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Research Article

STUDY OF GROWTH AND YIELD VARIATION OF CHICKPEA GENOTYPES UNDER MOISTURE STRESS CONDITION (PHYSIOLOGICAL BASIS OF GROWTH AND YIELD VARIATION OF CHICKPEA GENOTYPES UNDER MOISTURE STRESS CONDITION)

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Abstract- Six chickpea genotypes were evaluated for growth and yield variation under moisture stress condition during Rabi-2011 and 2012. Separate experiments were conducted under rainout shelter condition for moisture stress, mild stress and non-stress in split plot design with three replications. Observations were recorded on moisture status at 15 days interval. The per cent available moisture content was reduced and severity duration frequency (SDF) was increased with the advancing age of the crop. The initiation of flowering and 50% flowering was unaffected however the maturity period was declined due to moisture stress and mild stress condition in all the genotypes. The genotypes Vijay and Digvijay were earlier, whereas, PG-5 and Chaffa were late for days to initiation of flowering, 50% flowering and maturity under all the conditions. Vijay and Digvijay maintained higher dry matter accumulation in component parts of plant under different growing conditions at various stages of growth. The bold seed size genotypes Digvijay and Vishal and medium bold Vijay were promising in respect of yield and yield contributing characters under different growing conditions. Therefore, these genotypes might be considered as drought tolerant types.

Keywords- Soil moisture status, Crop phenology, Dry matter accumulation, Yield contributing characters.

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Introduction

Chickpea constitute an important crop component of drought prone agriculture among the grain legumes in the world. Crop yield is determined by the interaction of genotype, management and environment. Water availability is the major environmental variables affecting crop yield.. Drought may hit the chickpea crop at any stages of the crop growth, in the early stage, middle or at the end of the cropping season or in combinations of these stages. To overcome these problems, the breeding strategies are followed to alleviate the moisture stress: one by breeding traits that plant to escape drought and another by breeding drought tolerant lines. Early plant vigour, fast ground cover and large seed size besides high root biomass, long and deep root system, high leaf water potential, high water use efficiency and small leaflets are some of the attributes showing significant association with drought tolerance, whereas high harvest index, large number of pods/ unit area and high grain mass alongwith early maturity are associated with drought escape [1]. Chickpea cultivation is largely restricted under dry land condition as a rainfed crop by employing low inputs and poor technology. Due to uncertainty of rains in the region, the crop grows on stored soil moisture after cessation of mansoon. Consequently, the crop is subjected to moisture stress, due to receding moisture and rising temperatures [4]. Such situation leads to development of moisture stress of varying intensities during the course of crop growth that ultimately result in putting restrictions on expression of attributes of growth and development leading to huge loss in expression of yield. In this view, the present investigation was under taken to study the effect of moisture stress and mild stress on growth and yield variation of chickpea genotypes.

Materials and methods

Six chickpea genotypes were evaluated under rainout shelter at Pulses Improvement Project, MPKV, Rahuri during Rabi-2011-12 and 2012-13 imposing moisture stress, mild stress and non-stress condition separately in Split Plot Design with three replications. The moisture stress plot were irrigated only at the time of sowing for better germination, whereas, under mild stress one additional irrigation was given at anthesis i.e. 35DAS. Under non-stress condition, as per recommendation the irrigations were given at the time of sowing, anthesis and pod development stages for better crop growth. The soil moisture status was monitored with help of soil moisture probe at surface (0-15 cm depth) and sub-soil (15-30 cm depth) levels at every 15 days interval from sowing to maturity. The data on crop phenology was recorded during crop growth period. The observations on morphological characters and yield and yield contributing characters were recorded at the time of maturity, whereas, dry matter accumulation in component parts of plant were recorded during 50% flowering, pod development stage and at maturity. The physiological parameters were recorded during initiation of flowering, 50% flowering and at pod development stage. The data was analyzed as per the split plot design suggested by Panse and Sukhatme (1985) [6].

