SHORT COMMUNICATION

Morpho-Physiological Evaluation of Chickpea (*Cicer arietinum* L.) Cultivars Under Restricted Soil Moisture Conditions

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(Received: 29 January 2013; Revised: 23 February 2013; Accepted: 1 March 2013)

A field experiment was conducted to evaluate the performance of 12 cultivar of chickpea released from IARI including six *desi* type namely, BGD 72, Pusa 256, Pusa 362, Pusa 372, Pusa 391 Pusa 1103 and six *kabuli* type namely, Pusa 1003, Pusa 1053, Pusa 1088, Pusa 1105, Pusa 1108, Pusa 2024 were evaluated under restricted soil moisture conditions. On the basis of seed yield performance, Pusa 1105, Pusa 2024, Pusa 1053 and BGD 72 were found superior as compared other cultivars tested. Membrane Stability Index (MSI) and Relative Water content (RWC) were recorded relatively higher in BGD 72, Pusa 1103. The above cultivar may be recommended for cultivation in North-West Plains Zone under restricted soil moisture conditions. BGD 72, Pusa 1103 and Pusa 2024 are also suitable to be used as parent in breeding for improving the drought tolerance in chickpea as these cultivars exhibited higher MSI and RWC values amongst all the cultivars.

Key Words: Chickpea, Drought tolerance, Membrane stability index, Relative water content, Seed yield

Chickpea is the most important food legume in India by virtue of its maximum contribution in area and production among the pulses. India grows chickpea on about 8.56 million hectares area producing about 7.35 million tonnes with a productivity of 858 kg/ha during 2009-2010 (http://www.aicrpchickpea.res.in). It is one of the most important food legume crop of the world and is grown extensively throughout most of the Indian sub-continent, North Africa, West Asia and in the Mediterranean regions. The chickpea is grown exclusively in the arid and semiarid zones of the world. In these areas, chickpea is continuously exposed to increasing drought and high temperatures during flowering and maturity stages due to insufficient and irregular rainfall (Toker *et al.*, 2007). About 90% of world's chickpea is grown under rainfed conditions where terminal drought is the major stress, accompanying with high temperature stress. The high temperature at post flowering phase results in forced maturity and reduced biomass production, several physiological, morphological and phenological traits may play a significant role in crop adaptation to drought stress during soil drying. Zaman-Allah (2011) found that tolerant genotypes possessed lower water uptake and a lower index of stomatal conductance at the vegetative stage as compared to sensitive ones, while tolerant genotypes extracted more water than sensitive genotypes after flowering. The other major constraints of low productivity are abiotic stresses salinity and nutrients. However moisture and high temperature stress are most important for limiting productivity of chickpea. The present study was conducted to evaluate the performance related to morpho-physiological traits of 12 cultivars with different parentage under restricted soil moisture conditions.

An experiment was conducted at research farm of Indian Agricultural Research Institute (IARI), New Delhi, 2009 and 2010 with 12 cultivar of chickpea including six *desi* types, namely, BGD 72, Pusa 256, Pusa 362, Pusa 372, Pusa 391 Pusa 1103 and six *kabuli* types, namely, Pusa 1003, Pusa 1053, Pusa 1088, Pusa 1105, Pusa 1108, Pusa 2024. The parentage of above mentioned cultivars are presented in Table 1. Soil was sandy loam with 7.8 pH and contained organic carbon 0.42% and available P 12.8 kg/ha. A basal dose of 20 kg N and 60 kg $P_2 O_5$ was applied at sowing. The crop was sown with three replications in Randomized Block Design. The crop was irrigated only at 70 days after sowing and then grown on restricted soil moisture conditions in the field. Observations were recorded for duration of different phenophases, namely, days to first flowering, days to 50% flowering, days to first pod formation, days to 50% pod formation and days to physiological

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Table 1. Pedigree of chickpea cultivars used in experiment

