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Effect of inorganic, organic and different bio-fertilizers on growth and yield of desi gram (*Cicer arietinum* L.), under irrigated conditions

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Abstract
A field experiment was conducted during the *rabi* season of 2021-22 at the research farm, Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab to evaluate the effect of inorganic, organic and different bio-fertilizers on the growth and yield of desi gram (*Cicer arietinum* L.) under irrigated condition. The experiment was laid out in Randomized Block Design with nine treatments; T1 (control: 100% RDF), T2 (50% RDF + FYM, T3 (50% RDF + FYM + Rhizobium), T4 (50% RDF + FYM + VAM), T5 (50% RDF + Vermicompost), T6 (50% RDF + Vermicompost + Rhizobium), T7 (50% RDF + Vermicompost + VAM), T8 (50% RDF + FYM + PSB), T9 (RDF + Vermicompost + PSB). The result revealed that among all the treatments, T6 (50% RDF + Vermicompost + Rhizobium) recorded higher growth attributes and yield which is statistically at par with T7 (50% RDF + Vermicompost + VAM) and T9 (RDF + Vermicompost + PSB).

Keywords: Biofertilizer, chickpea, PSB, rhizobium, VAM, vermicompost

Introduction
Pulses are the important diet foods after the cereals that provide healthy and dietary food. Pulses are affordable, the cheapest, sustainable source of proteins and minerals. It is the main source of vegetarian protein thus demand for pulses increases by 2.8% per annum (Chauhan *et al.*, 2016) [4]. United Nations, declared 2016 as the International year of pulse. In India, according to the World Health Organization, the recommended requirement of a pulse is 80 g per capita per day whereas availability is much lower 41.9 g per day (Anonymous 2013) [1] thus a huge gap between the demand and supply that can be overcome by production and cultivation of pulse.

Chickpea (*Cicer arietinum* L.) is commonly called Bengal gram, Chana and also known as the king of pulse, belongs to Leguminosae or Fabaceae family. It originated from South West Asia and derived from the 'Greek' word 'kikus' meaning strength or force. It contains 21.1% protein, 61.5% carbohydrate, 4.5% fat, vitamins and minerals such as phosphorus, and potassium, and is also rich in calcium, magnesium, iron, niacin, riboflavin, thiamin, folate, and rich in unsaturated fatty acids like oleic and linoleic acid. It has two types; desi and Kabuli gram. Desi gram is produced as 80% of total production whereas Kabuli gram contributes 20% of total production (Merga and Haji, 2019) [16]. It is used in various forms such as split as dal, flour, preparing for sweets, snacks, and condiments, and also use as a blood purifier and dietary fodder for the animal.

It is generally grown in the arid and semi-arid zone of the world and grown in nearly 57 countries of varying climatic conditions (Merga and Haji, 2019) [16] but widely produced and consumed in all parts of the world. It is an important pulse crop grown all over the world occupying 2nd rank in the area after dry bean (FAO, 2021) [7] and 3rd largest legume produce after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). India is a leading country followed by Turkey, Myanmar, Pakistan, Australia, and Ethiopia (FAOSTAT, 2020) [9]. India is the largest consumer and producer of chickpea occupying 1st rank in the area as well as production in the world which contributes the highest share in production (71.9%) as well as in area (71.0%) of chickpea (FAO 2017) [6]. In the world, during 2017-18 total area, production, and productivity of chickpea is 149.66 lakh ha, 162.25 lakh tons, and an average yield of as1252 kg/ha respectively (FAOSTAT, 2019) [8] whereas in India 2019-20 total area, production, the average yield is 96.96 lakh ha, 109.31 lakh tons and 1127 kg/ha respectively (DES, Govt. of India, 3rd advance estimate 2019-20).

In India, it is widely cultivated in Madhya Pradesh, Rajasthan, Uttar Pradesh, Punjab, Haryana, Maharashtra, Karnataka, and Andhra Pradesh which contribute 95% of the area and 92% of the production in the country.

Production and productivity of chickpea are comparatively low in most of India. farmers mainly adopted intensive and exhaustive crops or hardly used organic and biofertilizer for the production of legume crops thus loss of fertility and productivity (Kumar *et al.*, 2015) [12]. In the current era, intensive use of chemicals shows a harmful impact on soil fertility and also on the environment and become a major threat of global concern (Laranjo *et al.* 2014, Verma *et al.* 2014) [13, 29]. Being a leguminous crop, it fixes the atmospheric nitrogen by forming nodules with the help of Rhizobium bacteria (Sevilmis and Sevilmis, 2019) [23] and enhanced crop yield. Recently, bio-inoculants are frequently used to improve soil fertility and reduce environmental pollution or minimize the use of chemical fertilizers (Roy Chowdhury *et al.* 2017) [22].

