The Pharma Innovation Journal 2020; 9(7): 309-311

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(7): 309-311

www.thepharmajournal.com
Received: 19-05-2020
Accepted: 21-06-2020

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Studies of row spacing and fertility levels on the performance of white gram (*Cicer kabulium* L.) in indo-gangetic plain zone of Uttar Pradesh

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Abstract
A field experiment was conducted during *rabi* season of 2014-15 at Soil Conservation and Water Management Farm of C S Azad University of Agriculture and Technology, Kanpur. The experiment consisted nine treatments *viz.* S_1F_1 (*i.e.* 30 cm and 10 kg N, 40 P, 20 kg K, 20 kg Sulfur), S_1F_2 (*i.e.* 30 cm and 20 kg N, 60 kg P, 20 kg K, 20 kg Sulfur), S_1F_3 (*i.e.* 30 cm and 30 kg N, 80 kg P, 20 kg K, 20 kg Sulfur), S_2F_1 (*i.e.* 40 cm and 10 kg N, 40 kg P, 20 kg K, 20 kg Sulfur), S_2F_2 (*i.e.* 40 cm and 20 kg N, 60 kg P, 20 kg K, 20 kg Sulfur), S_2F_3 (*i.e.* 40 cm and 30 kg N, 80 kg P, 20 kg K, 20 kg Sulfur), S_3F_1 (*i.e.* 50 cm and 10 kg N, 40 kg P, 20 kg K, 20 kg Sulfur), S_3F_2 (*i.e.* 50 cm and 20 kg N, 60 kg P, 20 kg K, 20 kg Sulfur), S_3F_3 (*i.e.* 50 cm and 30 kg N, 80 kg P, 20 kg K, 20 kg Sulfur) nine treatments were tested in factorial randomized block design with three replications. The results indicated that seed yield was maximum (10.23 q ha^{-1}) in 40 cm row spacing and (10.18 q ha^{-1}) fertility level 30 kg N, 80 kg P, 20 kg K, 20 kg S ha^{-1} of white gram would be quite remunerative for higher productivity alongwith seed yield in Indo-gangetic plain zone of Uttar Pradesh.

Keywords: Plant stand, plant height, number of branches, yield attributes and seed yield

Introduction
Globally, chickpea (*Cicer arietinum* L.) is the second most important legume crop after dry beans. Chickpea is grown in 54 countries with nearly 90% of its area covered in developing countries. Notably, almost 80% of global chickpea is produced in Southern and South-Eastern Asia and India ranks first in the world, contributing 68% of the global chickpea production accompanied by Australia (60%), Turkey (47%), Myanmar (42%) and Ethiopia (35%) Gaur *et al.*, (2012) [4]. Worldwide chickpea production is estimated to be 11.30 million tons from 12.14 million ha area with an average productivity of 931 kg ha^{-1}. In India, it tops the list of pulse crops and is cultivated in 8.32 million ha, producing a total of 7.70 million tons with an average yield of 925.5 kg ha^{-1} FAOSTAT (2014) [2]. From the nutrition perspective, chickpea seed contains 20-30% crude protein, 40% carbohydrate, and 3-6% oil. Besides, pulses supplemented diets are also good source of calcium, magnesium, potassium, phosphorus, iron and zinc Basavegowda *et al.*, (2019) [1].

Materials and Methods
The experiment was conducted during *rabi* season of 2014-15 in Soil Conservation and Water Management Farm of C S Azad University of Agriculture and Technology, Kanpur in alluvial soil. Soil of the experimental plot was sandy loam in texture and slightly calcareous having organic carbon 0.48%, total nitrogen 0.03%, available P_2O_5 12.6 Kg ha^{-1}, pH 7.3, electrical conductivity 0.34 dSm^{-1}, permanent wilting point 6.3%, field capacity 18.4%, maximum water holding capacity 29.6%, Bulk density 1.46 Mgm^{-3}, particle density 2.56 Mgm^{-3} and porosity 42.9%. The experiment was conducted in a factorial randomized block design with three replications and nine treatments *viz.* S_1F_1 (*i.e.* 30 cm and 10 kg N, 40 P, 20 kg K, 20 kg Sulfur), S_1F_2 (*i.e.* 30 cm and 20 kg N, 60 kg P, 20 kg K, 20 kg Sulfur), S_1F_3 (*i.e.* 30 cm and 30 kg N, 80 kg P, 20 kg K, 20 kg Sulfur), S_2F_1 (*i.e.* 40 cm and 10 kg N, 40 kg P, 20 kg K, 20 kg Sulfur), S_2F_2 (*i.e.* 40 cm and 20 kg N, 60 kg P, 20 kg K, 20 kg Sulfur), S_2F_3 (*i.e.* 40 cm and 30 kg N, 80 kg P, 20 kg K, 20 kg Sulfur), S_3F_1 (*i.e.* 50 cm and 10 kg N, 40 kg P, 20 kg K, 20 kg Sulfur), S_3F_2 (*i.e.* 50 cm and 20 kg N, 60 kg P, 20 kg K, 20 kg Sulfur), S_3F_3 (*i.e.* 50 cm and 30 kg N, 80 kg P, 20 kg K, 20 kg Sulfur).

