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Evaluation of yield parameters and biochemical characterization of drought tolerant and susceptible chickpea genotypes

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Abstract
Thirteen drought tolerant and susceptible chickpea (*Cicer arietinum* L.) genotypes *viz*., K850, KWR108, RSG 888, BG 256, BG 362, JG 315, JG 11, SAKI 9516, GCP 105, Pusa 372, Pant G 186, NDG 54 and DCP 92-3 grown on Student's Instructional Farm of Narendra Deva University of agriculture and technology, Kumarganj, Faizabad and were analyzed for their biochemical composition and yield attributes. The present study was conducted to evaluate the effect of drought stress on number of branches per plant, number of pods per plant, 100 seed weight and sugar composition of chickpea genotypes contributing to their adaptability to drought stress. Number of branches per plant was recorded maximum in genotypes GCP 105 and Pant G 186 in 2013-14 and in the 2014-15 GCP 105 recorded maximum number of branches per plant. Genotype K850 resulted maximum number of pods per plant in both of the year. In case of 100 seed weight genotype RSG 888 gave maximum value in experimental years. Sugar composition *i.e.* total sugar, reducing sugar and non reducing sugar of tolerant genotype (RSG 888) is highest in comparison to susceptible genotype (Pusa 372).

Keywords: Chickpea, drought stress, biochemical composition, branches, pods, seed weight, sugars

Introduction
Chickpea (*Cicer arietinum*) is a legume of the family Fabaceae, subfamily Faboideae. It is also known as gram, Bengal gram, garbanzo or garbanzo bean. Chickpea is largely cultivated in the temperate region (Joshi *et al.*, 2001) [14]. However, some studies show that it is grown across a wide range of environments (Rao *et al.*, 2002; Siddique *et al.*, 2000) [24, 29]. Chickpea is grown mainly in Central Asia, West Asia, South Europe, Australia and North Africa (Berger and Turner, 2007) [4].
Among the major chickpea producer countries, India, Pakistan, Turkey and Iran, most growing areas are classified as arid or semi-arid (Anonymous 2011) [2]. In these regions, chickpea is generally grown under rainfed conditions either on stored soil moisture in subtropical environments with summer-dominant rainfall or on current rainfall in winter-dominant mediterranean-type environments. In both environments, non irrigated chickpea plantations suffer yield losses from terminal drought (Yadav *et al.* 2006; Toker *et al.* 2007) [37, 34].
Agriculture is the major consumer of water resources in many regions of the world. Due to global warming and climate change, drought is increasing. In addition to this increase, the growing world population affects the availability of water. Therefore, water will become the most important vital substance in the near future. In recent years, understanding the effects of drought on plants has became a very important matter for improvement of plant breeding and management techniques in agriculture and in determination of the fate of natural vegetation in the environment (Chaves *et al.*, 2003) [6]. Yield of chickpea is determined by numerous aspects including genotype, growing season, geographical site, and agronomic practices (Tawaha *et al.*, 2005) [32]. However, in a particular chickpea genotype grain yield is an amalgamation of various yield contributing traits and has been remained the constant objective of the plant breeders (Saleem *et al.*, 2002) [26]. Some target is achieved by various studies based on different approaches either quantitative for example, grain yield, number of seeds per plant, number of pods (Rao *et al.*, 2007; Alwawi *et al.*, 2009; Kan *et al.*, 2010) [25, 1, 15] or qualitative for example, biochemical and molecular markers (Bhagyawant and Srivastava, 2008; Talebi *et al.*, 2008; Gujaria *et al.*, 2011) [5, 31, 12].

Under drought stress tolerant genotypes showed significantly higher total sugars in comparison to susceptible or moderately tolerant. Under high temperature stress the tolerant genotype showed 16.2% increase in total sugar content. The percent reduction in total sugars and non reducing sugars showed less in resistant genotypes compared to the susceptible genotypes (Kumar *et al.* 2012) [16].

Keeping in view, the present study was planned to understand the role of sugars like total sugars reducing sugars and non reducing sugars in stabilizing the grain yield under drought stress in chickpea genotypes.

