Variability Studies on Yield, Drought Tolerant and Mechanical Harvestable Traits in Genotypes of Chickpea (*Cicer arietinum* L.)

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ABSTRACT

Genetic variability among thirty chickpea genotypes with three replications utilising 19 yield, drought tolerance and mechanical harvestable traits was studied under rainfed and irrigated conditions at Regional Agricultural Research Station, Nandyal, Andhra Pradesh, India. The analysis of variance carried out for 19 yield, yield attributing and drought tolerant traits revealed highly significant differences among the genotypes for all characters under rainfed as well as irrigated conditions. Variability study revealed high heritability accompanied with high to moderate genetic advance for drought tolerant traits like SLA, SCMR and proline. Traits related to mechanical harvesting *viz.,* height of the first pod and plant height exhibited moderate variability, high heritability and high genetic advance both under rainfed and irrigated conditions. Seed yield, harvest index, 100 seed weight and days to 50 per cent flowering exhibited moderate to high genetic variability, high heritability coupled with high genetic gain under rainfed and irrigated conditions.

Key words: Chickpea, Drought tolerance, Genetic variability, Mechanical harvestablility.

India is the largest producer of chickpea in the world with annual production of 9.07 million tons from an area of 9.54 m ha. with productivity of 951.4 kgha^{-1} (FAO STAT, 2019). In India chickpea area is mainly distributed in six states *viz*., Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Andhra Pradesh and Karnataka. In Andhra Pradesh, the area under chickpea has increased from less than one lakh ha (1993-94) to more than 6.0 lakh ha by 2007-08 registering the highest productivity of 1449 kg ha^{-1}. Introduction and widespread adaptation of short duration, wilt resistant varieties such as 'JG 11', 'JAKI 9218' and 'KAK 2' and mechanization of farming operations has contributed to witness the highest productivity. However, farmers are unable to go for machine harvesting operation, as the existing varieties have semi spreading growth habit and attain a short plant height of 35-40 cm in warm growing environments of Southern India. To enable complete mechanization (machine harvesting and threshing) of chickpea cultivation, development of chickpea cultivars with 30 to 40 per cent more height than the existing cultivars with semi-erect to erect growth habit and with branching starting from 25- 30 cm from ground level with yield potential equal to or more than existing popular cultivars is pressing need of current chickpea breeding programmes. Location specific breeding programmes at Regional Agricultural Research Station, Nandyal of Acharya N G Ranga Agricultural University in Andhra Pradesh state of India have led to development of a chickpea cultivar Dheera (NBeG 47) which is suited to mechanical harvesting (Jayalakshmi *et al.,* 2017).

In Southern India, drought stress particularly at the end of the growing season is a major constraint to chickpea production and yield stability. This problem is more serious in Andhra Pradesh where chickpea is traditionally planted towards the end of the rainy season and generally grown on progressively declined residual soil moisture. With predicted climate change scenarios and continuous population explosion, there is a great need to develop high-yielding chickpea varieties with improved drought tolerance (Krishnamurthy *et al*., 2013). Therefore, breeding efforts are needed to develop chickpea varieties suitable for machine harvest and with inbuilt tolerance to drought conditions. Therefore, study of genetic variability utilising physiological traits to be utilised in breeding for drought along with seed yield and yield components and traits which make cultivar amenable to machine harvesting would be useful for planning suitable breeding strategies to develop new machine harvestable chickpea genotypes with increased drought tolerance.

The investigation was carried out during *rabi* 2018-19 at Regional Agricultural Research Station, Nandyal, situated at 15°29' North latitude and 78°29' East longitude at an altitude of 211.76 m above mean sea level. The research station comes under scarce rainfall agro-climatic zone of Andhra Pradesh. The experimental material comprised of 25 *desi* chickpea genotypes and five checks *viz*., NBeG 47, NBeG 49, JG 11, GBM 2 and HC 5 which were sown on 24th October *rabi,* 2018 in a Randomized Block Design (RBD) with three replications under rainfed and irrigated situations.

