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Flower numbers, Pod production, Pollen viability are Reduced with Flower and Pod abortion increased in Chickpea (*Cicer arietinum* L.) under Heat stress

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Abstract

In chickpea (Cicer arietinum L.) the sowing time may vary in different locations depending on the temperatures experienced at different stages of crop development. It is well adapted within temperature range of 30/15^{0}C (day maximum and night minimum) for optimum growth and pod filling. The crop often experiences abnormally high temperature (>35^0 C) and atmospheric heat stress during reproductive stage. A large number of germplasm were physiologically characterized for thermo tolerance and screening techniques developed based on flower drop %, and pollen fertility. The objective of this research is to study the effect of high temperature during pre- and post-anthesis stages of flower development on pollen viability, flower number, pod abortion, pollen tube growth and pod set. The plants were evaluated under two contrasting environments viz., normal and late planting. For which thirty promising genotypes were grown under three replications in RBD. High temperatures reduced pod set by reducing pollen viability and increased the flower drop percentage. Pollen from tolerant promising lines (ICC 3325 and JG 21) was fully viable at 35/20°C. The result obtained from present investigation suggested that selection for physiological traits such as pollen viability could not only improve the heat tolerance of chickpea but can also boost up the crop production under climate change, in addition to pod abortion, flower abortion is an important factor limiting yield in chickpea

Keywords: Flower production, , pod set, pollen, pollen fertility, terminal heat.

Introduction

Chickpea (*Cicer arietinum* L.) is considered one of the most drought-tolerant cool-season food legumes; heat stress still limits chickpea production. With terminal drought, seed yields can be reduced by 58–95% compared to irrigated plants and reductions in pod production and abortion are key factors impacting final seed yield[1,2]. It is widely cultivated under a range of climatic conditions not only in Madhya Pradesh but also in other states of India while MP ranks number one in production and productivity. Sowing time may vary in different locations depending on the temperatures experienced at different stages of crop development. Temperature, climate change and shifting in date of sowing are therefore the most important growth parameter that governs yield and high temperatures or heat stress during the reproductive stage in chickpea is a major cause of yield loss. Global warming is predicted to increase temperatures by up to 5°C by the end of this century, with associated changes in mean maximum temperature.

There are two types of chickpea, namely ‘desi’ and ‘kabuli’, respectively. The desi type has small, angular, dark-brown seeds, while kabuli types have large, rams-head-shaped, light-brown seeds[3]. Both types are 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 these environments, a water shortage and high temperature as the plant enters its reproductive phase induces the end of reproductive development[4-7]. This end-of-season drought is termed ‘terminal heat stress’. Yields of kabuli chickpeas are less than desi chickpea under terminal stress and pod abortion by kabuli chickpea is more sensitive to water stress than that of desi chickpea[2].

In the present study, promising genotypes under the chickpea project were used to investigate the effect of terminal heat on flower production and abortion, pod set, pod abortion, and seed production. Terminal drought was imposed when both cultivars had flower buds, flowers, and developing pods. The objectives of the study were to investigate the influence of heat stress on pollen viability secondly flower drops in regards to terminal heat stress at different stages in the thirty chickpea genotypes.

Material and Methods

The present investigation was carried out during *Rabi* 2010-11 under All India Coordinated Research Project on Chickpea (lead center) at seed breeding farm, College of Agriculture, JNKVV, Jabalpur (M.P). The experimental area occupied was quite uniform in respect of topography and fertility. The main features are hot and dry summer and cold winter with occasional showers. The average rainfall is about 1400 mm, which is received mostly during July to September. The temperatures vary from 4.0°C minimum in January to 42°C maximum in May.