Phosphorus solubilizing bacteria (PSB) solubilize the unavailable form of phosphate iron, aluminum, and tricalcium phosphates into a soluble form by releasing organic acid, mineral acid, chelating substances, proton extrusion mechanism, siderophores (Prajapati *et al.* 2017) [18], lowering pH, improve the fertility of soil besides increasing yield and quality of chickpea (Singh and Singh, 2014) [11]. Vesicular arbuscular mycorrhiza (VAM) has vesicles (bladder-like structure), and arbuscular (branch finger-like hyphae) that make the net-like association between fungi and root hence increasing root hair and surface area, thus increasing mobility, availability, and translocation of nutrient (Rouphael *et al*.,2015) [20]. Organic systems are based on the management of organic matter that improves over fertility and productivity of soil (Naik *et al.* 2014) [17]. Earthworms are used to convert organic waste to humus which is rich in nutrients (Lim *et al.*, 2015) [14]. Vermicompost has a positive effect on the physiological, chemical, and biological properties of the soil, microbial population, enzymatic activities, organic matter pH, EC, and pore of soil (Lim *et al.*, 2015) [14]. Therefore, organic manure, vermicompost, and different bio- fertilizer such as Rhizobium, PSB, and VAM are recently used for legume crop production which is an eco-friendly, cost-effective and integral component of an integrated nutrient management system that improved soil fertility, productivity, and also improve sustainability (Bana *et al.*, 2016) [2]. Therefore, the present study was done to evaluate the effect of inorganic, organic, and different biofertilizers on the growth and yield of chickpea.

Materials and Methods

The experiment was carried out during the *rabi* season of 2021-22 at the research farm, Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara, Punjab to evaluate the effect of inorganic, organic and different bio-fertilizers on the growth and yield of desi gram (*Cicer arietinum* L.) under irrigated condition" which is located at Gigantic Zone of India. The chickpea cultivated variety PBG-7 was sown at 30 cm x 10 cm spacing in a 3 m x 5 m plot. The experiment was laid out in Randomized Block Design with three replications and nine treatments: T1 (control: 100% RDF), T2 (50% RDF + FYM, T3 (50% RDF + FYM + Rhizobium), T4 (50% RDF + FYM + VAM), T5 (50% RDF + Vermicompost), T6 (50% RDF + Vermicompost + Rhizobium), T7 (50% RDF + Vermicompost + VAM), T8 (50%RDF + FYM + PSB), T9 (RDF + Vermicompost + PSB). Nitrogen, phosphorus, and potassium were applied through urea, single super phosphate and muriate of potash, respectively. The seed treatment was done by Rhizobium and PSB @ 20g/ kg of seeds. The treated seeds were kept in shade to get dry; thereafter the seeds were sown in plots as per treatment. Vermicompost and FYM 5t/ha were applied before sowing as soil application whereas VAM was applied at the time of sowing 10 kg/ha as soil inoculants. After germination thinning, gap filling was done and hand weeding was done to control weeds. Growth parameters were recorded at 30, 60, and 90 DAS and yield parameters were recorded at harvest. Four plants were randomly selected from each plot for a record of data. After physiological maturity crops were harvested, threshed, cleaned, and kept records of grain, stover, and biological yield. Analysis of variance (ANOVA) was calculated at a 5% level of significance to interpret the significant difference.

Result and Discussion

Growth parameters Plant height

Plant heights are presented in the table-1. The maximum plant height at 30, 60, and 90 DAS respectively was recorded with the application of a 50% recommended dose of fertilizer along with Vermicompost and Rhizobium. However, the recommended dose of fertilizer along with Vermicompost and VAM or PSB were statistically at par. It was observed that plant height increased as the number of days increased with all treatments. Rhizobium and phosphorus bacteria significantly increased nodule number, nodule weight, leghemoglobin content and nodule can fix atmospheric nitrogen. However, increased P availability and mobility due to the activity of phosphobacterin and arbuscular fungi tend to boost the growth of the crop by enhancing nutrient availability for vegetative growth of the plant thus plant height may increase. Similar results are also reported by Singh *et al*. (2016) [4, 25], Bashan *et al*. (2013) [3], and Rabieyan *et al*. (2011) [19].

