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Identification of suitable chickpea varieties for Zone-III B in general and Buxar in particular through farmers' participatory varietal selection approach

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Abstract
Most of the land under cultivation in Bihar state is monocropped, yet chickpea occupies a substantive area as a sequence "rabi" crop under rainfed condition in typical medium rice fallow. In the recent years, chickpea cultivation has increased manifolds throughout the country to meet the consumption of growing population and forced to switch over to the development and use of its high yielding varieties. Lack of sufficient variability has been one of the major bottlenecks in the improvement of self fertilized crop like chickpea. The existing genotypes of chickpea have very poor productivity potential. It has thus realized that if some suitable good yielding genotypes of chickpea could be identified and improved upon such situation, a quantum jump in increasing area and thereby increasing production of chickpea could be possible in Bihar state. In this present investigation an effort has been made to analyse the total variability. Keeping these aspects in view, the present experiment was conducted at the Farmer's field at Veer Kunwar Singh Agriculture College, Dumraon during the Rabi season of 2013-14 to 2016-17 in PVS mode. The material consisted of four genotypes of desi type and two Kabuli type which were evaluated for ten important quantitative three qualitative traits against local checks. The whole experiment was conducted in augmented block design. The result obtained in present investigation revealed that number of branches days to maturity, 100 seed weight, days to flowering are important yield contributing characters and hence these can be used for bringing yield improvement. The genetically divergent genotypes can be used as parents in hybridization programmes to develop superior genotypes. On the basis of mean performance of the germplasm, PG-186 and Pusa-372 for Desi type and Shubra for Kabuli type were found promising for more than one characters including grain yield and can be used for selection as genetically improved genotypes.

Keywords: varietal screening, chickpea, chickpea, improved varieties, self-sufficiency

Introduction
Chickpea is the third most important grain legume grown in the arid and semi-arid regions of the world Chickpea is one of the most important leguminous crop crop in Bihar and is extensively cultivated in dry and rain-fed areas. Chickpea (*Cicer arietinum* L.) with a genome size of 732 Mbp is a self-pollinated, diploid (2n = 2x = 16) cool season pulse crop grown in more than 44 countries representing all the continents under eight geographically diverse agro-climatic conditions (Croser *et al*., 2003) [2]. Chickpea production rose steadily to an all time high of 11.23 mt during 2017–18, which is 46% of the total pulses production (23.95 mt) in India. Among chickpea growing states, Madhya Pradesh, Maharashtra, Rajasthan, Uttar

Pradesh, Andhra Pradesh, Karnataka, Chhattisgarh, Bihar and Jharkhand contribute more than 95% to the total production. In India, both desi and kabuli type chickpea varieties are grown. In Bihar, chickpea occupies 0.06 million hectares area with an annual production of 0.066 million tonnes with productivity 1098 kg ha-1. It is also considered to have medicinal value for blood purification and is beneficial for diabetic patients.

Pulses maintain soil fertility through biological nitrogen fixation in soil and thus play a vital role in furthering sustainable agriculture (Kannaiyan, 1999) [3]. Chickpea (Cicer arietinum L.) is the fourth largest grain-legume crop in the world following soybean, dry pea and dry bean. However, the average productivity of chickpea in India is very low at about 600 Kg/ha against the average global productivity of 857 Kg/ha and 1,900 Kg/ha in Canada and USA in 2006-08.

Chickpea is being cultivated in more than 50 countries spread over Asia, Africa, Americas, Oceania and Europe. It is the most important pulse crop in India accounting for more than 48% of the total pulse production and 97% of total pulse export during 2013-14 (Anonymous, 2015) [1]. The productivity also varies between states indicating need for developing suitable high yielding varieties and matching crop production and protection technologies (Chaturvedi and Nandarajan, 2010) [4]. The seed coat contains most of the non-digestible carbohydrates and a relatively higher portion of calcium. Although the embryo is rich in protein, fat and minerals, its contribution is meager as the basis of total seed weight (Salunkhe and Kadam, 1989) [5]. Chickpea has major constituents like carbohydrates, protein, crude fibres, polyphenols and also provides vitamins and minerals.

Increase in chickpea production has been achieved through development of suitable technologies like high-yielding varieties along with matching production and protection technologies, quality seed producing units, etc. To attain self-sufficiency by 2050, the total pulse production in the country needs to reach 39 mt. This includes chickpea requirement of about 16–17.5 mt by 2050 from an area of about 10.5 m ha with average productivity of 15–17 q/ha. Nearly 90% of the crop is cultivated rain-fed mostly on receding soil moisture and on marginal lands. If managed well, the crop could bring high returns to the farmer in addition to enhancing sustainability of agricultural systems.

