nutrient Management on the Growth and Yield of Chickpea (*Cicer arietinum* L.) under Chickpea - forage Sorghum (*Sorghum bicolor* L.) Cropping Sequence

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ABSTRACT

Background: The ameliorating effect of legumes on the soil is considered to be the most important factor for increasing productivity of non-legume crops grown in rotation. The contribution of preceding legumes is often studied by measuring the yield of subsequent crop. The success of any cropping system depends upon the appropriate management of resources including balanced use of manures and fertilizers.

Methods: A field experiment was conducted at the Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India during *Rabi* - Summer seasons of the years 2017-18 and 2018-19 on chickpea-forage sorghum cropping system.

Result: Results showed that the growth, yield attributes and yield of chickpea were significantly influenced by the integrated nutrient management. On the basis of two year and pooled data, the results revealed that the plant height, dry matter production, dry root biomass, number of pods plant^{-1}, seed yield and stover yield of chickpea were increased with application of 50% RDF + 2 t VC ha^{-1} + Bio NP (*Rhizobium* + PSB) than any other treatments. The ameliorating effect of legumes on the soil is considered to be the most important factor in improving the production of non-legume crops grown in rotation. The contribution of preceding legumes is often studied by measuring the yield of subsequent crop. The success of any cropping system depends upon the appropriate management of resources including balanced use of manures and fertilizers. It can be concluded that growth and yield of chickpea was significantly increased with combine application of chemical fertilizers, organic manure and bio-fertilizers.

Key words: Cropping sequence, Growth and yield of chickpea, Integrated nutrient management.

INTRODUCTION

Pulses play in an important role in agriculture because they occupy a unique position in every known system of farming as a main, catch, cover, green manure, intercrop and mixed crop. Pulses are the cheapest source of quality protein for the human being. The protein hunger is common problem in India, where majority of the population are vegetarian. They also contribute to soil quality by fixing atmospheric nitrogen in to the soil. In India, production of pulses was around 19.3 million tonnes with a very low average productivity of 764 kg ha^{-1} (ESI, 2015). Currently, total area under pulses is about 26.3 million ha (Chaudhary and Suri, 2014), which shows the massive yield gap between India and other pulse producing developed countries. Pulses are largely cultivated under energy starved conditions, mostly on marginal and sub-marginal land. Chickpea (*Cicer arietinum* L.) is an important pulse crop grown and consumed all over the world. Chickpea is commonly known as Bengal gram and locally as *chana*. It is a good source of carbohydrates, protein and important vitamins and its protein quality is considered to be better than other pulses.

Chickpea is grown in more than 50 countries in the world, and India is the largest producer of chickpea. India occupied about 10.56 million hectares area and total production of 11.23 million tonnes with an average productivity of 1063 kg ha^{-1} during 2017-18 (Anonymous, 2018). The major chickpea growing states in India are Madhya Pradesh, Maharashtra, Karnataka, Rajasthan, Andhra Pradesh, Chhattisgarh, Uttar Pradesh, Jharkhand and Gujarat. In Gujarat, chickpea is grown in 0.29 million hectares, producing 0.37 million tonnes with an average productivity of 1253 kg ha^{-1}, which is high as compared to the national average productivity (Anonymous, 2018). The basic concept of integrated nutrient management is the maintenance of soil fertility and to supply the plant nutrients at an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner. Application of Farmyard manure (FYM) and vermicompost

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(VC) also improves soil health by improving nutrient availability, soil physical properties and microbial activity. Further, both *Rhizobium* and PSB are low cost ecofriendly bio-fertilizer input is an integral component of integrated nutrient management (INM) for pulse production, considering this an experiment was planned and conducted.

