Fertilizer Requirement of Promising Desi Chickpea Strains Under the Environmental Conditions of Bahawalpur Area

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Abstract

A field assessment was carried out during Rabi season 2019–2021 at the research area of Regional Agricultural Research Institute (RARI), Bahawalpur (27.2046°N; 77.4977°E), Punjab, Pakistan. In this study, the effect of fertilizer application on two desi chickpea (*Cicer arietinum* L.) strains and the most suitable dose was investigated in the field under Bahawalpur environmental conditions. New advance chickpea strains BRC-446 and BRC-474 were tested with five levels of NPK @ 30-60-0 kg ha^{-1}, 60-80-0 kg ha^{-1}, 90-100-0 kg $ha^{-1}$and 60-80-60 kg ha^{-1} and no fertilizer representing treatments T_2, T_3, T_4, T_5 and T_1 (as a control) respectively, in a Split Plot Design with a plot size of 22.5 m^2. All P, K and ½ N was applied at sowing and remaining ½ N was applied at 1st irrigation. Cultural practices and plant protection measures were adopted as per recommendations. Data on plant growth and yield were recorded upon harvesting. Soil samples were collected before sowing and after harvest from two depths of 0-15 and 15-30 cm for EC, pH, O.M. & NPK determination. The statistical analysis of data showed that fertilizer levels had a significant but differential effect on seed yield of chickpea strains. Maximum yield of 1996 kg ha^{-1} and 2046 kg ha^{-1} was obtained for the strains BRC-446 and BRC-47, respectively under T_5 which was statistically at par with T_2, T_3 and T_4. There was a linear increase in yield of the strains from 30-60-0 kg ha^{-1} to 60-80-60 kg ha^{-1} kg NP level. According to the results obtained, T_2 was found to be the economical dose for both chickpea strains. However, the yield varietal differences for both strains were statistically non-significant. Fertilizers composed of five treatments NPK @ T_2=30-60-0 kg ha^{-1}, T_3=60-80-0 kg ha^{-1}, T_4=90-100-0 kg $ha^{-1}$and

T_5=60-80-60 kg ha^{-1} and No fertilizer as a control (T1). The results showed a significant increase in plant height when treated with T_5 compared to the control treatment. The Number of pods, seed plant^{-1} and pods plant^{-1}, seeds weight (g plant-1), 100 seeds weight (g), increased with treatment, T5=60-80-60 kg ha^{-1} which recorded the highest value compared to the other treatments. Fertilizer dose of 60-80-0 kg NPK per hectare proved to be the best for increasing chickpea yield under Faisalabad conditions. It has been figured out that the characteristic growth-response curves because of exposing plants to different level of NP fertilizer display progressively increased growth with increasing rate of NPK, but there is usually a decrease in growth at higher rate of the NP with no K (90-100-0). The response of strains in this study showed that both Chickpea strains are statistically non-significant but BRC-446 gives higher seed yield than BRC-474.

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Introduction

Pulses are the nutritionally-dense edible seeds of legumes, including dry peas, beans, lentils and chickpeas. Dry peas, lentils, beans, and chickpeas-known as pulses. Chickpea from fabaceae family is known as vital food grain in pulses group stands next to cereals and one of the oldest pulses and cultivated from ancient times throughout the world and widely used in Europe and in Asia because of its high protein contents (Singh et al., 2018). (Ali, 2017). It is assumed that gram is originated either from Mediterranean or Himalayas region. Now it is cultivated in Pakistan, Italy, India, Rumania, Greece, North Africa, Egypt, Russia, North Africa and many other countries of the world. Chickpea have importance due to its nutritional values of seeds as it contains high protein contents about 25 – 28% after dehulling. Chickpea seeds are eaten fresh as green vegetables, roasted, boiled and fried; as snack food, sweet and condiments; seeds are ground, and the flour can be used as soup and to make bread; prepared with pepper, salt and lemon it is served as a side dish as well as dal channa is very popular.

