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Estimation of mean performance of quantitative characters in chickpea (*Cicer arietinum* L.) under irrigated and rainfed conditions

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Abstract
The present study was conducted to generate information on mean performance of the yield and yield attributes of chickpea under rainfed and irrigated conditions. The experiment was conducted in compact family block design with three replications under two separate irrigated and rainfed conditions. Observations were recorded on days to 50% flowering, days to maturity, plant height, fruiting branches per plant, pods per plant, seeds per pod, biological yield per plant, seed yield per plant, harvest index, 100-seed weight and protein content in each experiment, separately. Significant differences among the crosses were observed for all the characters under both the conditions. Pooled analysis of variance over environments revealed highly significant differences among generations and environments for most of the traits in most of the crosses. Reduction in performance was observed for all the studied characters under rainfed condition except protein content. Maximum reduction was observed in pods per plant followed by seed yield per plant, biological yield per plant, fruiting branches per plant, plant height, thus, it can be said that these characters were more prone to moisture stress. Seeds per pod and 100-seed weight showed less reduction indicated that these characters were not significantly affected by moisture stress and showing stable and highly heritable nature. Therefore it is suggested that more consideration should be given to the characters like pods per plant, fruiting branches per plant, biological yield per plant and plant height while deciding selection criteria for rainfed condition. Selection for seed weight and seeds per pod can be exercised at any stage of generation advancement due to their stable nature and high heritability. Cross IPC-94-94 x RSG-RSG-888 was observed to be earliest to flower and mature under both the conditions, which may be utilized for development of an early flowering and early maturing types. Bold seeded parents *viz.,* ICC-4958, BG-362 and IPC-94-94 and their crosses had higher mean values for yield and yield contributing characters even in rainfed condition indicated that bold seeded genotypes and their crosses generally showed higher degree of drought tolerance in comparison to medium seeded genotypes and can be bred for drought tolerance.

Keywords: Chickpea, mean performance, rainfed condition, moisture stress

1. Introduction

Chickpea (*Cicer arietinum* L.) is the third most important food legume. The global production of chickpea in 2014 was 13.00 million tons from an area of 13.59 million ha giving an average productivity of 956 kg/ha (FAOSTAT, 2019) [1]. Among chickpea-growing countries, India alone contributes about 70% of the world's total production (Korbu *et al.,* 2020) [2]. In India, chickpea cultivation was done on 9.69 million ha with production of 11.07 million and productivity of 1142 kg/ha tons in the year 2019-2020 (Anonymous, 2022) [3]. In spite of India being the largest chickpea producing country, a deficit exists in domestic production and demand which is met through imports.

Chickpea has special significance in the diet of the predominantly vegetarian population of India as it contains more protein (23%), which is complementary with cereals in amino acids profile. Production and productivity of chickpea have been stagnant for the past three decades; one of the main reasons of this is its sensitivity to moisture stress at critical stages since more than 80% area under chickpea is rainfed (Dhiman *et al.,* 2006) [4]. Moisture stress has been a major threat and the most unpredictable constraint with adverse effects on chickpea production and productivity worldwide (Korbu *et al.,* 2020; Kumar *et al.,* 2018) [2, 5]. Chickpea is mostly grown in the arid and semiarid areas and is commonly regarded as a drought-tolerant crop (Kumar *et al.*, 2018; Turner *et al.*, 2001; Varshney *et al.*, 2014) [5, 6, 7]. Despite the relative tolerance of chickpea to drought stress, severe or prolonged stress is detrimental to its growth and productivity (Daryanto *et al.*, 2015; Pang *et al.*, 2017) [8, 9]. Several studies revealed that moisture stress specifically at the reproductive stage can cause up to 70% yield reduction in chickpea (Nadeem *et al.*, 2019; Nayyar *et al.*, 2006) [10, 11]. Significant variation among genotypes for yield and yield contributing characters under moisture stress condition in chickpea has been observed by Kumar *et al.* (2004) [12], Meena *et al.* (2006) [13], Krishnamurty *et al.* (2011) [14] and Mishra and Babbar (2014) [15]. Yield losses occur due to reduction in germination, plant growth (biomass) and seed size. Therefore, a strong breeding programme is needed to develop genotypes suitable for moisture stress conditions. This requires a simple and fast procedure for selection of drought tolerant genotypes in segregating populations and evaluating cultivars. Quisenberry (1982) [16] defined drought resistance as the ability of a plant variety to produce a higher yield than another at a given limiting level of water availability. The aim of the present study was to generate information on mean value of the yield and yield contributing traits of chickpea under rainfed and irrigated conditions.