Results and discussion

Soil moisture status

The soil moisture status was monitored at surface (0-15 cm depth) and sub-soil (15-30 cm depth) levels at every 15 days interval from sowing to maturity. During

2011-12 soil moisture content under moisture stress, mild stress and non stress condition at surface level was ranged between 22.12 and 34.61, 27.10 and 35.17 and 30.82 and 35.81 percent. On the basis of permanent wilting point of the soil, the available moisture was ranged between 4.28 and 16.77, 9.26 and 17.33 and 12.98 and 18.01 percent under moisture stress, mild stress and non stress condition, respectively. The higher magnitude of severity duration frequency (SDF) was noticed under moisture stress and mild stress condition with the advancement of crop. In the present investigation, it was ranged between 0.158 and 0.470, 0.158 and 0.351 and 0.143 and 0.262 under moisture stress, mild stress and non stress condition, respectively [Table-1]. At sub-soil level, soil moisture content was ranged between 24.41 and 33.82, 27.11 and 36.33 and 31.18 and 37.10 percent, whereas, available moisture was ranged between 6.57 and 17.98, 9.27 and 15.76 and 13.34 and 19.26 percent and SDF was ranged between 0.142 and 0.415, 0.130 and 0.351 and 0.112 and 0.253 under moisture stress, mild stress and non stress condition, respectively.

Table-1 *Soil moisture status, available moisture and stress day factor during crop growth period*

Stage	DAS	Soil moisture content (SMC)			Available Moisture (%)			Severity Duration Frequency (SDF)		
2011-2012		I_0	I_1	I_2	I_0	I_1	I_2	I_0	I_1	I_2
0-15 cm depth										
1	0	34.61	35.17	35.81	16.77	17.33	18.07	0.158	0.158	0.143
2	15	32.13	32.97	33.43	14.29	15.13	15.59	0.231	0.211	0.200
3	30	29.77	30.15	31.23	11.93	12.31	14.37	0.287	0.278	0.253
4	45	28.32	32.43	33.10	10.48	14.59	15.26	0.322	0.223	0.262
5	60	26.53	29.71	31.18	8.69	11.87	13.34	0.365	0.289	0.207
6	75	24.84	29.44	32.10	7.00	11.60	14.26	0.405	0.295	0.253
7	90	22.12	27.10	30.82	4.28	9.26	12.98	0.470	0.351	0.262
15-30 cm depth										
1	0	33.82	36.33	37.10	17.98	15.76	19.26	0.142	0.130	0.112
2	15	33.22	34.10	35.02	15.38	16.26	17.18	0.205	0.180	0.162
3	30	31.41	32.36	32.97	13.57	14.52	15.13	0.248	0.225	0.211
4	45	29.57	33.84	34.17	11.73	16.00	16.33	0.292	0.190	0.182
5	60	28.70	31.18	32.42	10.86	13.34	14.58	0.313	0.253	0.224
6	75	26.67	29.23	33.37	8.83	11.39	15.53	0.360	0.298	0.201
7	90	24.41	27.11	31.18	6.57	9.27	13.34	0.415	0.351	0.253
2012-13		0-15 cm depth								
1	0	35.72	36.44	36.77	17.88	18.60	18.93	0.145	0.128	0.120
2	15	33.80	34.02	34.57	15.99	16.18	16.73	0.190	0.185	0.172
3	30	32.12	32.37	33.10	14.28	14.53	15.26	0.231	0.225	0.208
4	45	29.41	33.52	33.91	11.57	15.68	16.07	0.29	0.197	0.189
5	60	28.27	31.21	32.10	10.43	13.37	14.26	0.323	0.255	0.231
6	75	26.40	29.47	30.07	8.56	11.63	12.23	0.368	0.294	0.280
7	90	25.10	22.33	29.41	7.26	9.49	11.57	0.399	0.346	0.296
		15-30 cm depth								
1	0	36.11	36.89	38.05	18.27	19.05	20.21	0.135	0.117	0.089
2	15	34.18	35.37	36.40	16.34	17.53	18.56	0.182	0.154	0.129
3	30	32.21	33.57	34.22	14.37	15.73	16.38	0.229	0.197	0.181
4	45	30.41	34.19	34.41	12.57	16.35	16.57	0.272	0.181	0.176
5	60	29.50	32.18	32.37	11.66	14.34	14.53	0.294	0.229	0.225
6	75	28.10	30.21	33.18	10.26	12.37	15.34	0.327	0.277	0.206
7	90	26.42	29.18	31.12	8.54	11.34	14.37	0.368	0.302	0.255