Table-1
List of chickpea genotypes used in the experiment

S.No.	Entry name	Type	Source	S.No.	Entry name	Type	Source
1	GG2	D	Gujrat	16	ICCV07118	D	ICRISAT
2	ICC3325	D	ICRISAT	17	JG 16	D	JNKVV
3	ICC4958	D	ICRISAT	18	JG 130	D	JNKVV
4	ICC8474	D	ICRISAT	19	VISHAL	D	Maharashtra
5	ICC9942	D	ICRISAT	20	JG1-14	D	JNKVV
6	ICC16181	D	ICRISAT	21	JG 2003-14-16	D	JNKVV
7	ICC16216	K	ICRISAT	22	JG1307	D	JNKVV
8	ICCL81248	D	ICRISAT	23	MP JG 2003-115	D	JNKVV
9	ICCV06301	K	ICRISAT	24	JG 14-11	D	JNKVV
10	ICCV06302	K	ICRISAT	25	MP JG 99-115	D	JNKVV
11	ICCV07102	D	ICRISAT	26	JG 17	D	JNKVV
12	ICCV07105	D	ICRISAT	27	JG 18	D	JNKVV
13	ICCV07109	D	ICRISAT	28	JG 19	D	JNKVV
14	ICCV07110	D	ICRISAT	29	JG 21	D	JNKVV
15	ICCV07117	D	ICRISAT	30	JG 22	D	JNKVV

The crop season was favorable during experiment. The experimental material comprised of 30 promising lines (27 desi +3 Kabuli) of chickpea (table 1). These genotypes were grown in a Randomized Completely Block Design with three replications on two different dates under normal planting on 19th November 2010 , late and very late planting on 30th January 2011. Each Plot size was 4.0 m x 0.90m = 3.6m^2 consisting of 2 rows of 4m length, the row to row distance was 45 cm and plant to plant spacing was 10 cm. Fertilizer was applied in the ratio of 20N:60P_2O_5 :40K_2O kg/ha. The experiment was conducted with recommended agronomic practices.

Observations recorded: Pollen viability: Genotypes were analyzed for pollen fertility/viability test in the morning (8 to 10a.m). At the flowering stage pollens were ascertained by the aceto carmine stainbility test and the slides were observed under the microscope. The stained and normal size of pollen grains was recorded as fertile, whereas, unstained and smaller were counted as sterile. Observations of pollen fertility recorded in each genotypes of the microscopic field, three times in each replication. The pollen viability (%) was calculated based on the following formula:-

$$\text{Pollen fertility (\%)} \frac{\text{Number of normal pollens}}{\text{Total number of pollens observed in microscopic field}} \times 100$$

Flower drop: The observation was taken on three randomly selected plants of each genotype at 50% flowering. The total numbers of flowers were counted and tagged. At the time of pod initiation flowers were counted to observe how many flowers develop in pod or shed during developmental stage due to high temperature.

Flower drop (%) = (Total number of flowers per plant - number of flowers dropped) x100

Results and Discussion

Environment- I (Normal planting): Pollen viability % was found close to 100% in all the genotypes of the normal planting and the viability (%) ranges from 84.32 % to 99.30 %. Maximum viability % was observed in ICCV07102 (99.30) followed by ICCV 06301 (99.21), MPJG 99-115(99.12), Vishal (98.91), JG 130 (98.80), JG 22(98.32), ICCV07105 (98.32), ICCV06302 (98.25), ICC16216 (98.35) and ICCL81248 (98.13) while it was recorded minimum in ICC 8474. Out of thirty genotypes maximum flower drop percentage was recorded in JG 130 (18.33) followed by Vishal (16.32), JG-1-14(15.66), ICC3325 (15.66), ICC16216 (15.22) and JG 16(15.14) and minimum in ICCV 06301(6.66) in normal planting (table 2).

Environment – II (Late planting): The pollen viability % for late planting genotypes were slightly less as compare to the normal planting and it ranges from 76.36 % to 97.15 % .The maximum viability % was noted in genotype JG 21 (97.15) followed by JG 22 (95.12), JG 130(90.12), GG 2(89.42), MPJG 99-115(89.15), ICC4958 (87.81) and Vishal (87.15).The minimum viability % was accounted in the genotype ICCV 07118 (76.36). The maximum flower drop percentage was observed in the genotype JG 2003-14-16 (20.21) followed by Vshal (18.34) and GG2 (17.32) whereas it was noted minimum in the genotype ICC 9942 (10.12).