2. Materials and Methods

The present investigation on chickpea was carried out at Research Farm, Agricultural Research Sub Station, Hanumangarh, Rajasthan, India. The average precipitation was 241.6 mm and average temperature was 32.26^{0}C. The experiment was conducted in compact family block design with three replications maintaining 30 cm row to row and 10 cm plant to plant distances. The material for this experiment comprised of five generations namely, P_1, P_2, F_1, F_2 and F_3 of each of the five chickpea crosses viz., RSG-895 (Medium bold) x RSG-888 (Medium bold), RSG-888 (Medium bold) x ICC-4958 (Bold), IPC-94-94 (Bold) x RSG-888 (Medium bold), CSJD-901(Medium bold) x RSG-931(Medium bold) and BG-362 (Bold) x RSG-931(Medium bold). Parents were sown in two rows, F_1s in one row and F_2s and F_3s were sown in four rows under both irrigated (two supplemental irrigations) and rainfed (on receding soil moisture). All the recommended cultural practices were followed to raise a good and healthy crop in both conditions. Observation at vegetative, reproductive and maturity stages were recorded for different traits *i.e.* days to 50% flowering, days to maturity, plant height, fruiting branches per plant, pods per plant, seeds per pod, biological yield per plant, seed yield per plant, harvest index, 100-seed weight and protein content were recorded on randomly selected 10 plants from each of the P_1, P_2 and F_1 and 20 plants from each of the F_2 and F_3 generations under both irrigated and rainfed conditions. Analysis of variance was performed as per compact family block design for comparison of crosses as well as generations of each cross. Pooled analysis of variance was also done over two environments to comparison of environments (Irrigated and rainfed) according to Panse and Sukhatme (1985) [17]. Standard statistical procedure (Snedecor and Cochran, 1968) [18] was used to obtain means for each generation and character, separately.

3. Results and Discussion

Analysis of variance revealed significant differences among the crosses for all the characters under both the conditions, indicating the presence of diversity among the crosses (Table 1). Pooled analysis of variance over environments revealed highly significant differences among generations and environments for most of the traits in most of the crosses (Table 2). Generation x Environment interaction was also significant for most of the characters in most of the crosses showing differential response of irrigated and rainfed conditions.