Materials and Methods

Thirteen genotypes of chickpea differing in sensitivity to drought stress were evaluated in a randomized block design with three replications. Plant materials were obtained from the department of Genetics and Plant Breeding of the university (N. D. U. A. & T.) Kumarganj, Faizabad. After collection of the plant material it was grown on the Farm area of the Narendra Deva University of Agriculture and technology, Kumarganj, Faizabad in the Rabi season of year 2013-14 and 2014-15. In the selected genotypes seven genotypes (K 850, KWR 108, RSG 888, BG256, BG 362, JG 11 and SAKI 9516) were drought tolerant and rest of the six (DCP 92-3, JG 315, GCP 105, NDG 54, PUSA 372 and Pant G 186) were susceptible type. The climate of area was semi arid with hot summer and cold winter. Fertilizer and other crops were based on plant needs. Spacing between plants to plant was 10 cm and spacing between rows to row was 30 cm.

Number of branches per plant: Number of branches per plant was recorded by visual counting at maturity stage. Five tagged plants in each replication were counted and average number of branches plant^{-1} was computed.

Number of pods per plant: Total number of seeds bearing mature pods were counted separately from sampled five plants in each row and averaged out for single plant.

100-seed weight (g): The seeds of selected plants from each plot were mixed to draw a representative sample of 100 seeds, which was weighed in grams.

Sugar content in chickpea seeds: Ten ml alcohol (50%) was added to 0.1 g of well ground sample and then centrifuged at 5000 rpm for 15-20 minutes. Supernatant was collected and evaporated on water bath until 2-3 ml of it remained. This was followed by addition of 10 ml of CCl_4 and mixed well and left for 10 minutes at room temperature. After the addition of CCl_4 two layers were formed. The lower layer was discarded, while upper layer was separated and 10 ml of distilled water was added to it. This was used as a sugar extract for the estimation of both total and reducing sugars.

(a) Total sugar content in chickpea seeds: Total sugar was determined by the method of Dubois *et al.* (1956) [9] using phenol reagent. 0.1 ml of sugar extract was taken in test tube and volume was made up to 10 ml with distilled water. Then, 0.1 ml of 80 per cent phenol and 4 ml of concentrated H_2SO_4 was added by the side of test tube and then cooled down to room temperature. The intensity of the colour was recorded at 480 nm on spectronic-20 against blank solution. The calculation was done with the help of standard curve prepared from glucose solution.

(b) Reducing sugar content in chickpea seeds: Reducing sugar content in chickpea seed was determined by the method of Miller (1959) [20]. One ml of sugar extract was mixed with 3 ml of Dinitro salicylic acid (DNS) reagent, and kept over water bath for 10 minutes. The test tube was cooled to room temperature, and intensity of colour was measured at 575 nm against blank solution. The calculation was done with the help of standard curve.

(c) Non-reducing sugar content in chickpea seeds: The non-reducing sugar content was obtained by subtraction of reducing sugar from total sugar.

Non-reducing sugar = (Total sugar – Reducing sugar) x 0.95

Results and Discussion

Number of branches per plant

Number of branches per plant varied from 23 to 34 branches per plant and 21.07 to 33.00 branches per plant in the year 2013-14 and 2014-15, respectively. Maximum branches per plant were recorded in the genotypes GCP 105 and Pant G 186 (34 branches per plant) in the year 2013-14 and in the same genotype it was found 33 branches per plant in 2014-15. Minimum number of branches per plant was recorded in the genotype BG 256 (23 branches per plant) and BG 256 (21.07 branches per plant) in the year 2013-14 and 2014-15, respectively. Yadav *et al.* (2001) [36], Dhiman *et al.* (2006) [8] Obaidullah *et al.* (2006) [23], Lokare *et al.* (2007) [19], Valimohammadi *et al.* (2007) [35] and Kumar *et al.* (2015) [18] closely supported with variability in number of branches per plant. The reason weighed in favour of genetical characteristics, irrigated/rainfed condition and time of sowing.