There is significant shift in the growing environment of chickpea from the cooler, long-season environments of northern India to the warmer, short-season environments of central and southern India. Chickpea area under late sown conditions is increasing particularly in northern and central India due to inclusion of chickpea in new cropping systems and intense sequential cropping practices leading to a prolonged exposure of chickpea to high temperature. Heat stress is a serious constraint to chickpea production in northern and central India. Reproductive stages (flowering and podding) in chickpea are susceptible to changes in external environment and heat stress (Summerfield *et al.*, 1984; Wang *et al.*, 2006; Krishnamurthy *et al.*, 2011) [6-8]. Highest productivity of 1430 kg/ha was recorded in Bihar state in 2012-2013. Genetic crop improvement depends upon exploitation of traits diversity available in the gene pool by providing useful information in parents' selection and their further utilization through plant breeding approaches. Diversified germplasm is a source that may have genes of biotic and abiotic stress resistance for future breeding programs. Recent plant breeding practices have narrowed genetic base of cultivated chickpea. However, characterization of newly developed genotypes for economic traits will assist in the development of superior cultivars (Naveed *et al.*, 2015) [9].

The study of genetic variability reveals about the presence of variation in their genetic contribution and is very important as it provide the basis of effective selection. Grain yield is a complex trait and highly influenced by many genetic and environmental factors. So, direct selection for yield as such could be misleading. A successful selection depends upon the information on the association of morpho-agronomic traits with seed yield.

Material Methods

The present investigation entitled "Identification of suitable varieties chickpea, *Cicer arietinum L.* germplasm) was done during the year 2014-16 rabi season at Farmer's field at Veer Kunwar Singh College of Agriculture, Dumraon (Buxar). This geographical location of Bihar comes under agro-climatic zone IIIB. It is situated between 25°'15'40'' N latitude to 87°'2'42'' E longitude and 46 meters above sea-level. The soil condition of agro-climatic zone IIIB is sandy loam, well drained, fertile with pH varies from 7-8.

Experimental Design and Layout: The plot size was two rows of 4 metre length and spacing of 30 x 10 cm (row to row and plant to plant).The normal package of practices of chickpea cultivation was followed during the crop growth period. The germplasm were harvested as per maturity during 5th to 20th April.

Experimental Materials

Two (02) experiments were sown in two districts viz.; Buxar and Bhojpur with 06 (Six) better performing chickpea varieties viz; Subhra, KAK-2, PG-186, Pusa-372, JG-16 and JG-14 received from BAU, Sabour to check the performance against local variety in PVS mode. These genotypes along with local variety were sown as checks in two environments i.e., normal sown (D/S: 31th Oct.) and late sown (D/S: 09th December) at Farmer's field at Dumraon (Buxar). Bihar, India. The list of genotypes is given in below Table 1).

Table 1: List of genotypes, their pedigree and source of the seed

Sl. No	Entry Name	Pedigree	Source
1	Subhra	L 144 × H 82-2	IIPR,Kanpur
2.	KAK-2	(ICCC 2 × Surutato 77) × ICC 7344-ICC× 870026-PBPB-14P-BP-62AK-7AKBAK	KKV
3.	PG-186	ILL 613 × Pant G 114	GBPUA&T, Pantnagar
4.	Pusa-372	P1231× P1265	IARI, New Delhi
5.	JG-14	(GW 5/7X P327) X ICCL83149	JNKVV, Jabalpur
6.	JG-16	ICCV4× ICCV10	JNKVV, Jabalpur

Observations Recorded

The data was recorded for each genotype from each replication in order to avoid the sampling error.

Pre-harvest observations

The following observations were recorded for each genotype in the field condition.

1. Days to 50% Flower (D50F)
The numbers of days were counted from the date of sowing to appearance of flower on almost 50% plants for each genotype.

2. Days to Maturity (DPM)
The numbers of days were counted from the date of sowing to the date when 80% of the mature pods in a plot were recorded for each genotype.

3. Chlorophyll Index (CI)
The SPAD chlorophyll Meter Readings (SCMR) was taken at 50% flowering stage in both the environments by using SPAD-502 meter (Minolta Konica Co. Ltd., Japan). For each entry five observations were recorded in all the replications and averaged. The chlorophyll content was recorded from the leaf of the top third leaflet that is near to rachis for each genotype in the direction of sun after 1:00 pm. The measurement was recorded in terms of SPAD values.