The mean performance along with standard errors of five generations of five chickpea crosses for different characters under irrigated (IRG) and rainfed (RF) conditions is given in Table 3. In the present investigation, reduction in performance was observed for all the studied characters under rainfed except protein content, which might be due to terminal drought, moisture and heat stress (Table 4). Maximum reduction was observed in pods per plant followed by seed yield per plant, biological yield per plant, fruiting branches per plant, plant height, days to 50% flowering and days to maturity, thus, it can be said that these characters were more influenced to moisture stress. A considerable reduction in yield and associated traits under rainfed condition was also reported by Rao *et al*. (2003) [19], Shane *et al.* (2003) [20], Turner *et al.* (2003) [21], Kumar *et al.* (2004) [12], Ozgun *et al.* (2004) [22], Sanap *et al.* (2004) [23], Dhiman *et al.* (2006) [4] and Meena *et al*. (2014) [24]. Seeds per pod and 100-seed weight showed less reduction indicated that these characters were not significantly affected by moisture stress and showing stable and highly heritable nature. Kumar *et al.* (2004) [12] also observed non-significant effect of moisture stress on seeds per pod and 100-seed weight. The harvest index always calculated on the basis of the performance of seed yield and biological yield. Therefore, it increases or decreases accordingly and different index could be observed under different environments. The mean values for seed yield per plant under rainfed condition were reduced by 12.23 percent in P_{1S}, 19.62 percent in P_{2S}, 12.62 percent in F_1s, 11.41 percent in F_2s and 12.21 percent in F_3s. The detrimental effect of moisture stress in rainfed condition on seed yield was maximum through reduction in fruiting branches per plant, pods per plant, biological yield per plant and plant height (Table 4). Thus, these characters should be given more consideration while deciding selection criteria for rainfed condition. Under rainfed condition the poor seed yield of genotypes may be attributed to poor biomass production coupled with low harvest index. The results also revealed that the parents IPC-94-94, RSG-895 and CSJD-901 flowered earlier and also matured earlier, even in rainfed condition and imparted the early flowering and maturity even to their crosses. Cross IPC-94-94 x RSG-RSG-888 was observed to be earliest to flower and mature under both the conditions, which may be utilized for development of an early flowering and early maturing types. Although, a decrease in plant height was observed in all the generations in most of the crosses under rainfed condition but BG-362 was found to be least affected. BG-362 was observed to be tallest parent followed by RSG-888 and ICC-4958 under rainfed condition and imparted tallness to its crosses. Evaluation of performance across both the conditions revealed that bold seeded parents *viz.*, ICC-4958, BG-362 and IPC-94-94 and their crosses had higher mean values for yield and yield contributing characters *viz.*, plant height, fruiting branches per plant, pods per plant, seeds per pod, biological yield per plant, harvest index and 100-seed weight even in rainfed condition indicated that these parents and crosses were least affected by moisture stress in rainfed and can be bred for drought tolerance. These findings support the findings of Kumar *et al.* (2004) [12]. The highest seed yield and harvest index were recorded in bold seeded parents IPC-94-94, ICC-4958 and BG-362 even in rainfed condition indicated that bold seeded genotypes generally showed higher degree of drought tolerance in comparison to medium seeded genotypes. Similar results also reported by Kumar *et al.* (2004) [12] and Yadav *et al.* (2004) [25]. Among F_1s the highest mean value for seed yield per plant was observed in RSG-888 x ICC-4958 followed by BG-362 x RSG-931 and IPC-94-94 x RSG-888 even in rainfed condition and these crosses may be utilized for development of high yielding variety for rainfed condition.

Table 1: Analysis of variance (mean squares) for different characters in chickpea under irrigated (IRG) and rainfed (RF) conditions

Characters/ Source of variation	D. F.	Days to 50% flowering	Days to maturity	Plant height (cm)	Fruiting branches per plant	Pods per plant	Seeds per pod	Biological yield per plant (g)	Seed yield per plant (g)	Harvest index (%)	100-seed weight (g)	Protein content (%)
Irrigated												
Replications	2	0.070	0.174	0.058	0.258	0.578	0.002	0.365	0.131	0.248	0.098	0.016
Crosses	4	51.708**	88.793**	55.084**	1.455**	24.465**	0.045**	19.267**	7.788**	7.848**	35.574**	0.622**
Error	8	0.096	0.316	0.449	0.172	1.405	0.001	0.318	0.130	0.603	0.086	0.023
Rainfed												
Replications	2	0.037	0.167	0.148	0.043	1.281	0.003	0.478	0.089	0.251	0.030	0.005
Crosses	4	198.05**	147.186**	19.633**	6.927**	52.503**	0.019**	22.987**	18.029**	51.117**	29.679**	0.689**
Error	8	0.081	0.033	0.231	0.106	0.499	0.001	0.271	0.219	0.205	0.165	0.008

*, ** Significant at 5 percent and 1 percent level, respectively.