MATERIALS AND METHODS

A field experiment was conducted during the years 2017-18 and 2018-19 at College Agronomy Farm, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India. The experimental field had an even topography with a gentle slope having good drainage capacity and loamy sand soil in texture. The soil of the experimental field at 0-15 cm depth was low in organic carbon and available nitrogen (N), medium in available phosphorus and potassium and slightly alkaline in reaction. The experiment was comprised of six treatment *viz.,* 100 % RDF (T_1), 50% RDF + Bio NP (T_2), 50% RDF + 5t FYM ha^{-1}(T_3), 50% RDF + 2t VC ha^{-1} (T_4), 50% RDF + 5t FYM ha^{-1} + Bio NP (T_5) and 50% RDF + 2t VC ha^{-1} + Bio NP (T_6) laid down in randomized block design (RBD) in *Rabi* season for chickpea as main plot treatment. While during Summer season, main plot treatment was divided into three sub-plots along with three graded levels of fertilizers (F_1 : 0% RDF, F_2 : 50% RDF and F_3 : 100% RDF) applied to forage sorghum, resulting into eighteen treatment combinations and replicated four times in Split plot design (SPD). Fertilizer was applied as basal in both the crops as per treatments, except nitrogen application in forage sorghum 50% N as basal + 50% N at 30 days after sowing (DAS) as per treatment. Other recommended fertilizers package was adopted to raise the crop. Chickpea var. GG 5 was taken as main *Rabi* crop and all the treatments were conferred upon it during both the years. The data recorded were subjected to the analysis of variance techniques as described by Panse and Sukhatme (1967). The treatment effects on all the characters studied were compared by employing 'F' test. The data of the preceding chickpea and succeeding forage sorghum were analyzed by RBD and SPD, respectively.

RESULTS AND DISCUSSION

Growth attributes

Statistical analysis of the data indicated that integrated nutrient management showed significant influence on plant height (Table 1). The results indicated that application of 50% RDF + 2 t VC ha^{-1} + Bio NP (T_6) recorded significantly the tallest plant at all the growth stages during both year as well as on pooled basis. As compared to other treatments, the treatment T_6 produced the tallest plant of 28.25, 49.00 and 58.47 cm in the year 2017-18, 24.93, 49.93 and 53.69 cm in the year 2018-19 as well as on pooled basis 26.59, 49.47 and 56.08 cm at 30, 60 DAS and at harvest, respectively and it was remained at par with 50 % RDF + 5 t FYM ha^{-1} + Bio NP (T_5) but, plant height of chickpea at 30 DAS did not exercise any significant influence during 2017-18 and 2018-19. Increase in the plant height of chickpea could also be attributed to the higher production of plant growth promoting factors by beneficial microbial inoculants present in organic manures, which might have resulted in more intense root system and increase in shoot growth by enhanced nutrient uptake. Similar results were recorded by Rameshwar *et al*. (2017) in chickpea-okra cropping system. However, the shortest plant (44.90 cm) was observed in 50% RDF + Bio NP (T_2) at harvest (Table 1). INM treatments did not influence the number of branches plant^{-1} at harvest, the root length at 30DAS, 60 DAS and at harvest, and fresh and dry weight of root nodules at 45 DAS of chickpea during both years as well as in pooled basis.

Significantly the highest dry matter production of the chickpea (1.81, 19.63 and 43.17 g plant^{-1} in the year 2017-18, 1.91, 18.65 and 40.36 g plant^{-1} in the year 2018-19 as well as on pooled basis 1.86, 19.14 and 41.76 g plant^{-1}) was recorded with the treatment combination of 50% RDF + 2t VC ha^{-1} + Bio NP (T_6) as compared to other treatments at 30 DAS, 60 DAS and at harvest, respectively (Table 2). This might be due to the fact that more nutrient availability under INM treatments resulted into increased conversion of carbohydrates into protein which in turn elaborated into protoplasm and cell wall material increased the size of the cell, which expressed morphologically in terms of plant height, number of branches plant^{-1} ultimately dry matter accumulation, Cellulose is a highly persistent composition material, which requires longer time for decomposition. Thus, FYM and VC may have not fully utilized by chickpea crop during the first crop season and notably benefited the succeeding forage sorghum crop. Similar line of results were also reported by Patil *et al*. (2008); Singh *et al*. (2012); Tyagi *et al*. (2014); Sohu *et al*. (2015) and Sindhi *et al*. (2016).