During 2012-13 soil moisture content at surface level was ranged between 25.10 and 35.72, 22.33 and 36.44 and 29.41 and 36.77 percent, whereas, the available moisture was ranged between 7.26 and 17.88, 9.49 and 18.60 and 11.57 and 18.93 percent under moisture stress, mild stress and non stress condition, respectively. The SDF at this level was ranged between 0.142 and 0.399, 0.128 and 0.346 and 0.120 and 0.296 under moisture stress, mild stress and non stress condition, respectively. At sub-soil level, soil moisture content was ranged between 26.42 and 36.11, 29.18 and 36.89 and 31.12 and 38.05 percent, whereas, the available moisture was ranged between 8.54 and 18.27, 11.34 and 19.05 and 14.37 and 20.21 percent under moisture stress, mild stress and non stress condition, respectively. The SDF at this level was ranged between 0.135 and 0.368, 0.117 and 0.302 and 0.089 and 0.255 under moisture stress, mild stress and non stress condition, respectively [Table-1]. The available soil moisture (ASM) upto 75 per cent before sowing gave significantly higher grain yield in Bengal gram [6]. Chickpea crop gave average seed yield 21.2 q ha^{-1} when soil moisture content at 75 per cent of field capacity upto end of seed development stage compared with 15.4 q ha 1 without irrigation treatment [2]

Crop phenology

Early maturity is an important trait to avoid drought stress due to the onset of severe water deficits. Yield potential and early flowering are two major components of drought escape in lentil and chickpea [8-9] The differences amongst the genotypes were significant, whereas it was non-significant among stress conditions and it's interaction for days to initiation of flowering and 50% flowering during 2011-12, 2012-13 and in pooled analysis. However it was significant among genotypes, stress conditions and it's interaction for days to maturity during 2011-12, 2012-13 and in pooled analysis except for interaction in pooled analysis. The days to initiation of flowering and 50% flowering was not severely affected by moisture stress and mild stress condition in all the genotypes. However, the days to maturity were reduced by 3 to 4 days due to mild stress and 6 to 7 days due to moisture stress condition. The genotypes Vijay and Digvijay were earlier, whereas, PG-5 and Chaffa were late for days to initiation of flowering, 50% flowering and maturity under all the conditions [Table-2].

Dry matter accumulation in component parts of plant

The physiological processes results into a net balance and accumulation of dry matter and hence, the biological productivity of plant is judged from their actual ability to produce and accumulate dry matter. The differences among stress conditions, genotypes and its interaction were significant for dry matter production in component parts of plant recorded at 50% flowering, pod development and at maturity stages except in roots at pod development under non-stress during 2011-12 and in pooled data and at maturity in stem during 2011-12, 2012-13 and in pooled analysis under non-stress condition [Table-3]. The difference for dry matter accumulation in component parts of plant was meager under non-stress and mild

stress, whereas, reduction was more due to moisture stress condition at various stages of growth. Kumar *et al.* [2001][3] reported the percent reduction due to moisture stress for biomass production in chickpea.

Table-2 *Crop phenology influenced by chickpea genotypes under moisture stress condition.*

Genotype	Days to flower initiation			Days to 50% flowering			Days to maturity		
	I_0	I_1	I_2	I_0	I_1	I_2	I_0	I_1	I_2
Vijay	36.17	36.83	36.83	44.50	45.33	45.00	95.50	98.00	102.00
Digvijay	37.33	38.50	37.17	45.33	45.83	46.17	97.17	98.83	102.00
Vishal	39.67	40.17	40.17	47.00	47.67	48.17	98.17	101.33	106.33
Chaffa	45.17	45.33	45.33	51.67	52.67	53.00	102.00	104.67	108.83
PG-5	50.33	51.67	52.33	54.00	55.17	56.17	108.67	114.00	115.67
PG-12	38.50	39.17	39.83	47.67	48.83	49.17	98.50	101.67	103.50
Mean	41.19	41.94	41.94	48.36	49.25	49.61	100.00	103.08	106.39
	2011-12			2012-13			Pooled		
	Irriga-tion	Geno-type	Intera-ction	Irriga-tion	Geno-type	Intera-ction	Irriga- tion	Geno-type	Intera-ction
Days to flower initiation									
SE+	0.452	0.608	1.053	0.203	0.512	0.887	0.429	0.689	1.193
CD at 5%	NS	1.756	NS	NS	1.480	NS	NS	1.948	NS
Days to 50% flowering									
SE+	0.364	0.400	0.692	0.147	0.402	0.697	0.340	0.491	0.850
CD at 5%	NS	1.154	NS	NS	1.162	NS	NS	1.389	NS
Days to maturity									
SE+	0.480	0.461	0.798	0.301	0.371	0.643	0.490	0.512	0.888
CD at 5%	1.883	1.331	2.305	1.181	1.072	1.857	1.599	1.450	NS