Number of pods per plant

Number of pods per plant ranging from 37.33 to 57.33 pods per plant and 39.12 to 59.00 pods per plant in the year 2013-14 and 2014-15, respectively. Among all thirteen genotype, K850 (tolerant) resulted maximum number of pods per plant in both of the year which was found 57.33 pods per plant (2013-14) and 59.00 pods per plant (2014-15). Reduction in number of pods per plant was found in susceptible genotype Pusa 372 (37.33 pods per plant) in year 2013-14 and Pusa 372 (39.12 pods per plant) in year 2014-15. The reason caused due to genetical characteristics, time of sowing and irrigated/ rainfed condition. The results indicate close correlation with Lokare *et al.* (2007) [19], Kumar *et al.* (2014) [17], Nagar *et al.* (2014) [22], Shivakumar *et al.* (2014) [28], Kumar *et al.* (2015) [18], Singh and Kuhad (2015) [30].

100 Seeds Weight

Variation in 100 seeds weight was found 13.77 to 30.65 g and 15.63 to 28.00 g in the year 2013-14 and 2014-15, respectively. Out of thirteen chickpea genotype RSG 888 gave maximum 100 seeds weight in both of the year which was found 30.65 g and 28.00 g, respectively. Results of this study revealed that tolerant genotype RSG 888 showed significantly lesser reduction in yield. Variation in 100 seeds weight was found due to genetical characteristics, time of sowing and irrigated/ rainfed condition. The result was favourable agreement with Thagna *et al.*, (2009) [33], Munirathnam and Sangita (2009) [21], Kumar *et al.* (2014) [17], Nagar *et al.* (2014) [22], Bazvand *et al.* (2015) [3] and Kumar *et al.* (2015) [18].

Table 1: No. of branches per plant, No. of pods per plant and 100- seeds weight of different genotypes of chickpea

Genotypes name	No. of branches per plant		No. of pods per plant		100-seeds weight(g)	
	2013-2014	2014-15	2013-2014	2014-15	2013-2014	2014-2015
K 850	27.67	26.00	57.33	59.00	23.37	22.12
KWR 108	28.00	26.40	53.00	55.35	19.27	20.23
DCP 92-3	29.00	27.00	48.00	47.00	15.05	17.23
RSG 888	25.65	26.00	57.00	55.35	30.65	28.00
BG 256	23.00	21.07	48.33	49.55	25.66	26.17
BG 362	27.00	25.00	49.33	47.33	23.46	21.87
JG 315	30.33	28.42	38.67	40.00	15.69	17.32
JG 11	28.33	26.12	52.67	51.00	22.90	23.71
SAKI 9516	27.67	26.50	51.00	49.00	13.77	15.63
GCP 105	34.00	33.00	47.33	46.00	20.21	21.10
NDG 54	33.00	32.10	47.67	45.33	24.10	22.22
PUSA 372	33.00	32.00	37.33	39.12	24.54	23.12
Pant G 186	34.00	31.97	38.67	40.37	19.27	20.13
SEm±	1.35	0.21	2.47	2.46	0.48	0.24
CD (at 5%)	3.95	0.61	7.5	7.23	1.40	0.71

Reducing sugar content in chickpea seeds

Reducing sugar content in various genotypes was obtained between 1.57 to 2.89 g/100g in year 2013-14 and 1.50 to 2.62 g/100g in the year 2014-15. Maximum reducing sugar content in seeds was found in the tolerant genotype RSG 888 (2.89 g/100g) and minimum reducing sugar content in seeds was noticed in the susceptible genotype Pusa 372 (1.57 g/100g) during year 2013-14. In year 2014-15 maximum reducing sugar content in seeds was recorded in the genotype RSG 888 (2.83 g/100g) and minimum reducing sugar content in seeds was noticed in the genotype Pusa 372 (1.50 g/100g). The reason weighed in favour of environmental factor. These results have been favoured by Shad *et al.* (2009) [27] and Garg and Sabharwal (2014) [10].

Non reducing sugar content in chickpea seeds

Non reducing sugar content in various genotypes was obtained between 5.28 g/100 g to 6.66 g/100g (2013-14) and 5.36 g/100 g to 6.60 g/100 g (2014-15). During 2013-14 maximum non reducing sugar content in seeds was noticed in the tolerant genotype RSG 888 (6.66 g/100g). In the year 2014-15 maximum non reducing sugar content in seeds was noticed in the same genotype RSG 888 (6.60 g/100g). Decline non reducing sugar content in seeds was noticed in susceptible genotypes NDG 54 and Pusa 372 (5.28 g/100g) in 2013-14 and in 2014-15 it was recorded in Pusa 372 (5.36 g/100g). The reason caused due to environmental factor. This result was favourably associated with Shad *et al.* (2009) [27], Kumar *et al.* (2012) [16] and Garg and Sabharwal (2014) [10].