The close examination of data given in Table 3 revealed that application of 50% RDF + 2t VC ha^{-1} + Bio NP (T_6) recorded the highest dry root biomass of chickpea (0.484, 1.067 and 1.443 g plant^{-1} in the year 2017-18, 0.439, 1.024 and 1.342 g plant^{-1} in the year 2018-19 as well as on pooled basis 0.462, 1.046 and 1.392 g plant^{-1}) as compared to other treatments at 30, 60 DAS and at harvest, respectively. This result indicated that though the root length was found non-significant, but due to numerically higher root length contributes to increase the root dry biomass. The results are in close conformity with the findings of Tyagi *et al*. (2014).

Yield and yield attributes

The pooled data the of number of pods plant^{-1}, seed yield, stover yield, seed index and harvest index of chickpea recorded at harvest was influenced by the different INM treatments (Table 4). Application of 50% RDF + 2 t VC ha^{-1} + Bio NP (T_6) recorded the highest number of pods plant^{-1} (81.29, 74.88 and 78.09), seed yield (2803, 2538 and 2671 kg ha^{-1}) and stover yield (4060, 3699 and 3880 kg ha^{-1}) of chickpea than other treatments in the year 2017-18, 2018-19 and pooled analysis, respectively. The response of

Table 1: Plant height and number of branches per plant of chickpea influenced by different integrated nutrient management practices.

Treatment details	Plant height (cm)									No. of branches plant^{-1}		
	30 DAS			60 DAS			At harvest					
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1 - 100% RDF	25.00	24.45	24.72	47.73	46.61	47.17	56.86	54.78	55.82	11.25	10.97	11.11
T_2 - 50% RDF + Bio NP	26.25	24.72	25.49	37.73	36.62	37.17	46.40	43.40	44.90	9.97	9.88	9.92
T_3 - 50% RDF + 5t FYM ha^{-1}	28.00	24.35	26.17	44.80	38.65	41.72	55.10	47.15	51.13	10.25	10.10	10.17
T_4 - 50% RDF + 2t VC ha^{-1}	23.50	24.18	23.84	45.07	41.20	43.14	55.43	50.26	52.84	10.49	10.36	10.43
T_5 - 50% RDF + 5t FYM ha^{-1} + Bio NP	27.25	24.53	25.89	45.80	42.80	44.30	56.32	52.22	54.27	10.64	10.50	10.57
T_6 - 50% RDF + 2t VC ha^{-1} + Bio NP	28.25	24.93	26.59	49.00	49.93	49.47	58.47	53.69	56.08	11.98	11.50	11.74
S.Em. ±	1.16	0.92	0.56	1.69	1.74	1.397	2.04	1.95	1.558	0.47	0.57	0.444
CD at 5%	NS	NS	1.69	5.08	5.25	4.21	6.13	5.87	4.69	NS	NS	NS

Bio NP = (*Rhizobium* + PSB), RDF= Recommended dose of fertilizer, VC= Vermicompost and FYM = Farmyard maure.

Table 2: Dry matter production, fresh and dry weight of root nodules of chickpea influenced by different integrated nutrient management practices.