Number of branches per plant

The number of branches per plant was recorded at 30, 60, and 90 DAS and the data is presented in table-1. The number of branches per plant was presented in the table-1. The treatment with 50% RDF along with vermicompost and Rhizobium recorded significantly higher number of primary branches per plant (2.67, 3.90, 4.94) respectively was recorded at 30,60 and 90 DAS whereas secondary branches per plant (6.01, 20.01) respectively was recorded at 60 and 90 DAS. However, the treatment with 50% RDF along with vermicompost and VAM or PSB was found to be statistically at par. The number of branches depends upon vegetative growth. The combination of inorganic fertilizer with organic and biofertilizer prefers more vegetative growth and hence more branches per plant. Biofertilizers or organic fertilizers enhance the availability of nutrients. Rhizobium fixes atmospheric nitrogen. Arbuscular mycorrhizae increase hair root and soil surface increases mobility, availability, and translocation of nutrients. PSB converts unavailable form of phosphorus to available form which increases metabolic activities and photosynthesis, hence there might be an increased number of branches per plant. A similar finding was recorded by Kumar *et al.* (2014) [11], and Singh *et al.* (2017) [26, 27].

Number of nodules per plant

The number of nodules per plant was recorded at 60 and 90 DAS and the data is presented in table-1. The number of nodules per plant was increased with the application of biofertilizer and organic fertilizer. The maximum number of nodules (21.99, 33.81) respectively per plant was recorded with a combined application of 50% RDF along with vermicompost and Rhizobium which was statistically at par with 50% RDF along with vermicompost and VAM or PSB. Application of biofertilizers like along with vermicompost increased the number of nodules. The population of bacteria and actinomycetes recharge the soil with conditioner. PSB increases the soluble phosphorus and this phosphorus has a direct role in atmospheric nitrogen fixation in legumes which ultimately increases the microbial activity and this activity increases the formation of the nodule. The inoculation with biofertilizer act as a soil conditioner which increases the availability of vitamin and enzyme in the soil and due to this enzymatic activity, the number of microbial populations in legume crops. A similar finding was recorded by Tagore *et al.* 2014 [28], Yadav *et al.* (2017) [30] Sharma *et al.* (2019) [24].

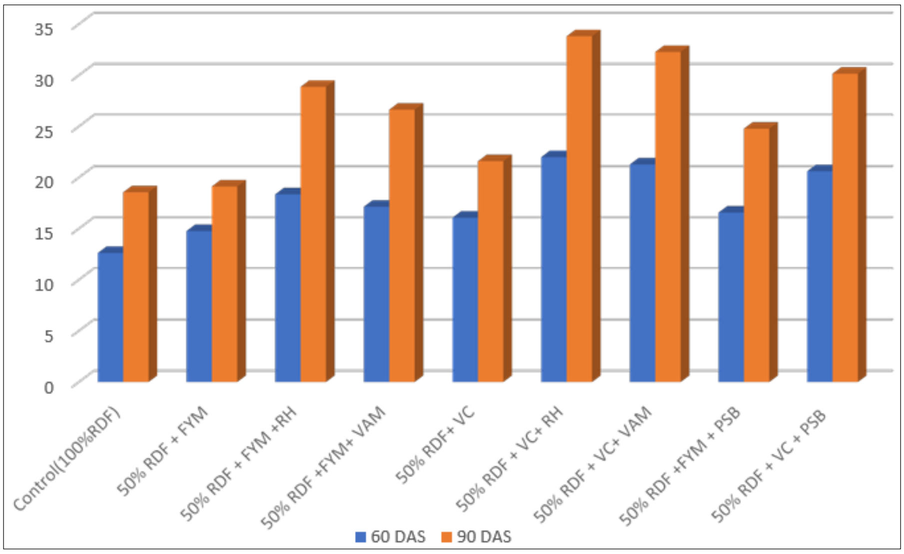

Fig 1: Effect of inorganic, organic and different biofertilizer on nodules of chickpea

Yield parameters

Seed yield, and straw yield

According to recorded data in table-1, significantly highest grain (24.47 q/ha) and straw yield q/ha) was found in the treatment (T6: 50% RDF + Vermicompost + Rhizobium). However, treatments with (T7: 50% RDF + Vermicompost + VAM) and (T9: 50% RDF + Vermicompost + PSB) were found to be statistically at par. Application of biofertilizer and vermicompost increase the seed yield. The seed yield of chickpea increased significantly with the inoculation of Rhizobium, VAM and PSB. Application of vermicompost and Arbuscular mycorrhiza enhance the microbial activity and nutrient availability and this availability increase the grain and straw yield. This might be due to mycorrhiza's increased root hairs and surface area, the solubility of Phosphorus and other nutrients increased resulting in sufficient formation of photosynthates which improved the metabolic activities. All the growth and yield contributing attributes were increased with the use of biofertilizers hence yield was increased and this was mainly due to the increased availability of N and P resulting in a well-developed root system with a higher nitrogen-fixing capacity, resulting in improved plant growth and development and better photosynthate diversion to sink. Farmers may also benefit from the use of a single or combination of biofertilizers (Singh *et al.*, 2017) [26, 27]. Similar results founded by Yadav *et al.* (2017) [30], Kumar *et al.* (2014) [11], Hemant Kumar *et al.* (2018) [10], Singh *et al.* (2017) [26, 27], and Jakhar *et al.* (2021) [15].