I_0: Moisture stress, I_1: Mild stress, I_2: Non stress

Genotypes	Root			Stem			Leaves			Pods		
	I_0	I_1	I_2	I_0	I_1	I_2	I_0	I_1	I_2	I_0	I_1	I_2
At 50% flowering												
Vijay	0.29	0.91	0.91	1.23	3.08	3.17	2.13	5.19	5.41	--	--	--
Digvijay	0.48	0.98	0.97	1.29	3.20	3.28	2.38	5.23	5.43	--	--	--
Vishal	0.28	0.69	0.68	0.66	1.84	1.90	1.53	2.00	2.65	--	--	--
Chaffa	0.28	0.56	0.48	0.72	1.01	1.07	1.11	1.90	2.03	--	--	--
PG-5	0.20	0.78	0.82	0.60	1.90	1.97	0.83	2.38	2.99	--	--	--
PG-12	0.23	0.48	0.49	0.56	1.72	0.98	1.05	1.65	2.75	--	--	--
Mean	0.29	0.73	0.72	0.84	2.12	2.06	1.50	3.06	3.54	--	--	--
At pod development												
Vijay	0.91	1.52	1.70	1.23	3.08	3.17	2.92	5.02	6.17	6.15	7.65	8.91
Digvijay	1.02	1.79	1.87	1.29	3.20	3.28	2.86	4.87	6.41	5.38	7.71	9.11
Vishal	0.54	1.03	1.13	0.66	1.84	1.90	2.09	3.79	4.73	5.82	7.71	8.22
Chaffa	0.64	1.00	1.15	0.72	1.01	1.07	1.52	2.74	3.38	5.01	7.42	8.74
PG-5	0.71	1.39	1.60	0.60	1.90	1.97	1.78	4.24	5.43	3.29	8.62	9.37
PG-12	0.51	0.81	0.94	0.56	1.72	0.98	1.46	2.63	3.21	3.38	6.92	7.50
Mean	0.72	1.25	1.40	0.84	2.12	2.06	2.10	3.88	4.89	4.84	7.64	8.64
At maturity												
Vijay	1.02	1.63	1.71	4.40	7.34	7.32	2.40	6.49	6.65	9.72	12.46	12.49
Digvijay	0.99	1.26	1.79	4.30	7.37	7.36	2.45	6.25	6.47	11.14	12.91	12.98
Vishal	0.55	1.24	1.51	3.36	5.72	5.39	0.75	2.42	2.53	8.83	13.66	13.78
Chaffa	0.69	1.51	1.26	4.48	6.69	6.14	0.73	3.22	3.90	9.77	12.48	12.73
PG-5	0.89	0.78	1.65	2.85	5.40	5.46	1.80	5.02	4.49	8.72	13.68	13.75
PG-12	0.51	1.73	0.79	3.29	3.91	4.17	0.66	3.04	3.22	6.67	9.08	9.52
Mean	0.77	1.34	1.45	3.78	6.07	5.97	1.47	4.41	4.54	9.14	12.38	12.54

Table-3 *Dry matter production in component parts of plant as influenced by chickpea genotypes under moisture stress condition*