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Since very meagre rainfall was received during *rabi* season, a pre sowing irrigation was given to take up the sowing of experiments. In rainfed condition genotypes were grown on receding soil moisture where as in irrigated condition two supplemental irrigations were given at 35 and 55 days after sowing through sprinklers. Each genotype was sown in two rows in a plot of 3m row length at spacing of 30 cm between rows and 10 cm between plants within the row. Observations were recorded on 19 traits *viz*., angle of the primary branch (°), height of the first pod (cm), plant height (cm), days to 50 per cent flowering, days to maturity, duration of reproductive phase, number of primary branches per plant, number of secondary branches per plant, SPAD Chlorophyll Meter Reading (SCMR), number of pods per plant, biological yield (g), harvest index (%), seed yield (g), 100 seed weight (g), Specific leaf area (SLA) ($cm^2 g^{-1}$), Relative water content (RWC) (%) at 30 DAS and 60 DAS, proline (µ mole g^{-1}) and protein content (%). The measures of variability were categorized in to high, medium and low as reported by various researchers. PCV and GCV were classified as low (< 10 per cent), moderate (10-20 per cent) and high (> 20 per cent) as per Subramanian and Menon (1973). Johnson *et al*. (1955) classified heritability as low (< 30 per cent), medium (30 to 60 per cent) and high (> 60 per cent) and; genetic advance as per cent of mean as low (< 10 per cent), medium (10 to 20 per cent) and high (> 20 per cent).

In crop improvement program, the efficiency of selection largely depends upon the magnitude of genetic variability present in the working germplasm. Hence, an insight into the magnitude of variability present in the working germplasm is of paramount importance to a plant breeder for starting a sensible plant breeding programme. Quantifying the extent of genetic variability, heritability of traits and the expected gains through selection are fundamental parameters that help in choosing a breeding programme. Chickpea is highly self-pollinated crop and limited variability has been reported for various traits of importance. Terminal drought is the major constraint limiting the productivity of chickpea since the crop is predominantly cultivated under residual and receding soil moisture conditions of rainfed environments. Under rainfed, residual soil moisture conditions, seed yield in chickpea can be increased by accumulation of genes for modified phenology, resistance to major biotic and abiotic stresses for maximum expression of yield potential and those traits that increase biomass and harvest index (Hegde *et al*., 2010). In view of increased demand for machine harvestable genotypes, there is also need to look for variability in the germplasm to incorporate these traits in new varieties that are being developed. In the present study the extent of genetic variability and the heritable portion of variability for yield attributing traits and traits amenable to mechanical harvesting and drought tolerance attributes under rainfed and irrigated conditions were studied and presented in Table 1.

Genetic variability for traits related to yield

High PCV and high GCV was recorded for seed yield per plot (rainfed : PCV = 31.6%, GCV = 30.1% and irrigated : PCV = 25.3%, GCV = 21.8%) under both rainfed and irrigated conditions; number of secondary branches per plant, number of pods per plant and harvest index recorded high PCV and high GCV under rainfed alone. High PCV and GCV values for number of pods per plant, harvest index and seed yield were reported earlier by Swarup and Holkar (2014).

High PCV coupled with moderate GCV was exhibited by number of primary branches per plant under rainfed and number of pods per plant under irrigated condition which was in accordance in with Parameshwarappa *et al.* (2012), Parhe *et al.* (2014) and Warkad *et al.* (2018).

Moderate PCV coupled with moderate GCV was recorded for days to 50% flowering, 100 seed weight and biological yield per plot under both rainfed and irrigated conditions. Moderate GCV and PCV for days to 50% flowering were reported earlier by Parhe *et al.* (2014), Singh *et al*. (2014) and Thakur *et al.* (2018). Under irrigated conditions, number of primary branches per plant, number of secondary branches per plant, harvest index and protein exhibited PCV and moderate GCV.

Protein content exhibited moderate PCV coupled with low GCV (PCV = 12.2%, GCV = 7.4%) under rainfed condition. Parhe *et al.* (2014), Singh *et al.* (2014) and Kumar *et al.* (2018) also reported low GCV for protein content.

Low PCV coupled with low GCV was observed for days to maturity (rainfed : PCV = 6.1%, GCV = 5.9% and irrigated : PCV = 5.9%, GCV = 5.8%) and duration of reproductive phase (rainfed : PCV = 6.6%, GCV = 5.3% and irrigated : PCV = 8.0%, GCV = 6.5%) under both the conditions. Low PCV and GCV for days to maturity were also reported by Kanouni *et al.* (2012) and Kumar *et al*. (2016).

Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection (Johnson *et al.,* 1955). Under both the tested environments, high heritability coupled with high genetic advance as percentage of mean was exhibited by days to 50% flowering (rainfed : h^2 b = 95.4%, GAM = 29.7% and irrigated : h^2 b = 92.6%, GAM = 30.6%), harvest index (rainfed : h^2 b = 92.3%, GAM = 47.1% and irrigated : h^2 b = 90.6%, GAM = 30.8%), 100 seed weight (rainfed : h^2 b = 97.2%, GAM = 37.6% and irrigated : h^2 b = 96.7%, GAM = 34.0%) and seed yield (rainfed : h^2 b = 90.9%, GAM = 59.1% and irrigated : h^2 b = 74.7%, GAM = 38.9%). Purushothaman *et al*. (2017) observed high heritability values for days to 50% flowering under drought stress conditions compared to irrigated treatments. He also observed high heritability for grain yield under drought treatments.

Effective selection for superior genotypes would be possible in chickpea by considering seed yield, harvest index, 100 seed weight and days to 50 per cent flowering under both rainfed and irrigated conditions where they exhibited moderate to high variability estimates as well as high heritability coupled with high genetic advance. Due to predominant additive gene effects in the inheritance of these traits, simple breeding procedures such as pure line

selection, mass selection and progeny selection can be followed. Exclusively under rainfed condition, number of secondary branches per plant, number of primary branches per plant, number of pods per plant and biological yield per plot associated with moderate variability, high heritability coupled with high genetic advance as percentage of mean can also be used as target traits as they exhibited sizeable genetic advance expected from simple selection. Under irrigated condition, protein with moderate variability, high heritability coupled with high genetic advance as percentage of mean can also be considered as a target trait.

Genetic variability for traits related to drought tolerance

Though breeding for high yield under drought tolerance through drought escape mechanism by early maturity is being practised, trait based breeding utilising physiological

Table 1: Genetic variability parameters for 19 characters in 30 chickpea genotypes under rainfed and irrigated condition during *rabi* 2018-19.

Characters		General	Range		PCV (%)	GCV(%)	h^2 b (%)	GAM (%)
		Mean	Min	Max				
Angle of the primary branch (°)	RF	74.7	69.1	81.1	4.2	3.7	78.6	6.8
	IR	75.8	70.9	83.2	4.1	3.8	83.9	7.1
Height of the firstpod (cm)	RF	25.3	18.4	35.4	17.0	16.4	92.6	32.4
	IR	26.3	20.5	34.9	14.0	13.3	89.6	25.9
Days to 50% flowering	RF	46.0	34.3	58.0	15.1	14.7	95.4	29.7
	IR	46.7	34.3	58.7	16.1	15.4	92.6	30.6
Days to maturity	RF	89.4	81.0	96.7	6.1	5.9	93.4	11.7
	IR	90.1	81.7	98.7	5.9	5.8	98.1	11.8
Duration ofreproductive phase (days)	RF	50.7	44.0	58.0	6.6	5.3	64.1	8.7
	IR	51.0	44.3	58.3	8.0	6.5	66.3	10.9
Plant height (cm)	RF	39.0	33.3	49.5	10.5	10.2	93.3	20.3
	IR	40.2	30.9	50.3	10.8	10.2	89.8	20.0
No. of primary branches $plant^{-1}$	RF	2.5	1.4	3.4	21.3	18.5	75.1	33.0
	IR	2.7	1.8	3.3	17.4	13.2	57.7	20.7
No. of secondary branches $plant^{-1}$	RF	7.8	4.2	13.4	30.5	28.2	85.9	53.9
	IR	8.0	6.5	11.9	16.4	12.6	58.6	19.8
SCMR	RF	54.9	47.1	63.7	9.7	8.1	68.6	13.8
	IR	56.3	43.6	70.7	11.8	10.5	78.9	19.1
SLA (cm^2 g^{-1})	RF	170.8	107.9	232.2	22.0	19.5	78.2	35.5
	IR	201.0	130.3	279.8	20.6	19.2	87.1	37.0
No. of pods $plant^{-1}$	RF	27.6	16.0	38.9	22.5	21.5	91.0	42.3
	IR	31.6	17.9	47.9	26.5	18.7	49.5	27.0
Biological yield $plot^{-1}$ (g)	RF	543.2	388.3	820.0	18.5	16.3	91.0	29.7
	IR	654.0	490.0	850.0	16.3	11.8	52.5	17.6
Harvest index (%)	RF	43.6	26.1	59.8	24.8	23.8	92.3	47.1
	IR	46.8	26.9	56.4	16.5	15.7	90.6	30.8
100 seed weight (g)	RF	24.9	16.0	32.3	18.8	18.5	97.2	37.6
	IR	25.4	17.7	33.7	17.1	16.8	96.7	34.0
RWC at 30 DAS (%)	RF	76.4	67.3	87.7	8.9	6.2	48.5	8.9
	IR	80.7	64.0	91.7	9.8	8.0	67.1	13.6
RWC at 60 DAS (%)	RF	62.2	49.0	72.1	10.4	6.1	34.2	7.3
	IR	63.5	56.7	70.0	8.3	4.3	27.2	4.6
Proline(µ mole $gram^{-1}$)	RF	3.7	1.4	5.6	33.4	30.6	84.0	57.8
	IR	2.7	0.9	4.8	34.9	30.6	76.8	55.2
Protein (%)	RF	18.2	14.7	22.2	12.2	7.4	36.1	9.1
	IR	19.0	14.5	24.5	15.9	14.8	87.1	28.5
Seed yield $plot^{-1}$ (g)	RF	237.2	139.0	403.3	31.6	30.1	90.9	59.1
	IR	308.3	141.7	426.7	25.3	21.8	74.7	38.9

