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Effect of crop geometry and phosphorus levels on growth and productivity of chickpea (*Cicer arietinum* L.)

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Abstract
An experiment was conducted during *rabi* season of 2014 -15 at Student Instructional Farm (SIF) of CSAUA&T, Kanpur, to investigate the effect of crop geometry and phosphorus levels on growth and productivity of chickpea (*Cicer arietinum* L.). The experiment was laid out in split plot design assigning ten treatment combination of two crop geometry (30cm x 15cm and 45cm x 15cm) as main-plot and five levels of phosphorous(00 kg P_2O_5(control), 30kg P_2O_5, 40kg P_2O_5, 50kg P_2O_5, 60kg P_2O_5) as sub-plot and found that 45cm x 15cm spacing with 20 kg 60 kg P_2O_5 ha^{-1} gave highest grain yield (13.15q ha^{-1}) followed by 30cm x 15cm spacing with 60 kg P_2O_5 (12.05 q ha^{-1}) while the lowest grain yield (8.23q ha^{-1}) was received in 30cm x 15cm spacing with 00 kg P_2O_5 ha^{-1}.

Keywords- Chickpea, Crop Geometry, Phosphorus Levels, Productivity, Growth.

1. Introduction
Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops of *rabi* season mainly sown in September-November and harvested in February. Crop duration is 90-120 days, depending on the variety. It is cultivated for its seeds which are rich source of protein and form an important part of vegetarian diet. Chickpea seeds contain about 17-20 per cent of protein. It is one of the major pulses cultivated and consumed in India, is also known as Bengal gram. In India, chickpea accounts for about 45% of total pulses produced in the country, similar to the case of other pulses, India is the major producing country for chickpea, contributing for over 75 per cent of total production in the world. Chickpea is the third most important pulse crop, after dry bean and peas, produced in the world. It accounts for 20 per cent of the world pulses production. Global production, as per the latest available estimates of Food and Agricultural Organization (FAO), is about 12 million metric tons in 2011. Chickpea is the third most important food legume crop Six countries including India, Australia, Turkey, Myanmar, Pakistan and Ethiopia account for about 90 per cent of world chickpea production and India is the largest producer contributing to 65 per cent of world's chickpea production (FAOSTAT, 2008). Chickpea are heavy feeder of phosphorus and less response of nitrogen because of their capacity to meet their own nitrogen requirement through symbiotic fixation. Phosphate fertilization of chickpea promotes growth, nodulation enhance yield of chickpea. Phosphorus also imparts hardiness to shoots, improves grain quality, regular the photosynthesis, governs other physico-bio-chemical processes and also helps in root enlargement, nodule production and thereby increases nitrogen fixation (Singh and Ram, 1990). Among other factors, phosphorus fertilization is of vital significance in affecting pulse production. Since an appreciable fraction of the phosphorus fertilizer added to the soil remains relatively unavailable to the crop. The availability of phosphorus rather than its total application assumes greater importance, although phosphorus availability is governed by a number of factors, moisture regime and phosphorus status of the soil. Phosphorus is a key nutrient element required for high and sustained productivity of grain legumes such as chickpea. For instance, low soil phosphorus and poor utilization efficiency of phosphorus is a major constraint limiting the productivity of most grain legumes (Aulakh *et al*., 2003) [2]. Legume crops usually respond well to phosphorus fertilizers (Shukla, 1964) [20] while the response of chickpea is variable (Saxena, 1980) [19]. Many studies found a positive yield response of chickpea to phosphorus fertilizer (Johansen and Sahrawat, 1991; Riley, 1994; Islam *et al*., 2011) [11, 18, 7-8], however, Chen *et al*., (2006) [4] reported that the rate of phosphorus required varies according to growth conditions. Phosphorus fertilization of chickpea promotes nodulation in chickpea and enhance yield.

It improves grain quality, regulates the photosynthesis and governs other physio-biochemical process besides holding root enlargement and increasing nitrogen fixation (Pyare and Dwivedi, 2005) [17]. Optimum plant population density in chickpea is an important factor to realize the potential yields as it directly affects plant growth and development. In our region, chickpea producers are choice high plant populations since they suppose that high seed rates are high yield, however, sometimes high seed rates are resulted in diseases and lodging. Earlier studies show that chickpea yields are remarkably stable over a wide range of population densities. The plants are able to fill available space by initiating lateral branches and, thus, can compensate for poor emergence and thin stands (Muehlbauer, 1973; Morrison and Muehlbauer, 1986; Salem *et al*., 2012). Increasing row spacing significantly influenced of growth, yield attributes and yield characters (Verma and Pandey, 2008) [23] Number of plants per unit area influences plant size, yield components and ultimately the seed yield (Beech and Leach, 1989). Both over and under plant densities resulted in significant yield decrease (Ashour, *et al.* 1995) Phosphorus is essential for cell division, seed and fruit development (Masood Ali *et al*. 2010), Thus the optimum plant population and suitable dose of phosphorus may play an important role for achieving quality production of chickpea. After considering the above facts in view the present investigation is carried out.