Plant parts		2011-12			2012-13			Pooled		
		Irriga-tion	Geno-type	Intera-ction	Irriga-tion	Geno-type	Intera-ction	Irriga-tion	Geno-type	Intera-ction
At 50% flowering										
Roots	SE+	0.017	0.015	0.027	0.015	0.020	0.027	0.019	0.022	0.038
	CD at 5%	0.066	0.044	0.077	0.058	0.057	0.077	0.063	0.062	0.107
Stem	SE+	0.149	0.222	0.091	0.028	0.029	1.04	0.131	0.194	0.098
	CD at 5%	0.586	0.641	0.384	0.109	0.083	0.050	0.428	0.548	0.336
Leaves	SE+	0.199	0.175	0.304	0.022	0.035	0.061	0.173	0.155	0.268
	CD at 5%	0.781	0.506	0.877	0.087	0.101	0.175	0.565	0.438	0.758
At pod development										
Roots	SE+	0.020	0.042	0.073	0.025	0.031	0.054	0.028	0.045	0.079
	CD at 5%	0.078	0.122	NS	0.099	0.090	0.156	0.091	0.128	NS
Stem	SE+	0.149	0.222	0.91	0.028	0.029	1.04	0.131	0.194	0.98
	CD at 5%	0.586	0.641	0.384	0.109	0.083	0.050	0.428	0.548	0.336
Leaves	SE+	0.050	0.078	0.135	0.027	0.047	0.081	0.049	0.079	0.136
	CD at 5%	0.195	0.225	0.390	0.107	0.136	0.235	0.160	0.223	0.386
Pods	SE+	0.119	0.193	0.334	0.216	0.288	0.499	0.213	0.300	0.520
	CD at 5%	0.466	0.557	0.965	0.847	0.832	1.441	0.696	0.850	1.471
At maturity										
Roots	SE+	0.034	0.029	0.049	0.015	0.032	0.055	0.032	0.037	0.064
	CD at 5%	0.133	0.128	0.143	0.060	0.093	0.160	0.105	0.105	0.182
Stem	SE+	0.193	0.267	0.463	0.111	0.181	0.314	0.193	0.280	0.484
	CD at 5%	0.757	0.771	NS	0.434	0.523	NS	0.628	0.791	NS
Leaves	SE+	0.029	0.039	0.067	0.028	0.063	0.109	0.035	0.064	0.111
	CD at 5%	0.116	0.111	0.193	0.110	0.182	0.316	0.115	0.181	0.314
Pods	SE+	0.052	0.083	0.144	0.097	0.140	0.243	0.095	0.141	0.245
	CD at 5%	0.202	0.241	0.417	0.382	0.405	0.701	0.311	0.399	0.692

The genotypes, Vijay and Digvijay recorded maximum dry matter accumulation in roots, stem and leaves at various stages of growth, whereas, the genotypes, PG-5 (9.37 g) and Digvijay (9.11 g) at pod development stage and Vishal (13.78 g) and PG-5 (13.75 g) at maturity recorded the higher dry matter production in pod plant^{-1} [Table-4]. At 50% flowering, Digvijay recorded higher dry matter accumulation plant^{-1} in roots (0.48, 0.98 and 0.97 g), stem (1.29, 3.20 and 3.28 g) and leaves (2.38, 5.23 and 5.43 g) under moisture stress, mild stress and non-stress condition, respectively. At pod development stage, Digvijay maintained higher dry matter accumulation plant^{-1} in roots (1.02, 1.79 and 1.87 g), stem (1.29, 3.20 and 3.28 g) and leaves (2.86, 4.87 and 6.41 g) under moisture stress, mild stress and non-stress condition, respectively, whereas, Vijay under moisture stress (6.15) and PG-5 under mild stress (8.62 g) and non-stress (9.37 g) recorded higher dry matter accumulation plant^{-1} in pods. At maturity, Vijay under moisture stress (1.02 g) and mild stress (1.63 g) and Digvijay under non-stress (1.79 g) in roots, Chaffa under moisture stress (4.48 g) and Digvijay under mild stress (7.37 g) and non-stress (7.36 g) in stem, Vijay under moisture stress (6.49 g) and mild stress (6.65 g) and Digvijay under non-stress (11.14 g) in leaves and Chaffa under moisture stress (9.77 g) and Vishal mild stress (13.66 g) and non-stress (13.78 g) recorded higher dry matter accumulation^{-1} in pods.

Genotypes	I_0	I_1	I_2	I_0	I_1	I_2
	100 seed Weight (g)			(Seed Yield (Kg per ha)		
Vijay	21.67	27.50	23.28	895.77	1047.54	1118.92
Digvijay	27.27	27.77	28.18	1159.81	1399.42	1580.38
Vishal	25.93	27.43	29.42	869.67	1202.26	1397.88
Chaffa	13.04	17.39	18.83	750.84	1025.93	1052.17
PG-5	29.74	29.12	31.21	761.67	979.64	1292.93
PG-12	14.13	17.55	19.23	540.56	646.66	844.98
Mean	21.36	24.46	25.69	829.72	1054.62	1210.17

Table-4 *Yield and yield contributing characters influenced by chickpea genotypes under moisture stress condition*

Character		2011-12			2012-13			Pooled		
		Irriga-tion	Geno-type	Intera-ction	Irriga-tion	Geno-type	Intera-ction	Irriga- tion	Geno-type	Intera-ction
100 seed Weight (g)	SE±	0.458	0.889	1.539	0.689	0.978	1.694	0.716	1.145	1.982
	CD at 5%	1.797	2.567	NS	2.703	2.825	NS	2.335	3.238	NS
Seed Yield (Kg ha^{-1})	SE±	19.88	36.23	62.75	31.86	35.58	61.62	32.52	43.97	76.16
	CD at 5%	78.06	104.64	181.24	125.09	102.75	NS	106.06	124.39	NS