4. Canopy Temperature (CT)
Canopy temperature was recorded twice during whole crop season. First at vegetative stage (CT@VS) data was recorded at 55 days after sowing and second at pod filling stage (CT@PFS) data was recorded at 108 days after sowing. An infrared thermometer was used to record the plant canopy temperature after 12.00 pm. For each genotype two observations were recorded at a time from plant exposed in direction of sunlight.

5. Pollen Viability (PV) (%)
Five to ten floral buds were collected between 08:00 h and 08:15 h to examine pollen viability during 50% flowering. The anthers of all genotypes were mounted using 2% acetocarmine stain and replicated three times. Each anther was squashed and mounted on a slide. The samples were examined under a compound microscope in 40 x magnification. The fertile pollen grains inside the anthers were red in colour, while the sterile pollen grains were colourless. Stained (fertile) and non-stained (sterile) pollen grains were counted within whole focusing area and percentage of pollen viability was determined.

6. Plant Height (PH) (cm)
The plant height was taken from the shoot portion above the ground up to tip of all plants and an average of five plants was calculated and recorded.

7. Number of Primary Branches (PB)
Number of branches emerging directly from the tap root system of 5 plants of each genotype were counted and averaged.

8. Number of Secondary Branches (SB)
Number of branches emerging from primary branches of plants were counted and averaged for five plants

9. Post- harvest observations
Before harvest, at physiological maturity, five plants were randomly selected and all the post- harvest data were recorded for each genotype. An average of five plants was calculated.

10. Total Number of Pods per Plant (TPPP)
The total number of pods per plant was computed by counting the total number of pods on five plants and averaged.

11. Number of Effective Pods per Plant (EPPP)
The number of unfilled pods per plant was computed by counting the number of unfilled pods on five plants. It was then subtracted from total number of pods per plant and averaged.

12. Biological Yield (g) (BY)
The total weight of the biomass was taken on five plants basis along with pods and averaged.

13. Harvest Index (%) (HI)
The value of harvest index in percentage was calculated from the following formula given by Donald and Hamblin (1976).
Harvest index= Economical Yield/ Biological Yield ×100

14. Seed Index (g) (SI)
Weight of 100 seeds expressed in gram. Those plants which had number of seeds less than 100, weight of 50 seeds were recorded and doubled.

15. Grain Yield per Plant (g) (GYPP)
The total amount of seeds from each plant was weighed and recorded in gram (g) after threshing the dried pods. It was then averaged for five plants.

16. Grain Yield per Plot (kg/ha)
The total amount of seeds from each plot was weighed and recorded in kg/ha after threshing the dried pods.

Results and Discussion

1. Days to 50% flowering (D50F)
Days to 50% flowering varied from 67.54 days to 87.02 days in normal sown condition and 60.32 days to 78.24 days in late sown condition. Among the varieties PG-186 in normal sown condition 84 days and 68.4 days in late sown condition were earliest in days to 50% flowering. Rest of the varieties were at par with the checks in days to 50% flowering.

2. Days to maturity (DPM)
Days to maturity ranged from 128.22 days to 138.75 days in normal sown condition and 111.39 days to 117.21 days in late sown condition. Pusa-372of desi type and Kak-2 of kabuli type were the earliest under late sown condition, however all genotypes were at par with the checks in days to maturity.

3. Chlorophyll Index (CI)
The chlorophyll content ranged from 54.12 to 68.12 under normal sown condition and from 55.02 (JG 14) to 65.03 (PG-186) in late sown condition.

4. Canopy temperature at vegetative stage (CT)
Canopy temperature at vegetative stage ranged from 19.19 ˚C (JG-14) to 24.84 ˚C (PG 186) in normal sown condition and 25.74 ˚C to 30.56 ˚C in late sown condition. However, under late sown condition, the genotypes did not show any significantly higher or significantly lower canopy temperature at vegetative stage than the checks.

5. Canopy temperature at pod filling stage
Canopy temperature at pod filling stage ranged from 28.86 ˚C (PG 186) to 37.97 ˚C (Pusa-372) in normal sown condition and 39.48 ˚C to 44.78 ˚C in late sown condition. However, under normal sown condition, the genotypes did not show significantly higher or significantly lower canopy temperature at pod filling stage than the checks.

6. Pollen viability (%)
The data obtained on the basis of mean performance of pollen viability (%) revealed that there was a significant difference among the genotypes. The pollen viability varied from 100% to 72.06 % (Pusa -372) in normal sown condition and 76.27 % (PG 186) to 100 % in late sown condition.