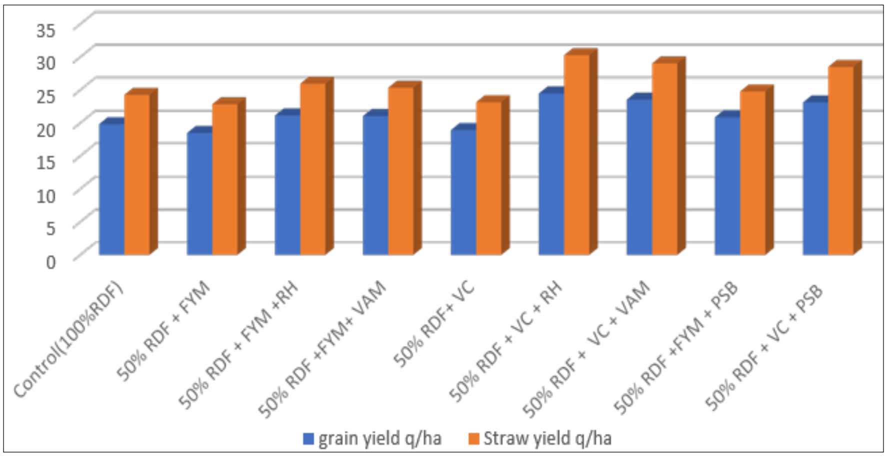

Fig 2: Effect of inorganic, organic and different biofertilizer on grain and straw yield of chickpea

Table 1: Effect of inorganic, organic and different biofertilizer on plant height, no. of primary and secondary branches, no. of nodules, yield (grain and straw) of chickpea

Treatment	Plant height (cm)			Primary branches			Secondary branches		Number of nodules		Grain yield q/ha	Straw yield q/ha
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS		
RDF (Control)	9.99	18.4	23.73	2.09	3.31	3.87	4.35	14.08	12.62	18.55	19.82	24.25
50% RDF + FYM	7.78	15.84	23.5	1.5	2.53	3.25	3.35	10.58	14.76	19.12	18.47	22.82
50% RDF+ FYM + Rhizobium	8.31	19.64	27.5	2.34	3.55	4.29	5.08	16.51	18.35	28.86	21.14	25.94
50% RDF + FYM + VAM	9	19.07	26.63	2.17	3.48	4.15	4.67	15.57	17.14	26.63	21.04	25.33
50% RDF + Vermicompost	8.56	17.5	25.18	1.92	2.84	3.49	3.69	12.75	16.07	21.59	18.93	23.13
50% RDF + Vermicompost + Rhizobium	10.54	21.54	31.81	2.67	3.9	4.94	6.01	20.01	21.99	33.81	24.47	30.27
50% RDF + Vermicompost+ VAM	10.26	20.5	29.46	2.5	3.72	4.72	5.58	18.51	21.28	32.27	23.54	29.02
50% RDF + FYM + PSB	8.72	18.69	24.32	2.02	3.31	4.01	4.5	14.64	16.57	24.77	20.87	24.77
50% RDF + Vermicompost+ PSB	9.76	20.02	29.29	2.42	3.66	4.49	5.41	17.55	20.61	30.15	23.11	28.48
S.Em±	0.47	1.04	1.32	0.11	0.22	0.25	0.28	0.87	0.96	1.36	1.08	1.30
CD (P = 0.05)	1.4	3.11	3.97	0.34	0.67	0.76	0.85	2.6	2.88	4.09	3.25	3.9

*FYM- Farm yard manure, PSB- Phosphorus solubilizing bacteria, VAM-Vesicular arbuscular mycorrhiza, RDF- Recommended dose of fertilizer

Conclusion

Based on present investigation, the result revealed that the application of inorganic, organic, and bio-fertilizer significantly affect the growth attributes and yields such as plant height, number of primary and secondary branches, number of nodules, grain, and straw yield of chickpea. 50% RDF along with 5 t/ha vermicompost and seed inoculation with Rhizobium was found to be superior as compared to other treatments which are statistically at par with 50% RDF along with vermicompost and VAM and 50% RDF along with Vermicompost and PSB. Thus, it may be concluded that biofertilizer along with vermicompost is the best option to obtain higher growth attributes and yield of chickpea. It could be suggested to the farmer to get benefited from the use of biofertilizer along with vermicompost and minimize the use of inorganic fertilizer. It also improves the soil health and maintain soil fertility for longer period of time.

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