There are two main types of chickpea, distinguished by seed size, shape and color. The first relatively small seeds are called desi and with large seed called Kabuli. Desi chickpea is cultivated mainly in the Indo-Pakistan subcontinent. Chickpeas are used both for human consumption and animal feeds in rural and urban areas. Chickpea is grown in tropical, sub-tropical and temperate regions. Kabuli type is grown in temperate regions, while the desi type chickpea is grown in the semi-arid tropics. Gram covers a major portion of rice area in winter season and is common Dubari crop of rice tract in Sindh. Khushab, Thal desert, Cholistan and Bahawalpur are main growing areas are in Punjab.

Chickpea provide a balance diet to millions of people. Pulses are known as poor man's meat in developing countries while in developed world these are perceived as 'health food'. Being leguminous, pulses maintain soil fertility by converting and fixing atmospheric nitrogen in available form through symbiosis with rhizobial strains. Chickpea is an important conventional pulse crop of Pakistan. Due to high protein contents (20-25 percent) (Ali et al., 2010) it is considered as an economical source of quality vegetable protein in human diet. It contains 21 percent protein, 61 percent carbohydrates and 2.2 percent oil (5). It is not only a good source of protein but also a food of high nutritive value having considerable amount of vitamin A, B and C along with iron, phosphorus and calcium (Ali et al., 2010).

Production ranks third after beans with a mean annual production of over 11.5 million tons with most of the production centered in India. Land area devoted to chickpea has increased in recent years and now stands at an estimated 14.56 million hectares. Production per unit area has slowly but steadily increased since 1961 at about 6 kg/ha per annum. Over 2.3 million tons of chickpea enter world markets annually to supplement the needs of countries unable to meet demand through domestic production. Australia, Canada, and Argentina are leading exporters. Since 1961, the global production of the entire grain legume crops, namely chickpea, pigeon pea, cowpea, dry bean, faba bean, lentil, has increased at the rate of more than 1% per annum. Globally, chickpea has yield levels of about 850 kg/ha. The crop yields in the developing regions are very low. However, in the case of chickpea, some developing regions have exceeded the developed countries in terms of yield levels. The yield level in South and South-East Asia has increased by 13% from 717 kg/ha in 1994–1996 to 812 kg/ha in 2008–2010, growing at an annual rate of 0.8% (Nedumaran et al., 2013). Mean annual production share of chickpeas by region from 2008 to 2017 revealed that Asia shares 83% globally (Merga et al 2019)

Chickpea is grown in Pakistan on an area of about 2.2 million hectares and more than 80% of chickpea is grown in Thal area and the rest of the area is spread all over the country with the total production of 0.868 million tons and an average grain yield of 794 kg per hectare, which is too low than its potential (1600 kg/ha). Among various reasons for low yield, insufficient and non-judicious use of fertilizer is of prime importance (Economic Survey of Pakistan) and also climate effect (Ghazanfar, Komal et al. 2021, Mahmood, Rafique et al. 2021, Rebi, Ahmed et al. 2021, Rebi, Ashfaq et al. 2021, Rebi, Hussain et al. 2023). Pakistani soils are deficient of nitrogen and phosphorus in general, but rainfed areas are also deficient of potassium and other micronutrients. Low organic matter contents in soil is one of major causes of deficiency of the nutrients (Ahmad et al., 1998). Both nitrogen and phosphorus have a significant role in the performance and production of a crop(Rebi, Kashif et al. 2022, Rebi, Zhou et al. 2022, Naz, Rebi et al. 2023). Nitrogen is an important constituent of chlorophyll, protoplasm, protein and nucleic acid(Rasool, Ghani et al. 2023, Raza, Abbas et al. 2023). It is associated with high photosynthetic activity, the dark green colour of stem and leaves, vigorous growth, branching/tillering, leaf production and size enlargement. It improves the quality of fodders and protein contents of food grains. Phosphorus also stimulates early root development, leaf size, tillering, flowering, grain yield and hastens maturity. It is a constituent of certain nucleic acids i.e. phospholipids, chromosomes and the coenzymes nicotinamide adenine dineucleotide (NAD), adenosine triphosphate (ATP) and nicotinamide adenine dineucleotide phosphate (NADP). Phosphorus is essential for cell division, seed and fruit development (Ahmad, et al., 2003, Ghaffar, 1990). Application of nitrogen along with adequate amount of phosphorus has been reported to improve the grain yield even under low moisture conditions. Potassium is a major macro element taken up from the soil in large quantity used as a catalyst, chlorophyll formation, respirations, photosynthesis, water regulation and synergistic effect with nitrogen and phosphorus (Sahai, 2004). Fertilizer is not only the useful input by itself but also a catalyst in the promotion of other improved agricultural practices which have to be introduced simultaneously to get the best results from use of fertilizer (Kumar and Trivedi. 2005, Meena et al., 2003, Saeed, et al., 2004. Sharer, et al 2000). As chickpea is a legume crop, it requires fewer nitrogen application. Thus, there is a need to derive the adequate level of phosphorus and nitrogen for obtaining higher yield with good quality (Jain, and Singh. 2003). The present study was carried out to investigate the effect of different combinations of nitrogen, phosphorus and potassium on growth and yield of grain chickpea strains under agro-environment of Bahawalpur.