Total sugar content in chickpea seeds

Total sugar content in various genotypes was found between 6.84 g/100 g - 9.55 g/100 g (2013-14) and 6.86 g/100 g to 9.43 g/100 g (2014-15). Highest total sugar content in seeds was noticed in tolerant genotype RSG 888 *i.e.* 9.55 g/100g and 9.43 g/100g in 2013-14 and 2014-15, respectively. Minimum total sugar content in seeds was found in the susceptible genotype Pusa 372 (6.84 g/100g) in the year 2013-14 and 6.86 g/100g in the year 2014-15 in same genotype. The result was highly favours with Kumar *et al.* (2012) [16], Garg and Sabharwal (2014) [10] and Ghribi *et al.* (2015) [11]. Jain and Jain (2013) [13] analyzed that a higher amount of grain protein and soluble sugars were found under moisture stress however, starch content decreased. Choudhary *et al.* (2013) [7] observed total soluble sugar and total starch in leaves and stem increased from vegetative to pod initiation stage in all the chickpea genotypes of different seed size, but the contents were significantly higher in large-seeded genotypes at pod initiation stage. Higher total soluble sugars and total starch was observed in podwall of large-seeded genotypes till 20 days after flowering (DAF) as compared to small and medium seeded genotypes, which indicates better capacity of podwall to acts as a major sink for assimilates and afterwards it became a source for the developing sinks. Singh and Kuhad (2015) [30] showed water deficit resulted in marked reduction in starch, total soluble sugars, proteins and accumulation of free amino acids in seeds.

Table 2: Reducing sugar, non-reducing sugar and total sugar content (g/100g) of different genotypes of chickpea seeds

Genotypes Name	Reducing sugar (g/100g)		Non reducing sugar (g/100g)		Total sugar (g/100g)	
	2013-2014	2014-15	2013-2014	2014-15	2013-2014	2014-2015
K 850	2.60	2.62	6.57	6.48	9.17	9.10
KWR 108	2.35	2.32	6.43	6.40	8.78	8.72
DCP 92-3	1.59	1.57	5.73	5.64	7.32	7.21
RSG 888	2.89	2.83	6.66	6.60	9.55	9.43
BG 256	1.92	1.89	6.48	6.45	8.40	8.34
BG 362	1.81	1.86	6.06	5.96	7.89	7.82
JG 315	1.68	1.70	5.64	5.66	7.31	7.36
JG 11	2.44	2.40	5.89	5.81	8.33	8.21
SAKI 9516	2.49	2.41	6.13	6.16	8.62	8.57
GCP 105	1.70	1.63	5.41	5.38	7.11	7.01
NDG 54	1.62	1.58	5.28	5.42	6.90	7.00
PUSA 372	1.57	1.50	5.28	5.36	6.84	6.86
Pant G 186	1.58	1.60	5.33	5.39	6.91	6.99
SEm±	0.12	0.02	0.15	0.04	0.11	0.05
CD (at 5%)	0.36	0.05	0.45	0.11	0.34	0.16

Conclusions

The present research work entitled "Evaluation of yield parameters and biochemical characterization of drought tolerant and susceptible chickpea genotypes" was carried out in different genotypes of chickpea. Number of branches per plant was recorded maximum in genotypes GCP 105 and Pant G 186. Tolerant genotype K850 resulted maximum number of pods per plant in both of the year. In case of 100 seed weight genotype RSG 888 gave maximum value in experimental years. Sugar composition *i.e.* total sugar, reducing sugar and non reducing sugar of tolerant genotype (RSG 888) showed highest value in comparison to susceptible genotype (Pusa 372). It was found that there was less reduction in yield parameters under drought stress in tolerant genotypes, which may possibly be due to the higher accumulation of sugars.

In the present study an attempt has, therefore been made to study the precise nature of differential responses of chickpea genotypes and basis for tolerance and susceptibility of different genotypes under drought stress condition. This will facilitate to search the possibility of chickpea under drought stress environment and also to generate new information for further research. Therefore, these genotypes can be used as sources of drought tolerance in further breeding programme for evolving the drought tolerant genotypes in chickpea.

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