7. Plant height (cm)
Plant height ranged from 44.6 cm (PG 186) to 86.79 cm (JG 14) in normal sown condition and from 36.21 cm (JG 16) to 63.7 cm (JG 14) in late sown. All genotypes namely JG 14, JG 16, PG 186 and Pusa 372 showed significantly higher plant height than the check.

8. Number of primary branches per plant (PB)
Number of primary branches per plant varied from 1.1 to 2.6 in normal sown condition and from 1.15 to 3.08 under late sown condition. Among the varieties (Pusa 372) (2.25) in normal sown condition and PG 186 (2.05) under late sown condition.

9. Number of secondary branches per plant (SB)
Number of secondary branches per plant varied from 2.76 to 5.75 in normal sown condition and from 3.29 to 6.49 under late sown condition. Among the checks, PG 186 (5.3) was considered as the best check in normal sown condition and Pusa 372 (5.5) under late sown condition. Under late sown condition, no genotypes had significantly more number of secondary branches per plant than the check but two genotypes; JG 14,JG 16 had significantly less number of secondary branches per plant than the check.

10. Total number of pods per plant (TPPP)
The mean performance of total number of pods per plant ranged from 23.73 to 197.68 in normal sown condition and 12.04 to 81.75 in late sown condition. Among the varieties, PG 186 (55.99) in normal sown condition and Pusa 372 (24.84) in late sown condition were considered more superior than the normal sown condition. Under late sown condition genotypes, PG 186, JG 16, JG 14 were found significantly superior Remaining all genotypes were at par with the check under both conditions.

11. Effective pods per plant (EPPP)
The mean performance of effective pods per plant ranged from 16.29 to 190.14 in normal sown condition and 9.76 to 75.27 in late sown condition. Among the varieties Pusa 372 (50.13) in normal sown condition and PG 186 (20.98) in late sown condition were considered as superior under normal sown condition genotypes; JG 14,JG 16 were found to have significant and more number of effective pods per plant.

12. Biological yield per plant (g)
Biological yield of the genotypes varied from 14.82 g to 314.59 g in normal sown condition whereas, in late sown condition it varied from 5.94 g to 43.2 g. Among varieties PG 186 (70.48 g) was identified as superior in normal sown condition whereas Pusa 372 (14.32 g) in late sown condition.

13. Harvest index (%)
The range of harvest index varied from 14.51% to 37.19% in normal sown condition and 20.1% to 55.63% in late sown condition. Among the varieties Pusa 372 (32.57%) in normal sown condition and PG 186 (40.41%) in late sown condition were considered as the best. Remaining varieties under both, normal sown condition and late sown condition were found at par with the checks in the respective environments.

14.100-Seed weight (g)
The 100 seed weight of genotypes ranged between 11.75 g and 38.25 g in normal sown condition and 13.03 g to 36.76 g in late sown condition. Among the varieties Pusa 372 was found to have the highest 100 seed weight (20.00 g) in normal sown condition whereas in late sown condition, PG 186 with 14.75 g as 100 seed weight had highest value. Under normal sown condition, genotypes; JG 14 and JG 16 were found to have significant and more 100-seed weight. However under late sown condition, twenty one genotypes; JG 14, JG 16 was found to have significant and more 100-seed weight. Remaining varieties under normal sown condition and under late sown condition were found at par with the checks.

15. Grain yield per plant (g)
The mean performance of grain yield per plant ranged from 3.9 g to 75.8 g in normal sown condition and 3.97 g to 24.99 g in late sown condition. Among the varieties PG186 (14.66 g) in normal sown condition and Pusa 372 (5.79 g) in late sown condition was considered as the best varieties across the environments. Remaining varieties under normal sown condition and under late sown condition were found at par with the checks in the respective environments.

16. Grain yield per plot (kg/ha)
Plot yield of the genotypes varied from 1095.9 kg/ha to 2988.7 kg/ha. Among varieties PG186 was identified as superior in normal sown condition whereas Pusa 372 (1151.48 kg/ha) in late sown condition. Remaining genotypes under normal sown condition and late sown condition were found at par with the checks in the respective environments.

Conclusions
In view of the results obtained in trials it can be concluded that significant differences exists among the genotypes for all the characters under study under both normal sown condition and late sown condition which indicated that considerable amount of variability was present in the genotypes. Hence, there is an ample scope for inclusion of promising genotypes in breeding programme for yield and its component characters. On the basis of mean performance the genotypes viz. Pusa-372, PG-186 and Shubra of Kabuli type were identified as the superior genotypes for yield and yield attributing traits viz. grain yield per plant, total number of pods per plant, effective pods per plant, primary branches per plant and 100-seed weight under normal condition and late sown condition.

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