Type	Cultivar	Parentage
Desi	BGD 72	(Pusa 256 x E 100 YM) x Pusa 256
	Pusa 256	(JG 62 x 850 – 3/27) x (L – 550 x H 208)
	Pusa 362	(BG 203 x P 179) x BG 303
	Pusa 372	(P 1231 x P 1265)
	Pusa 391	(ICC 3935 x Pusa 256)
	Pusa 1103	(Pusa 256 x *Cicer reticulatum*) x Pusa 362
Kabuli	Pusa 1003	(ICCV 32 x Rabat)
	Pusa 1053	(ICCV 3 x FLIP 88 – 120)
	Pusa 1088	(Pusa 256 X ICCV 32) x ICCV 32
	Pusa 1105	(C 104 x BG 1003) x (ICC 88503 x BG 1048)
	Pusa 1108	(BG 315 x ILC 72) x (ICCV 13 x FLIP 85 – 11) x (ICCV 32 x Surutoto 77)
	Pusa 2024	(BG 261 x ICC 88503) x (GL 920 x BG 1003)

maturity. Data on yield and yield component traits namely, plant height (cm), number of primary branches, number of pods/plant, pod weight/plant (g), 100-seed weight (g), biological yield/plant (g), seed yield/plant (g) and harvest index (%) were also recorded under restricted soil moisture conditions. Membrane stability index (MSI) and relative water content (RWC) were estimated by following methods suggested by Deshmukh *et al.* (1991) and Barrs and Weatherlay, (1962), respectively.

Data recorded on different phenophases, MSI, RWC are presented in Table 2. Wide range of variations were recorded in all the phenophases of cultivars. Lower values of phenophases and higher values for MSI (%) and RWC (%) are the indicators for better performance under restricted water conditions. The *kabuli* type cultivars flowered earlier (56-66 days) as compared to *desi* types (62-72 days). Nearly similar trend was observed in days to 50% flowering also. In Pusa 1105, Pusa 2024, Pusa 1088 and Pusa 1003 achieved 50% pods relatively earlier (85-90 days) in comparison to other cultivars tested. No much significant differences were observed in physiological maturity amongst the two types of cultivars. However, *kabuli* type Pusa 1105 (145 days), and *desi* type Pusa 256 (146 days) were found as early maturing cultivars (Table 2). Nanda and Saini (1991) observed five days reduction in total flowering duration under restricted soil moisture. Earliness is a desirable trait for better adaptation to such environments, characterized by terminal drought and heat stress. It helps in drought escape whereby the crop completes its life cycle before the onset of terminal drought. It has been reported that the reduction of flower production due to water stress may reach up to 60% in chickpea (Fang *et al.*, 2010).

Membrane stability index values were significantly higher (76.17-78.47%) in BGD 72, Pusa 1103, Pusa 1108, and Pusa 256 (Table 2). Higher RWC (73.6-74.11%) were also recorded in BGD-72 and Pusa-1103. Gupta *et al.* (2000) observed that the genotypes, which were more tolerant to moisture stress, had lower membrane injury (less ion leakage) and low drought susceptibility index. Singh *et al.* (2004) observed that at pod formation stage all genotypes showed relatively higher membrane injury than at vegetative and flowering phases. This indicated natural senescence of leaves or more realization of stress during pod formation stage and also reported that BGD 72 and Pusa 1103 possessed significantly higher values of RWC, so these genotypes performed better under limited water environments. RWC was a measure of stress adaptation and accounts for osmotic adjustment, which is considered to be one of the important mechanism for adaptation to water limited environments in plants. BGD 72 registered high RWC than ICCV2 at the end point (Jain and Chattopadhyay, 2010).

The data on plant height, number of primary branches, number of pods/plant, pod weight/plant, 100-seed weight, biological yield/plant, seed yield/plant and harvest index (%) are presented in (Table 3). Plant height (cm) ranged from 63.87 to 85.00 in all the cultivars tested. Pusa 1105, Pusa 2024, Pusa 1053, and BGD 72 gave seed yield equal to or more than 24 g/plant; similarly higher number of pods/plant (84-96), pod weight/plant (32-34 g), 100-seed weight/plant (27-28 g) and biological yield/plant (55-66 g) were recorded (Table 3). High harvest index values were observed in all the cultivars mentioned above except BGD 72. It is evident that pods/plant, 100-seed weight and biological yield have contributed towards higher seed yield in the cultivars grown in restricted water conditions. Mwanamwenge *et al.* (1999) observed that maximizing the number of flowers, pods and seeds are the most important traits for maintaining stable and high seed yield under water deficit condition in Faba bean. The development of water deficit during the reproductive stage plays an important role in determining the number of flowers and pods that produce seed yield. Pod abortion was known to be important in determining seed yield of chickpea when exposed to terminal drought, but flower production and abortion were, important factors reducing seed yield (Fang *et al.*, 2010). Krishnamurthy *et al.* (1999)