Table 2: Pooled analysis of variance of generation means for different characters in five crosses of chickpea over two environments (Irrigated and rainfed)

Character/Cross	Mean sum of squares				
	Rep./ Env. (4 df)	Gener. (4 df)	Env. (1 df)	G x E (4 df)	Error (16 df)
Days to 50% flowering					
RSG-895 x RSG-888	0.722	9.586**	412.799**	16.483**	1.504
RSG-888 x ICC-4958	0.159	20.624**	208.086**	3.938*	1.096
IPC-94-94 x RSG-888	0.466	428.814**	1320.254**	133.202**	3.384
CSJD-901 x RSG-931	0.326	7.858**	265.083**	3.885*	0.816
BG-362 x RSG-931	0.366	26.680**	40.756**	3.913**	0.741
Days to maturity					
RSG-895 x RSG-888	0.766	20.391**	418.133**	7.868**	1.294
RSG-888 x ICC-4958	1.312	30.251**	172.400**	11.586**	0.843
IPC-94-94 x RSG-888	1.300	494.347**	580.800**	32.892*	8.508
CSJD-901 x RSG-931	0.533	22.371**	224.079**	5.630**	0.867
BG-362 x RSG-931	0.434	32.991**	73.299**	18.471**	1.683
Plant height (cm)					
RSG-895 x RSG-888	0.121	41.525**	337.234**	11.768**	2.008
RSG-888 x ICC-4958	1.812	24.789**	250.377**	28.089**	3.178
IPC-94-94 x RSG-888	0.936	86.982**	43.056**	20.519*	4.311
CSJD-901 x RSG-931	3.006	36.605**	121.874**	21.657**	2.540
BG-362 x RSG-931	1.446	59.894**	318.220**	23.755*	5.010
Fruiting branches per plant					
RSG-895 x RSG-888	0.565	17.083**	137.217**	6.903**	0.776
RSG-888 x ICC-4958	0.983	18.536**	27.950**	6.496**	1.073
IPC-94-94 x RSG-888	0.570	24.441**	24.300**	13.369**	0.991
CSJD-901 x RSG-931	1.311	22.873**	19.976**	3.395*	0.738
BG-362 x RSG-931	0.099	19.045**	11.371**	4.941**	0.441
Pods per plant					
RSG-895 x RSG-888	7.163	419.413**	973.674**	86.127**	9.789
RSG-888 x ICC-4958	3.330	341.484**	650.164**	64.771**	7.821
IPC-94-94 x RSG-888	2.256	251.215**	635.904**	52.686**	7.710
CSJD-901 x RSG-931	8.139	224.393**	1152.828**	68.672**	10.861
BG-362 x RSG-931	2.795	231.613**	555.212**	43.422**	8.834
Seeds per pod					
RSG-895 x RSG-888	0.011	0.071**	0.033*	0.004	0.006
RSG-888 x ICC-4958	0.004	0.150**	0.033	0.003	0.007
IPC-94-94 x RSG-888	0.001	0.069**	0.039*	0.016*	0.005
CSJD-901 x RSG-931	0.006	0.066**	0.035*	0.015*	0.005
BG-362 x RSG-931	0.001	0.057**	0.017	0.004	0.004
Biological yield per plant (g)					
RSG-895 x RSG-888	2.206	60.081**	191.572**	17.504**	2.564
RSG-888 x ICC-4958	0.936	111.629**	385.137**	38.121**	2.276
IPC-94-94 x RSG-888	0.787	54.584**	140.078**	29.749**	2.428
CSJD-901 x RSG-931	2.351	30.553**	358.111**	28.498**	2.689