Materials And Methods

This study was conducted during 2019–2021 in Rabi Season (Winter) at the research area of Regional Agricultural Research Institute (RARI), Bahawalpur (27.2046°N; 77.4977°E), Punjab Province, Pakistan. According to Climate/Bahawalpur, Bhawalpur.punjab.gov.pk, this region has the climate characteristics of desert. During the year, there is virtually no rainfall in Bahawalpur. According to Köppen and Geiger, this climate is classified as BWh. The average annual temperature is 26.1 °C (79.0 °F) in Bahawalpur. The rainfall here is around 223 mm (8.8 inch) per year around 3852.73 hours of sunshine are counted in Bahawalpur throughout the year.

Experimental And Planting Materials And Design

The two desi Chickpea strains viz. BRC-446 and BRC-474 was used as a planting material having high yield, good quality and drought tolerant. It was advance lines evolved by the Regional Agricultural Research Institute, Bahawalpur. The fertilizer sources used for N fertilizer (urea containing 46% N), P fertilizer (Di Ammonium Phosphate containing 46% P_2O_5), and K fertilizer (potassium sulfate containing 50% K_2O) were applied according to treatment's plan.

The experiment was comprised of five treatments along with control; N-P-K @ T1=0-0-0 @ T2=30-60-0 kg ha^{-1}, T3=60-80-0 kg ha^{-1}, T4=90-100-0 kg $ha^{-1}$and T5=60-80-60 kg ha^{-1} respectively. All treatments in this experiment were laid out in split plot design maintaining a plot size of 2.5 m x 9 m(22.5m^{-2}) with three replications comprising of total 30 trial plots. Fertilizer levels were kept in main plots while chickpea strains were subjected to subplots. Row to row distance was maintained at 45 cm whereas plant to plant distance of 15 cm was maintained by thinning 30 days after sowing. The crop was sown with a single row hand drill using 60 kg per hectare seed in first week of October on well prepared seed bed using recommended methods of land preparation.

Soil Sampling and Analysis

Soil samples (pre-sowing) from experimental area were collected, processed and analyzed, after collecting composite soil samples for physico-chemical analysis. Soil texture and saturation parentage (sp) was determined. The pH of saturated extract and electrical conductivity (EC) of the soil sample were determined as described by Mclean (1982). while the soil organic matter (SOM) was determined by Nelson and Somer (1982) method. Total N & soil available P in soil was determined by Kjeldahl's, while available k in soil was determined by (NH4OAC-PH7) Ammonium acetate extraction method as descried by Knudsen, *et al* (1982).