Generative growth and sink capacity

The generative growth and sink capacity relates with final produce of the plant. It can reduce by soil moisture deficit condition. The differences among stress conditions and genotypes were statistically significant for pods plant^{-1} during 2011-12, 2012-13 and pooled mean, however it's interaction were significant during 2011-12 and non-significant during 2012-13 and pooled mean [Table-4]. The genotypes, Chaffa (32.37) and Digvijay (28.59) under moisture stress and Chaffa (38.10 and 38.32) and Vijay (33.29 and 33.09) under mild stress and non-stress condition recorded higher number of pods plant^{-1}. The differences for 100 seed weight were significant for stress conditions and genotypes, whereas, it was non-significant for interaction during 2011-12, 2012-13 and pooled mean. The genotype, PG-5 exhibited bolder seed size under moisture stress (29.12 g 100 seed^{-1}), mild stress (29.74 g 100 seed^{-1}) and non-stress (31.21 g1 00 seed^{-1}). Even though, the varieties, Vishal and Digvijay has higher reduction due to moisture stress for 100 seed weight maintained bold seed size under various conditions of growth. Rahangadale *et al.* (1994)[7] in the field experiment on chickpea genotypes under soil moisture deficit reported that, under water stressed condition; there was decrease in dry matter production and seed yield (15.2%) as compared to irrigated conditions.

The differences among stress conditions, genotypes and it's interaction were statistically significant for seed yield ha^{-1}except for interaction during 2012-13 and in pooled data. The variety Digvijay maintained higher seed yield under moisture stress (1159.81 Kg ha^{-1}), mild stress (1399.42 Kg ha^{-1}) and non-stress condition (1580.38 Kg ha^{-1}). In addition to this, Vishal and Vijay under moisture stress (895.77 and 869.67 Kg ha^{-1}) and mild stress (1202.26 and 1047.54 Kg ha^{-1}) and Vishal and PG-5 under non-stress (1397.88 and 1292.93 Kg ha^{-1}) were found promising for seed yield ha^{-1}. Nanda and Saini (1992)[5] reported reduction in yield by 17 per cent due to limited moisture available at critical stages in chickpea.

Conclusion

The genotypes, Vijay and Digvijay were earlier, whereas, PG-5 and Chaffa were late for days to initiation of flowering, 50% flowering and maturity under all the conditions. Vishal, Vijay and Digvijay maintained higher dry matter accumulation in component parts of plant. Digvijay, Vishal and Vijay were found superior in terms of yield and yield contributing characters under different growing conditions. The genotypes, Digvijay and Vishal under moisture stress, mild stress and and non-stress, Vijay and PG-5 under moisture stress and mild stress found better for respective environments. Therefore, these genotypes might be utilized in breeding programme for boosting up the yield improvement under their respective environments.

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Abbreviations:

SDF: - Severity Duration Frequency
DAS: - Days after sowing
ASM:- Available soil moisture

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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References

[1] Guha Sarkar C. K., Srivastava P. S. L. and Deshmukh P. S. (2001) *Indian J. Genet.*, 61(3), 209-212.
[2] Koinov G. and Vitkov M. (1976) *Rasteniev dni Nauki*, 13(8): 59-62.
[3] Kumar P., Deshmukh P.S., Kushwaha S.R. Sunita Kumari P., Kumar and Kumari S. (2001) *Annals of Agric. Res.*, 22(3), 48-51.
[4] Kumar S. and Sinha S. K. (1988) *The Society of Physiol. and Biochem.*, pp 21-42.
[5] Nanda R. and Saini A.D. (1992) *Indian J. Plant Physiol.*, 3591, 16-24.
[6] Panse V.G. and Sukhatme P.V. (1985) Statistical Methods of Agricultural

Workers, ICAR Publ., New Delhi (4 Edn.).
[7] Rahangaldale S. L., Dhopte A. M. and Wanjari K. P. (1994) *Annl. Pl. Physiol.,* 8(2), 179-189.
[8] Saxena N.P., Krishnamurthy L. and Johansen C. (1993) *Crop Sci.,* 33(6), 14-24.
[9] Silim S.N. and Saxena M.C. (1993) *Field Crop Res.,* 34(2), 137-146.