Table 2. Duration of different phenophases, membrane stability index (MSI) and relative water content (RWC) of chickpea cultivars under restricted moisture conditions in the field

Type	Cultivar	Days to first flowering	Days to 50% flowering	Days to first pod formation	Days to 50% pod formation	Days to physiological maturity	MSI (%)	RWC (%)
Desi	BGD 72	66	75	89	104	155	78.47	74.11
	Pusa 256	66	75	86	96	146	76.17	67.63
	Pusa 362	62	75	87	93	155	64.00	58.80
	Pusa 372	71	75	88	99	156	55.27	58.00
	Pusa 391	72	82	89	95	154	65.47	63.43
	Pusa 1103	72	80	87	95	154	78.30	73.63
Kabuli	Pusa 1003	58	74	82	90	154	64.80	58.53
	Pusa 1053	58	76	88	104	155	61.80	62.30
	Pusa 1088	66	75	84	90	155	68.27	57.13
	Pusa 1105	56	67	76	85	145	54.76	56.97
	Pusa 1108	57	69	86	95	154	76.17	64.17
	Pusa 2024	56	70	84	90	153	68.90	61.63
CD 0.05)		2.16	2.67	1.56	4.22	2.27	2.02	1.61

Table 3. Yield and yield component traits of chickpea cultivars under restricted moisture conditions in the field

Type	Cultivar	Plant height (cm)	No. of primary branches	No. of pods/ plant	Pod weight/ plant(g)	100-seed weight (g)	Biological yield/ plant (g)	Seed yield/ plant (g)	Harvest index (%)
Desi	BGD 72	76.06	6	84.37	32.77	27.50	60.27	24.93	37.03
	Pusa 256	63.87	6	73.10	15.83	17.43	35.57	12.80	34.93
	Pusa 362	79.33	4	61.50	21.67	22.89	37.23	16.47	46.00
	Pusa 372	72.17	4	65.09	16.57	21.73	32.27	12.60	41.97
	Pusa 391	74.13	5	59.66	18.73	23.40	35.63	15.77	45.43
	Pusa 1103	82.53	6	52.60	19.77	22.67	32.47	15.03	43.43
Kabuli	Pusa 1003	71.43	4	33.40	10.80	21.93	22.69	8.72	37.63
	Pusa 1053	83.81	6	91.30	32.67	28.53	55.28	24.73	45.33
	Pusa 1088	85.07	4	57.47	29.33	25.63	47.77	22.17	42.67
	Pusa 1105	83.78	6	84.57	34.00	27.70	65.90	26.93	43.13
	Pusa 1108	76.21	5	67.03	28.57	25.87	42.30	17.67	38.93
	Pusa 2024	71.73	6	96.90	32.60	27.43	65.97	25.60	45.30
CD 0.05)		1.93	1.37	2.18	1.23	1.38	1.59	1.30	1.09

noticed that highest contribution of harvest index to seed yield has been demonstrated in chickpea only when the terminal drought conditions were severe. On the basis of seed yield data recorded, Pusa 1105, Pusa 2024, Pusa 1053, and BGD 72 were found promising in restricted soil moisture conditions. In general, MSI (%) and RWC (%) were also recorded relatively higher in BGD 72, Pusa 1103 and Pusa 2024. It is recommended that above cultivars may be grown in water restricted conditions in Northern Plain Zones particularly Delhi like conditions. Cultivars BGD 72, Pusa 1103 and Pusa 2024 may be used as parents in breeding programme for improving drought tolerance in chickpea. It is also observed that such morpho-physiological traits may be used as selection criteria for end season drought and terminal heat tolerance in chickpea breeding programme.

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