"Pragati" was the variety of Kabuli gram was sown in different rows spacing in cm apart using 5 kg seed ha^{-1}. Full dose of P and K while half dose of N was applied as basal dose at the time of sowing where rest of N was given in two split doses during experimentation. Available moisture at sowing time upto 100 cm soil profile was 269.8 mm. Whereas amount of rainfall received during the crop period was nil against the average annual rainfall of about 800 mm. Recommended package of practices were applied in different treatments. Soil moisture was monitored gravimetrically using the sample collected from 0-25, 25-50, 50-75 and 75-100 cm soil depths at regular monthly intervals to quantify the soil moisture content and growth parameters by randomly selecting three plants for each plots till the harvest.

The data collected on growth, yield attributes and yields were statistically analyzed (Fisher and Yates, 1958) [3]. Recommended package of practices and fertilizers doses were applied in different treatments.

Results and Discussion

The Plant stand (Initial & final) was found maximum (14.12 m^{-2}) and (14.02 m^{-2}) under narrow (30 cm) row spacing and high fertility levels (*i.e.* 50 cm and 30 kg N, 80 kg P, 20 kg K, 20 kg S ha^{-1}) and low population (12.54 m^{-2}) and (11.86 m^{-2}) under wider (50 cm) row spacing and lower fertility levels (*i.e.* 10 kg N, 40 kg P, 20 kg K, 20 kg S ha^{-1}). Plant height at 30, 60, 90 and 120 days after sowing stage were found maximum at 30 cm along with the application of 30 kg N, 80 kg P, 20 kg K, 20 kg S ha^{-1}. It is well known fact that adequate fertilization to crop is known to improve various physiological and metabolic processes in the system. Phosphorus plays an important role as a structural component of the cell constituents and metabolic active compound. Increase N and P provide congenial nutritional environment to the crop plants. Such improvements under increased metabolic process in plants resulted in greater meristematic activities and applied growth thereby improving growth and development ultimately contributing towards improved photosynthesis of the plants Kumar *et al.*, (2016) [5] and Verma and Yadav (2017) [7, 8].

Number of branches $plant^{-1}$ Maximum branches observed under row spacing of 50 cm at 30 kg N_2, 80 kg P_2O_5, 20 kg K_2O, 20 kg S ha^{-1}. Yield attributing like number of pods $plant^{-1}$, number of seeds pod^{-1}, were higher under 50 cm row spacing at 30 kg N_2, 80 kg P_2O_5, 20 kg K_2O, 20 kg S ha^{-1} fertility levels. Except the number of seed per pod is higher in 40 cm row spacing Yadav *et al.*, (2014) [10].

This could be attributed to amending of soil with organic manure in conjunction with mineral fertilizers which helped in growth and development of plants. The yield attributing characters of white gram crop such as number of pods $plant^{-1}$, number of seeds pod^{-1}, Seed yield $plant^{-1}$ (g) and 1000-seed weight (g) were affected significantly due to different levels of fertilizers application. Yield attributing characters were found in increasing trend with increasing doses of fertilizers application Verma and Pandey, (2008) [9].

The seed yield differences due to fertilizer were found to be statistically significant over control. Seed yield was maximum (10.23 q ha^{-1}) in 40 cm row spacing and (10.18 q ha^{-1}) fertility level 30 kg N, 80 kg P, 20 kg K, 20 kg S ha^{-1}. All these characters might have resulted in appreciably higher seed yield $plant^{-1}$ which might be held responsible for seed yield per hectare Verma *et al.*, (2017) [7, 8] and Singh *et al.*, (2020) [6].