Treatment details	Dry matter production (g plant^{-1})									Fresh wt. of root nodules (mg)			Dry wt. of root nodules (mg)		
	30 DAS			60 DAS			At harvest			45 DAS			45 DAS		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1 - 100% RDF	1.55	1.62	1.59	16.68	16.52	16.60	37.63	37.31	37.47	131.65	127.28	129.47	47.40	44.83	46.11
T_2 - 50% RDF + Bio NP	1.24	1.31	1.28	13.44	12.77	13.11	29.61	27.55	28.58	116.62	114.55	115.58	41.98	40.59	41.29
T_3 - 50% RDF + 5t FYM ha^{-1}	1.31	1.44	1.38	14.74	13.53	14.13	31.65	30.41	31.03	119.93	117.13	118.53	43.17	41.91	42.54
T_4 - 50% RDF + 2t VC ha^{-1}	1.43	1.50	1.46	15.45	14.93	15.19	33.98	31.77	32.87	122.76	120.18	121.47	44.19	43.76	43.98
T_5 - 50% RDF + 5t FYM ha^{-1} + Bio NP	1.54	1.56	1.55	16.31	15.44	15.87	35.14	34.50	34.82	124.52	121.80	123.16	44.83	43.24	44.03
T_6 - 50% RDF + 2t VC ha^{-1} + Bio NP	1.81	1.91	1.86	19.63	18.65	19.14	43.17	40.36	41.76	140.05	133.45	136.75	49.17	47.37	48.27
S.Em. ±	0.07	0.09	0.079	0.79	0.74	0.73	1.38	1.30	1.18	5.25	6.05	4.85	1.74	1.75	1.47
CD at 5%	0.22	0.27	0.24	2.37	2.23	2.21	4.16	3.92	3.56	NS	NS	NS	NS	NS	NS

Bio NP = (*Rhizobium* + PSB), RDF= Recommended dose of fertilizer, VC= Vermicompost and FYM = Farmyard maure.

Table 3: Root length and dry root biomass of chickpea influenced by different integrated nutrient management practices.

Treatment details	Root length									Dry root biomass								
	30 DAS			60 DAS			At harvest			30 DAS			60 DAS			At harvest		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1 - 100% RDF	9.34	8.83	9.09	11.13	10.81	10.97	11.99	11.79	11.89	0.414	0.371	0.393	0.916	0.859	0.888	1.238	1.123	1.180
T_2 - 50% RDF + Bio NP	8.27	8.20	8.24	10.33	9.51	9.92	11.21	10.37	10.79	0.332	0.302	0.317	0.732	0.701	0.717	0.990	0.918	0.954
T_3 - 50% RDF + 5t FYM ha^{-1}	8.51	8.13	8.32	10.24	9.76	10.00	11.38	10.64	11.01	0.352	0.331	0.341	0.776	0.767	0.772	1.050	1.005	1.027
T_4 - 50% RDF + 2t VC ha^{-1}	8.71	8.34	8.52	10.51	10.09	10.30	11.56	11.00	11.28	0.382	0.346	0.364	0.842	0.802	0.822	1.139	1.050	1.095
T_5 - 50% RDF + 5t FYM ha^{-1} + Bio NP	8.83	8.45	8.64	10.65	10.17	10.41	11.72	11.09	11.40	0.413	0.358	0.386	0.910	0.831	0.871	1.232	1.092	1.162
T_6 - 50% RDF + 2t VC ha^{-1} + Bio NP	9.95	9.26	9.60	11.66	11.56	11.61	12.83	12.61	12.72	0.484	0.439	0.462	1.067	1.024	1.046	1.443	1.342	1.392
S.Em. ±	1.12	1.26	0.33	0.53	0.47	0.39	0.51	0.55	0.43	0.02	0.02	0.018	0.039	0.040	0.033	0.04	0.05	0.042
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.054	0.058	0.054	0.119	0.120	0.098	0.135	0.138	0.128

·Bio NP = (*Rhizobium* + PSB), RDF= Recommended dose of fertilizer, VC= Vermicompost and FYM = Farmyard maure.

Table 4: Yield and yield attributes of chickpea influenced by different integrated nutrient management practices.