GCV: Genotypic coefficient of variation; PCV: Phenotypic coefficient of variation;
h^2 b: Heritability in broad sense; GAM: Genetic advance as percent of mean.
RF = Rainfed; IR = Irrigated.

and shoots traits such as photosynthetic efficiency, chlorophyll content, chlorophyll refraction, ABA content, proline accumulation, stomatal conductance etc. has been proposed by several researchers for increasing the efficiency in selecting drought tolerant genotypes (Purushothaman *et al.,* 2016).

High PCV and high GCV was exhibited by proline (rainfed : PCV = 33.4%, GCV = 30.6% and irrigated : PCV = 34.9%, GCV = 30.6%) under both rainfed and irrigated conditions. High PCV coupled with moderate GCV was recorded by SLA under both the tested conditions.

Under both the tested environments, high heritability coupled with high genetic advance as percentage of mean was exhibited by SLA (rainfed: h^2 b = 78.2%, GAM = 35.5% and irrigated : h^2 b = 87.1%, GAM = 37.0%) and proline (rainfed: h^2 b = 84.0%, GAM = 57.8 % and irrigated : h^2 b = 76.8%, GAM = 55.2%). High heritability accompanied with moderate genetic advance was observed for SCMR under both rainfed and irrigated conditions. High heritability of SCMR was reported earlier by Jayalakshmi *et al.* (2011). Under irrigated condition, RWC at 30 DAS exhibited high heritability combined with moderate genetic advance as percentage of mean whereas under rainfed condition, it exhibited moderate heritability combined with low GAM. RWC at 60 DAS recorded moderate to low heritability together with low genetic advance which indicates that this trait is highly influenced by environmental effects and selection would be ineffective considering this trait.

Genetic variability for traits related to mechanical harvest

Under both rainfed and irrigated conditions, moderate GCV coupled with moderate PCV was recorded by height of the first pod and plant height. Mannur *et al.* (2017) reported moderate PCV for height of the first pod. Low GCV coupled with low PCV was observed for angle of primary branch under both rainfed and irrigated conditions.

High heritability coupled with high genetic advance as percentage of mean was exhibited by height of the first pod (rainfed: h^2 b = 92.6%, GAM = 32.4 % and irrigated: h^2 b = 89.6%, GAM = 25.9%) under both rainfed and irrigated conditions. Plant height also exhibited high heritability combined with high genetic advance as percentage of mean under rainfed condition in accordance to Akthar *et al.* (2011) and Babbar *et al.* (2012) whereas under irrigated condition it showed high heritability combined with moderate genetic advance as percentage of mean. High heritability combined with low genetic advance as percentage of mean was exhibited by angle of primary branch under both rainfed and irrigated conditions. Vishnu *et al.* (2018) also reported that height of the first pod under rainfed and irrigated conditions and plant height under irrigated condition exhibited moderate variability combined with high heritability and high genetic gain under selection. Among traits related to mechanical harvesting, height of the first pod and plant height exhibited moderate variability, high heritability and high genetic advance as percentage of mean under both environments.

CONCLUSION

In the present set of genotypes, substantial genetic variability with heritable portion of variability has been reported by days to 50% flowering, 100 seed weight, seed yield and harvest index under both rainfed and irrigated conditions; by number of primary and secondary branches per plant, number of pods per plant and biological yield under rainfed condition; by protein under irrigated condition. Drought tolerant attributes (proline, SLA and SCMR) and mechanical harvestable traits (plant height and height of the first pod) also had considerable amount of genetic variability under both the tested environments which can be exploited in breeding programmes aimed towards developing machine harvestable varieties of chickpea suitable for rainfed environments.

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