Table 1: Physico-chemical characteristics of soils of experimental sites

Characteristics	Results
pH	8.3
EC_e (dS m^{-1})	3.1
O.M. (%)	0.52
N (mg kg^{-1})	26
P (mg kg^{-1})	5.1
K mg kg^{-1})	118
Textural Class	loam

Statistical analysis

The data on different yield parameters collected after providing similarly cultural practices during the growing season, was analyzed Statistically according to Steel *et al.*, (1997). The data were analyzed by Statistix 8.1 and means were compared by using least significant difference test (LSD $_{0.05}$). Statistical analysis of all the data were calculated as NPK rate treat as a main plot and strains took as sub- plot.

Land preparation and seed soiling

Chickpea is highly sensitive to soil aeration and required a loose and well aerated seedbed. This sensitivity imposed a restriction for its cultivation on heavy soils and calls for special care in seedbed preparation that's why loamy soil was used. A rough seedbed was prepared as per recommended method for chickpea. In this case the chickpea crop is taken after a kharif fellow so, deep ploughing was done during the monsoon as the same would help in larger conservation of rain water in the soil profile for subsequent use by this crop. After land preparation seeds were soiled with hand drill at a seed rate of 60 kg ha^{-1}. Each plot had an area of 22.5 m^2 (9 m long, 2.4 m wide), rows spacing ~ 60 cm apart. The plants were thinned at the two-leaf stage to a uniform density of 150,000 plants ha^{-1}. The fertilizers were applied to soil as a basal fertilizer to a depth of 15 cm when the seeds were sown. All P, K and ½ N were applied at sowing and remaining ½ N will be applied at first irrigation to avoid Nitrogen losses.

Cultural practices

Intercultural operations such as thinning, weeding, re-sowing, drainage, irrigation and plant protection measures were taken as and when necessary and kept usual and uniform for all the experimental plots.

Harvesting and Storage

Chickpea crop physically matured in almost 6 months when at maturity time all leaves turn brown/yellow. Plants are harvested slightly earlier or at maturity for dry seeds, by uprooting or cutting them near to the ground. After harvesting, crop is well dried by stacking plants in field for a few days. Threshing is made by beating with wooden flails, and then grains and chaff are separated by winnowing.

Measurement of chickpea yield and yield components

At Pod Maturity level in chickpea all plants were hand-harvested when one half to two third of the pods were mature within a 22.5 m^2 area of each plot. A 22.5 m^2 sample area was used to measure the yield per hectare. The seeds were first dried to 13% -15 % moisture before yield determination. The harvested plants were swathed to allow further maturity of the pods and further threshing. Selected three locations of 1m^2 in each plot randomly at the stage of physiological maturity, counted the pods per plant, and the 1000-grain weight was measured for five plants per plot and then average was calculated. The pods per plant were calculated from the average pods of five samples. For 1000-seed weight, 1000 seeds were weighed three times and the average weight was calculated. Grain yield was recorded by harvesting 1m^2 per plot. Grains were threshed and weighed manually. Grain yield was then converted to get the final grain yield in $kgha^{-1}$. Calculated Grain yield data regarding square meter was then converted into the final grain yield in $kgha^{-1}$. Collected data were analyzed following the analysis of variance using statistically by using computer application / software Statistix 8.1.

Results And Discussion

Plant height at maturity (cm)

The analysis of data (Table 2) represented that different NPK levels affected plant height significantly. Maximum plant height (89.3 cm) irrespective of varieties was obtained at NPK dose of 60-80-60 kg per hectare. Minimum plant height (74.6 cm) was recorded at NPK

level of 30-60-0 kg per hectare and 71.06 cm at NPK level 0-0-0.

Chickpea Strain BRC-446 (later on approved as variety "Bahawalpur Channa-21") produced taller plants (88.8 cm) (Table 2). The interaction between fertilizer levels and Strains (Table 2) was non-significant during this trial. Similar results were reported by Saad and Sharma (2003), Menaria *et al.* (2003) and Rajput, A., 2018.

Table 2. Impact of NPK on Plant height at maturity (cm)

Tr.	Nutrients (kg ha^{-1})			Plant height at maturity (cm)	
				BRC-446 (cm)	BRC-474 (cm)
	N	P_2O_5	K_2O		
T_1	0	0	0	72.8	71.06
T_2	30	60	0	75.1	74.6
T_3	60	80	0	82.1	81.8
T_4	90	100	0	89.3	89.1
T_5	60	80	60	88.8	88.5

Number of pods per plant (No.)