BG-362 x RSG-931	1.716	90.519**	68.675**	24.570**	3.300
Seed yield per plant (g)					
RSG-895 x RSG-888	1.125	25.269**	172.777**	10.524**	0.970
RSG-888 x ICC-4958	0.726	62.193**	23.870**	6.248**	1.004
IPC-94-94 x RSG-888	0.650	16.413**	9.509**	15.542**	0.978
CSJD-901 x RSG-931	1.132	14.272**	62.400**	2.879*	0.606
BG-362 x RSG-931	0.414	51.234**	19.018**	4.280*	1.328
Harvest index (%)					
RSG-895 x RSG-888	5.879	96.939**	231.778**	37.386**	4.537
RSG-888 x ICC-4958	1.553	123.058**	29.489**	25.721**	1.600
IPC-94-94 x RSG-888	0.609	48.440**	132.806**	42.067**	1.310
CSJD-901 x RSG-931	0.229	16.441**	30.724**	13.326**	1.944
BG-362 x RSG-931	1.054	107.491**	17.328**	21.276**	1.497
100-seed weight (g)					
RSG-895 x RSG-888	0.191	3.784**	1.152**	0.344*	0.077
RSG-888 x ICC-4958	0.669	131.818**	14.658*	0.774	2.299
IPC-94-94 x RSG-888	0.912	67.174**	8.175*	0.984	1.593
CSJD-901 x RSG-931	0.144	4.718**	4.074**	1.753*	0.394
BG-362 x RSG-931	0.913	78.924**	3.931*	0.563	0.796
Protein content (%)					
RSG-895 x RSG-888	0.125	1.947**	1.298**	0.145	0.134
RSG-888 x ICC-4958	0.035	3.075**	0.252*	0.111	0.045
IPC-94-94 x RSG-888	0.057	8.523**	0.666**	0.241*	0.078
CSJD-901 x RSG-931	0.113	2.610**	1.285**	0.823**	0.109
BG-362 x RSG-931	0.037	1.288**	2.191**	0.505**	0.104

Table 3: Mean performance (mean±SE) of five generations in five chickpea crosses for different characters under irrigated (IRG) and rainfed (RF) conditions

Cross/Character	Env.	$\bar{P}_1$	$\bar{P}_2$	$\bar{F}_1$	$\bar{F}_2$	$\bar{F}_3$
Days to 50% flowering						
RSG-895 x RSG-888	IRG	88.33±0.22	91.67±0.30	94.67±0.29	93.00±0.23	89.90±0.33
	RF	83.67±0.16	86.67±0.18	82.64±0.22	83.17±0.11	84.33±0.11
RSG-888 x ICC-4958	IRG	91.00±0.20	96.33±0.16	94.33±0.14	94.00±0.14	92.33±0.19
	RF	86.33±0.16	91.33±0.16	87.67±0.22	87.00±0.14	89.33±0.16
IPC-94-94 x RSG-888	IRG	65.67±0.34	91.00±0.33	87.00±0.20	87.67±0.30	88.33±0.16
	RF	64.00±0.33	86.33±0.22	69.67±0.16	66.33±0.26	67.00±0.23
CSJD-901 x RSG-931	IRG	89.33±0.22	91.33±0.16	92.33±0.22	91.90±0.12	90.67±0.11
	RF	84.00±0.20	87.67±0.16	84.33±0.22	85.83±0.11	84.00±0.11
BG-362 x RSG-931	IRG	96.67±0.16	92.33±0.16	94.33±0.16	95.33±0.16	93.67±0.16
	RF	94.00±0.20	87.33±0.16	93.00±0.20	93.67±0.11	92.67±0.11
Days to maturity						
RSG-895 x RSG-888	IRG	137.33±0.32	134.67±0.32	139.33±0.28	138.67±0.43	135.67±0.23
	RF	126.67±0.29	130.33±0.28	132.67±0.29	130.67±0.23	128.00±0.24
RSG-888 x ICC-4958	IRG	134.67±0.32	142.33±0.32	137.00±0.31	138.00±0.22	136.33±0.23
	RF	129.33±0.28	133.33±0.28	135.67±0.29	134.03±0.23	132.00±0.23
IPC-94-94 x RSG-888	IRG	109.67±0.69	134.67±0.44	124.00±0.48	125.00±0.50	127.67±0.38
	RF	104.33±0.29	130.67±0.29	116.00±0.41	114.00±0.29	112.00±0.29
CSJD-901 x RSG-931	IRG	133.00±0.31	130.00±0.31	135.33±0.28	134.67±0.20	133.00±0.23
	RF	124.67±0.29	127.00±0.31	130.67±0.32	129.00±0.20	127.33±0.23
BG-362 x RSG-931	IRG	139.67±0.28	130.63±0.33	133.33±0.32	134.00±0.22	135.67±0.29
	RF	130.67±0.29	127.67±0.41	133.67±0.29	132.33±0.23	133.33±0.23
Plant height (cm)						
RSG-895 x RSG-888	IRG	57.97±1.08	53.87±1.15	62.13±0.90	61.00±0.98	54.80±0.98
	RF	49.33±0.76	51.73±0.73	53.93±0.99	52.33±0.66	48.92±0.55
RSG-888 x ICC-4958	IRG	53.13±0.85	62.07±1.44	57.40±1.17	59.23±0.73	61.17±0.85
	RF	51.87±0.70	49.60±0.77	54.67±0.73	52.82±0.71	55.15±0.59
IPC-94-94 x RSG-888	IRG	42.77±1.08	53.90±0.95	48.37±0.92	50.23±0.84	51.90±0.70
	RF	41.77±0.77	51.57±0.76	50.20±0.79	48.05±0.76	43.60±0.48
CSJD-901 x RSG-931	IRG	49.53±0.70	54.73±0.60	58.40±0.89	56.45±0.96	51.23±0.70
	RF	48.43±1.40	46.57±0.76	52.10±0.85	50.92±0.51	52.17±0.54
BG-362 x RSG-931	IRG	59.27±0.91	55.17±0.97	62.20±0.93	60.45±0.76	62.93±0.75
	RF	58.47±0.66	47.33±0.87	55.27±0.85	55.18±0.71	51.20±0.68
Fruiting branches per plant						
RSG-895 x RSG-888	IRG	12.57±0.58	15.07±0.56	18.33±0.61	17.68±0.47	14.77±0.57
	RF	8.80±0.57	12.23±0.48	11.73±0.34	11.28±0.38	12.98±0.47
RSG-888 x ICC-4958	IRG	15.33±0.86	12.27±0.57	17.83±0.58	16.67±0.44	18.58±0.59