Materials and Methods

The present field experiment was conducted at the Student Instructional Farm (SIF) of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) India during the *rabi* season of 2014-15, experimental is located between latitude of $25^0$28' to $26^0$58' north and $79^0$31' to $80^0$34' east with an elevation of 125.9 m from the sea level. The average rainfall during crop season is 7.25 cm, the experimental site comes under the sub-tropical and semi-arid zone. The experiment was aimed to find out suitable crop geometry and optimum level of phosphorous for achieving higher yield. The soil of the experimental area was loam in texture with neutral in reaction (pH 7.4) low in available nitrogen (254.00 kg ha^{-1}), medium in available phosphorus (14.30 kg ha^{-1}) and medium in available potash (235.57 kg ha^{-1}). The experiment consisted of ten treatment combinations of two cropping geometry (30cm x 15cm and 45cm x 15cm) and five phosphorous level (00 kg P_2O_5(control), 30kg P_2O_5, 40kg P_2O_5, 50kg P_2O_5, 60kg P_2O_5) were replicated thrice in a split plot design. Besides the phosphorous crop was also fed as per recommendation with nitrogen @ 20kg ha^{-1} and potassium @ 40kg ha^{-1} in different treatment before sowing as plough sole placement. The popular recommended chickpea variety 'Uday' was sown in the starting of second fortnight of November of 2014 after a pre-sowing irrigation in the experiment at the seed rate of 70 kg $ha^{-1}$and 80 kg/ha seeds of chickpea were treated with *Rhizobium* culture as per two different spacing respectively. The sowing was done in furrows opened by *desi* plough at 30cm line (S_1) and 45cm line (S_2) to line distance and covers the seeds with fine soil after sowing.

Results and Discussion

The result revealed that the highest plant height was recorded in "30cm x 15cm spacing with 00 kg P_2O_5", fallowed by "45cm x 15cm spacing with 00 kg P_2O_5" , and "30cm x 15cm spacing with 30 kg P_2O_5" respectively. The fresh and dry weight $plant^{-1}$ recorded significantly improved in "45cm x 15cm spacing with 60 kg P_2O_5 fallowed by "45cm x 15cm spacing with 50 kg P_2O_5 ha^{-1}, "30cm x 15cm spacing with 60 kg P_2O_5" respectively. The root length , no of root branches , and no of root nodules $plant^{-1}$ recorded at all stage significantly improved in "45cm x 15cm spacing with 60 kg P_2O_5 ha^{-1}" fallowed by 45cm x 15cm spacing with 50 kg P_2O_5 ha^{-1}" and "30cm x 15cm spacing with 60 kg P_2O_5 ha^{-1}" respectively. The spacing and phosphorus levels improved the soil *tilth* and aeration increases the water holding capacity of the soil and stimulate the actively of micro organism that make the plant food element to the soil easily available to the crop by enhancing root growth and development. It enhances the microbial activities in the soil readily available to the enhance the microbial activities, improve the soil health physical properties of the soil mainly its component into various group are soil texture, soil structure, density, porosity consistent a colour and temperature significantly increases are growth parameter. Similar findings were also reported by Kamithi *et al*. (2009) [12], reported Increasing fertilizer rates and plant population increased dry matter at all stages and also the grain yield. Siag (1995) [21], Singh and Agrawal (2001) [22], Choudhary *et al.* (2008) [5] and Guriqbal Singh *et al.* (2008) [6].

Yield Attributes

In the present study the yield attributes *viz*- number of branches number of leaves $plant^{-1}$, pod $plant^{-1}$, straw weight $plant^{-1}$ and seed weight $plant^{-1}$ were significantly increased in "45cm x 15cm spacing with 20 kg N + 60 kg P_2O_5" fallowed by "45cm x 15cm spacing with 50 kg P_2O_5" and "30cm x 15cm spacing with 60 kg P_2O_5" respectively. It was because of the beneficial effect of spacing and phosphorus levels which promoted the growth and yield parameters significantly. The reasons attributed to this favourable effect of applied 30cm x15cm spacing with 60 kg P ha $^{-1}$ important role played by this including element in promoting reproductive process and seed development in the plant. Similar findings were also supported by Arya *et al.* (2002), Kumar and Sharma (2005) [13], Mansoor *et al.* (2006) Pingoliya, *el al.* (2014) [16].

Yields:- Biological yield, grain yield and straw yield of chickpea were also positively affected by row spacing and phosphorus levels so, highest biological yield recorded in "45cm x 15cm spacing with 60 kg P_2O_5" followed by "45cm x 15cm spacing with 50 kg P_2O_5" and "30cm x 15cm spacing with 60 kg P_2O_5" respectively while, grain yield recorded in "45cm x 15cm spacing with 60 kg P_2O_5" followed by "30cm x 15cm spacing with 60 kg P_2O_5" and "45cm x 15cm spacing with 50 kg P_2O_5" respectively. The harvest index in study year also increase of significantly in present experimentation in the crop with in "45cm x 15cm spacing with 60 kg P_2O_5 ha^{-1}" fallowed by "45cm x 15cm spacing with 50 kg P_2O_5 ha^{-1}" and "30cm x 15cm spacing with 60 kg P_2O_5 ha^{-1}" respectively. In present result may be because of significantly increased in vegetative characters such as growth and yield attributes. It is wall know that the presence of heavy nutrient would increase photosynthesis and enhanced the plant capability to produce carbohydrates, sugar starch formation of amino acid and protein and thus helping in fruiting and seed production, these all had played great roles in enhancing biological, grain and straw yield in present experimentation, Enania and Vyas (1995), Singh and Singh (1998), Jarande *et al.* (2006) [10] Nawange, *el al.* (2011) [15] Badini, S. A. *et al.* (2015) [3] also reported that significant increase in grain yield of chickpea row spacing and phosphorus levels.

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