The data (Table 3) exhibited that number of pods per plant was affected significantly by different NPK levels. Number of pods per plant was significantly higher (151) at 60-80-60 kg per hectare NPK level. It is because of better supply of NPK which resulted in more photosynthetic activity and ultimately greater number of pods per plant was produced. Minimum number of pods per plant (110) was produced in control. Strain BRC-446 (Bahawalpur Channa-21) showed maximum pods per plant (151).

Table 3: Impact of NPK on Number of pods per plant (No.)

Tr.	Nutrients (kg ha^{-1})			Number of pods per plant (No.)	
				BRC-446	BRC-474
	N	P_2O_5	K_2O		
T_1	0	0	0	112	110
T_2	30	60	0	123	119
T_3	60	80	0	138	126
T_4	90	100	0	131	120
T_5	60	80	60	151	137

1000-grain weight (g)

Higher 1000-grain weight (Table 4) was recorded at fertilizer level of 60-80-60 kg

NPK (296.2 g). The lowest 1000-grain weight was recorded where no fertilizer was used

However, these results were non-significant. However, difference between varieties/strains towards 1000-grain weight was non-significant. Increasing phosphorus levels increased 1000-

grain weight by improving photosynthetic activity and source sink relationship.

Interaction of fertilizer and genotypes was non-significant. These results correspond to those of Kumar (2005).

Table 4: Impact of NPK on1000-grain weight (g)

Tr.	**Nutrients (kg ha^{-1})**			**1000-grain weight (g)**	
				BRC-446	**BRC-474**
	N	**P_2O_5**	**K_2O**		
T_1	0	0	0	228.61	223.0
T_2	30	60	0	237.3	229.6
T_3	60	80	0	268.2	257.1
T_4	90	100	0	251.3	249.2
T_5	60	80	60	296.2	281.7

Seed yield

Seed yield was also significantly affected by NPK treatments. All fertilizer doses enhanced chickpea seed yield significantly over control (no fertilizer) irrespective of varieties (Table 5). However, higher grain yield (2046 kg ha^{-1}) with the application of 60-80-60 kg NPK was noticed. Beyond this NP level seed yield reduced during this experiment. Higher dose of fertilizer (90-100-0 kg NPK) resulted in overgrowth (89.3 cm plant height), but less bearing (131 and 120 pods/plant) resulting in less grain yield in comparison with 60-80-0 kg NPK. This indicated that 60-80-0 kg NPK proved an optimum dose for obtaining maximum seed yield, under Bahawalpur conditions. Ghaffar, (1990), Jain et al., (2003), Jain et al., (2005), Kumar, et al (2005), Meena et al (2003), Sharer et al., (2000), Saad and Shama (2003), Ali et al., 2010 reported same differential response of chickpea to various fertilizer doses. Interactive effect of genotypes and NPK levels did not affect chickpea yield significantly.

Table 4: Impact of NPK on Seed yield

Tr.	Nutrients (kg ha^{-1})			Seed yield (kg ha^{-1})	
				BRC-446 (kg ha^{-1})	BRC-474 (kg ha^{-1})
	N	P_2O_5	K_2O		
T_1	0	0	0	1463	1413
T_2	30	60	0	1777	1727
T_3	60	80	0	1912	1862
T_4	90	100	0	1798	1748
T_5	60	80	60	2046	1996
					CV=12.92, LSD=243(0.05)

Conclusion

Both Chickpea Strains statistically at par but BRC-446 giving higher seed yield than BRC-474. Fertilizer dose of 60-80-0 kg NPK per hectare proved to be the economically best for increasing chickpea yield under Bahawalpur environmental conditions. It has been figured out that the characteristic growth-response curves because of exposing plants to different level of NP fertilizer display progressively increased growth with increasing rate of NPK, but there is usually a decrease in growth at higher rate of the NP with no K (90-100-0)

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