Treatment details	No. of pods $plant^{-1}$			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Seed index (g)			Harvest index (%)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T1 - 100% RDF	70.86	69.22	70.04	2443	2347	2395	3543	3452	3497	24.00	23.55	23.77	40.98	40.47	40.73
T_2 - 50% RDF + Bio NP	60.69	56.05	58.37	1923	1733	1828	2906	2713	2809	23.90	23.05	23.48	40.02	38.95	39.49
T_3 - 50% RDF + 5t FYM ha^{-1}	64.98	60.28	62.63	2055	1913	1984	3090	2863	2976	23.51	23.21	23.36	39.92	39.93	39.92
T_4 - 50% RDF + 2t VC ha^{-1}	67.35	61.56	64.45	2206	1998	2102	3188	3052	3120	23.37	23.36	23.37	40.99	39.60	40.29
T_5 - 50% RDF + 5t FYM ha^{-1} + Bio NP	73.33	64.01	68.67	2282	2170	2226	3305	3170	3238	23.82	23.46	23.64	40.84	40.63	40.73
T_6 - 50% RDF + 2t VC ha^{-1} + Bio NP	81.29	74.88	78.09	2803	2538	2671	4060	3699	3880	24.95	24.11	24.53	40.93	40.70	40.81
S.Em. ±	3.44	3.25	2.43	98	96	85	195	129	123	0.69	0.70	0.54	1.16	1.16	0.88
CD at 5%	10.35	9.81	7.32	294	290	256	586	389	372	NS	NS	NS	NS	NS	NS

·Bio NP = (*Rhizobium* + PSB), RDF= Recommended dose of fertilizer, VC= Vermicompost and FYM = Farmyard maure.

different treatments on those traits was observed in order of $T_6>T_1>T_5>T_4>T_3>T_2$. This might be due to the fact that integrated use of organic, inorganic and bio fertilizer resulted in better growth attributes of the plants (*viz*., plant height, No. of branches plant^{-1}, dry matter production and dry root biomass). The increased availability of nutrients due to use of INM was observed by Tyagi *et al*. (2014) which enhanced greater translocation of photosynthates from the source to sink site that resulted in to higher yield contributing characteristics like number of pods plant^{-1} and seed index and ultimately increased the seed yield as compared to other treatments. Results further indicated that application of 50% RDF + Bio NP (T_2) and 50% RDF + 5 t FYM ha^{-1} (T_3) recorded lower seed yield might be due to reduction of 50% recommended dose of fertilizer in both the treatments and this deduction of 50% RDF was not fulfilled by either Bio NP (*Rhizobium* + PSB) or 5 t FYM ha^{-1} in respective treatment. The favourable effect of integration of organic manures, inorganic fertilizers and bio fertilizer on yield of chickpea was also recorded by Tolanur and Badanur (2003); Sindhi *et al*. (2016); Shivran *et al*. (2017); Singh *et al*. (2017) and Kemal *et al*. (2018).

Stover yield (kg ha^{-1}) was also recorded significantly the highest under application of 50% RDF + 2 t VC ha^{-1} + Bio NP (T_6). This might be due to benefits accruing from the integrated use of organic with inorganic fertilizer resulting in better supply of nutrients along with congenial environment leading to better root activity and higher nutrient absorption, which resulted in better plant growth like plant height, dry matter production and dry root biomass contributes to increase the stover yield. Similar results were also recorded by Lakpale *et al*. (2003) in chickpea, Singh *et al*. (2010) in lentil, Tyagi *et al*. (2014) in green gram and Rameshwar *et al*. (2017) in chickpea-okra cropping system.

It is clear from the data (Table 4) that harvest index and seed index were remained unchanged or found non-significant due to integrated nutrient management treatments in the year 2017-18, 2018-19 as well as pooled basis. However, effect of integrated nutrient management in chickpea on the harvest index and seed index was found numerically higher under application of 50% RDF + 2 t VC ha^{-1} + Bio NP (T_6). Similar finding were also recorded by Elamin and Madhavi (2015); Sindhi *et al*. (2016); Shivran *et al*. (2017) and Kemal *et al*. (2018).

CONCLUSION

On the basis of the results of two years of field experimentation, it can be concluded that application of 50% RDF (12.5-25 NP kg ha^{-1}) + 2 t VC ha^{-1} + Bio NP (*Rhizobium* + PSB) to chickpea recorded significantly higher growth attributes (plant height, dry matter production and dry root biomass), number of pods per plant, seed yield and stover yield of chickpea as compared to other treatments in chickpea - forage sorghum cropping sequence in loamy sand soil of middle Gujarat, India.

Conflict of interest

All authors declare that they have no conflicts of interest.

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