Table 2
Pollen viability% and flower drop % in Normal, late and very late sown planting

S.N.	Entry name	NORMAL PLANTING		LATE PLANTING		VERY LATE PLANTING	
		Physiological characters		Physiological characters		Physiological characters	
		Pollen *via*bility (%)	Flower drop (%)	Pollen *via*bility (%)	Flower drop (%)	Pollen *via*bility (%)	Flower drop (%)
1.	GG 2	95.46	14.66	89.42	17.32	79.42	17.32
2.	ICC 3325	87.65	15.66	80.23	15.66	77.19	15.66
3.	ICC 4958	96.83	14.66	87.81	10.36	77.81	12.36
4.	ICC 8474	83.23	14.15	78.01	10.99	78.01	19.99
5.	ICC 9942	96.66	12.66	80.12	10.12	80.12	10.12
6.	ICC 16181	97.23	14.12	85.36	14.56	85.36	19.56
7.	ICC 16216	98.35	15.22	84.66	16.13	74.66	19.13
8.	ICCL81248	98.13	9.84	87.65	17.14	87.65	17.14
9.	ICCV06301	99.21	6.66	83.25	16.98	93.25	16.98
10.	ICCV 06302	98.25	14.51	79.36	16.25	99.36	16.25
11.	ICCV 07102	99.30	10.66	81.32	16.54	81.32	16.54
12.	ICCV 07105	98.32	13.15	80.25	16.32	80.25	16.32
13.	ICCV 07109	94.93	11.22	81.21	16.84	81.21	16.84
14.	ICCV 07110	95.99	10.66	80.21	15.32	70.21	25.32
15.	ICCV 07117	94.38	11.66	80.98	14.32	70.98	14.32
16.	ICCV 07118	97.61	14.52	76.36	15.32	76.36	15.32
17.	JG 16	97.81	15.14	82.21	12.32	82.21	22.32
18.	JG 130	98.80	18.33	90.12	16.32	80.12	16.36
19.	VISHAL	98.91	16.32	87.15	18.34	77.15	28.34
20.	JG 1-14	96.14	15.66	85.12	11.21	75.12	18.25
21.	JG 2003-14-16	96.63	8.65	80.15	20.21	80.15	20.24
22.	JG 1307	96.44	12.66	84.13	15.32	74.13	15.38
23.	MP JG-2003-115	95.58	12.66	86.13	16.32	76.13	16.35
24.	JG 14-11	87.98	13.66	87.13	14.32	77.13	17.34
25.	MP JG-99-115	99.12	12.34	89.15	12.35	79.15	19.34
26.	JG 17	94.12	12.14	85.13	14.32	75.13	14.37
27.	JG 18	96.91	13.66	82.13	16.35	72.13	16.35
28.	JG 19	84.32	13.66	80.13	16.58	80.13	16.58
29.	JG 21	96.53	17.31	97.15	16.91	87.15	16.91
30.	JG 22	98.32	15.12	95.12	14.82	85.12	14.82

Environment - III (Very late planting): The pollen viability % for very late planting genotypes were very less as compare to the late and normal planting. It ranges from 70.98 to 99.36 %. The maximum viability % was noted in genotype ICCV06302 (99.36) followed by ICCV06301 (93.25), JG 21(87.15) and ICCL 81248(87.65) and the minimum viability % was accounted in the genotype ICCV 07117 (70.98). In regards to flower drop in very late sown condition it ranged from maximum to minimum 28.34-10.12. The minimum flower drop percentage was observed in the genotype ICC9942 (10.12) followed by ICC3325 (12.36), ICCVO7117 (14.32), JG 17(14.37) and JG 22(14.82) minimum was in the genotype ICC 4958 and ICC 8474.