Table 1: Effect of row spacing and fertility levels on plant stand, plant height of white gram crop under different treatments.

Treatment	Plant stand (m^{-2})						Plant height (cm)														
	Initial			Final			30 DAS			60 DAS			90 DAS			120 DAS			At harvesting		
Row spacing (cm)																					
S_1	14.12			14.02			8.05			21.62			41.34			42.01			51.96		
S_2	13.10			12.82			7.52			20.72			40.50			40.96			50.98		
S_3	12.54			11.86			7.25			20.13			39.74			40.18			50.26		
Fertility levels (N,P,K,S in kg ha^{-1})																					
F_1	12.24			11.92			7.21			19.10			40.28			40.64			50.84		
F_2	12.98			12.72			7.49			20.56			40.54			41.19			51.24		
F_3	13.92			13.86			8.06			21.45			41.58			41.82			51.88		
	S	F	SXF	S	F	SXF	S	F	SXF	S	F	SXF	S	F	SXF	S	F	SXF	S	F	SXF
SE(d)±	0.45	0.45	0.74	0.48	0.48	0.84	0.22	0.22	0.38	0.34	0.34	0.65	0.38	0.38	0.66	0.20	0.20	0.35	0.29	0.29	0.51
CD (P=0.05)	0.96	NS	NS	1.02	1.03	NS	0.46	0.47	NS	0.79	0.79	NS	0.81	0.81	NS	0.42	0.42	NS	0.62	0.62	NS

Table 2: Effect of row spacing and fertility levels on number of branches of white gram crop under different treatments

Treatment	Number of branches														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvesting		
Row spacing (cm)															
S_1	5.80			11.36			12.34			12.64			13.32		
S_2	6.70			13.14			13.46			13.57			13.50		
S_3	7.76			14.12			14.52			14.62			14.61		
Fertility levels (N, P, K, S, in kg ha^{-1})															
F_1	6.36			12.27			12.94			13.12			13.34		
F_2	6.55			12.95			13.22			13.40			13.55		
F_3	7.00			13.63			14.13			14.48			14.61		
	S	*F*	*SXF*	*S*	*F*	*SXF*	*S*	*F*	*SXF*	*S*	*F*	*SXF*	*S*	*F*	*SXF*
SE(d)±	0.21	0.21	0.36	0.19	0.19	0.33	0.39	0.39	0.68	0.45	0.45	0.77	0.30	0.30	0.52
CD (P=0.05)	0.44	0.44	NS	0.40	0.40	NS	0.83	0.83	NS	0.94	0.94	NS	0.63	0.63	NS

Table 3: Effect of row spacing and fertility levels on yield attributing and yield of white gram crop under different treatments

Treatment	No. of pods plant^{-1}			No. of seeds pod^{-1}			Seed yield plant^{-1} (g)			1000 - seed weight (g)			Seed yield (q ha^{-1})		
Row spacing (cm)															
S_1	73.15			1.17			13.66			184.98			9.08		
S_2	75.62			1.52			15.08			191.78			10.23		
S_3	76.44			1.34			15.46			192.68			9.65		
Fertility levels (N, P, K, S in kg ha^{-1})															
F_1	74.00			1.32			14.28			186.10			9.06		
F_2	76.02			1.34			14.68			190.48			9.28		
F_3	76.83			1.38			15.14			191.98			10.18		
	S	F	SXF	S	F	SXF	S	F	SXF	S	F	SXF	S	F	SXF
SE(d)±	0.36	0.36	0.62	0.01	0.01	0.02	0.17	0.17	0.30	0.39	0.39	0.68	0.22	0.22	0.37
CD (P=0.05)	0.76	0.76	NS	0.02	0.02	NS	0.36	0.36	NS	0.83	0.83	NS	0.46	0.46	NS

Conclusion

From the foregoing discussion it can be concluded that application of Seed yield was maximum (10.23 q ha^{-1}) in 40 cm row spacing and (10.18 q ha^{-1}) fertility level 30 kg N, 80 kg P, 20 kg K, 20 kg S ha^{-1} of white gram would be quite remunerative for higher productivity alongwith seed yield in Indo-gangetic plain zone of Uttar Pradesh.

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