In present scenario of climate change and shifting of date of showing the genotype having maximum viability percentage with minimum flower drop should be given due consideration either they preferred any date of showing. In normal date of sowing genotype ICCV06301 (99.21 - 6.66%) and JG 2003-14-16 (96.36-8.65%) exhibited maximum pollen viability with minimum flower drop indicated their importance for timely planting. Similarly in second date of sowing (late planting) genotype ICC 4958 (87.81-10.36%) performed better to other genotypes under study.

In very late sown condition the genotypes ICC9942 (80.12-10.21%) and JG 22(85.12-14.82) revealed promising having maximum pollen viability with minimum flower drop. The overall study indicated that the chickpea genotypes ICCV06301, ICCV07102 and ICCVO 7105 found promising for all three date of sowing while genotype ICC9942, ICCL81248, ICCVO6302, ICCV07109 and JG 19 were noted for late and very late planting.

Conclusion

The genotype suitable for late and very late indicated its importance under terminal heat condition and should given due consideration under climate change and shifting date of sowing. The present study has demonstrated that terminal drought reduced flower and pod production, increased flower and pod abortion and therefore reduced seed yield in both chickpea cultivars, indicating that both flower and pod abortion are important in determining seed yield. Secondly, the study showed that water deficits impaired both pollen and stigma/style function, and the impairment of pistil function was an important factor relating to flower abortion, while, thirdly, it showed that initiation date significantly affected flower and pod development with early-initiated flowers and pods less likely to abort, while late-initiated flowers and pods largely aborted. The present result is the results obtained by Xiangwen Fang et al[8].

References

1. Leport L., Turner N.C., French R.J., Barr M.D., Duda R., Davies S.L., Tennant D. and Siddique K.H.M., Physiological responses of chickpea genotypes to terminal drought in a Mediterranean-type environment, *European Journal of Agronomy* **11,** 279-291 (**1999**)

2. Leport L., Turner N.C., Davies S.L. and Siddique K.H.M., Variation in pod production and abortion among chickpea cultivars under terminal drought, *European Journal of Agronomy,* **24,** 236-246 *(***2006)**

3. Malhotra R.S., Pundir R.P.S and Slinkard A.E., Genetic resources of chickpea. *In: Saxena MC, Singh KB, editors, The chickpea. Aberystwyth, UK: CAB* International, 67-8 (**1982)**

4. Siddique K.H.M., Brinsmead R.B., Knight R., Knights E.J., Paull J.G. and Rose I.A., Adaptation of chickpea (Cicer arietinum L.) and faba bean (Vicia faba L.) to Australia. In: Knight R, editor. Linking research and marketing opportunities for pulses in the 21st century. Dordrecht, The Netherlands*: Kluwer Academic Publishers;* 289-303 **(2000)**

5. Turner N.C., Adaptation to drought: lessons from studies with chickpea, *Indian Journal of Plant Physiology (Special issue)* 11–17 **(2003)**

6. Turner N.C., Agronomic options for improving rainfall-use efficiency of crop in dryland farming systems, *Journal of Experimental Botany,* **55,** 2413-2425, **(2004)**

7. Turner N.C., Abbo S., Berger J.D., Chaturvedi S.K., French R.J., Ludwig C., Mannur D.M., Singh S.J. and Yadava H.S., Osmotic adjustment in chickpea (Cicer arietinum L.) results in no yield benefit under terminal drought, *Journal of Experimental Botany,* **58,** 187-194 *(***2006)**

8. Xiangwen Fang, Neil C. Turner, Guijun Yan, Fengmin and Kadambot H.M. Siddique, Flower numbers, pod production, pollen viability, and pistil function are reduced and flower and pod abortion increased in chickpea (*Cicer arietinum* L.) under terminal drought, *Journal of Experimental Botany,* **61(2),** 335-345 **(2009)**