	RF	12.04±0.58	14.03±0.77	14.97±0.60	13.97±0.45	16.02±0.37
IPC-94-94 x RSG-888	IRG	11.83±0.61	15.97±0.59	18.53±0.78	16.78±0.57	12.37±0.46
	RF	10.07±0.77	12.97±0.49	14.17±0.81	13.62±0.42	15.65±0.45
CSJD-901 x RSG-931	IRG	12.10±0.70	16.03±0.92	18.63±0.63	16.43±0.60	13.20±0.56
	RF	11.93±0.46	13.47±0.54	14.90±0.52	15.13±0.51	12.80±0.41
BG-362 x RSG-931	IRG	13.30±0.70	15.70±0.72	18.47±0.61	17.32±0.63	19.33±0.50
	RF	15.30±0.92	13.37±0.55	16.60±0.59	15.37±0.68	17.32±0.47
Pods per plant						
RSG-895 x RSG-888	IRG	42.30±2.62	56.60±2.45	65.67±2.05	62.75±2.30	44.70±2.57
	RF	32.87±1.39	37.47±1.28	49.03±1.35	50.63±1.67	45.05±1.94
RSG-888 x ICC-4958	IRG	58.93±1.25	51.57±1.39	65.43±1.58	63.28±1.52	69.68±1.88
	RF	38.40±1.61	48.37±1.56	57.20±1.72	55.72±2.02	62.65±1.93
IPC-94-94 x RSG-888	IRG	47.37±1.34	57.30±1.67	63.53±1.41	60.17±1.86	65.53±1.45
	RF	45.73±1.11	39.33±1.52	56.60±1.33	51.00±1.53	55.20±1.50
CSJD-901 x RSG-931	IRG	52.13±1.51	57.20±1.52	65.90±1.75	61.37±1.98	51.23±1.90
	RF	34.93±1.59	41.27±1.91	47.20±1.73	55.67±2.09	46.77±1.57
BG-362 x RSG-931	IRG	50.90±1.08	57.83±1.42	64.80±1.81	61.58±2.00	67.65±1.72
	RF	49.80±2.28	41.73±2.79	56.67±1.91	51.52±3.23	60.02±1.74
Seeds per pod						
RSG-895 x RSG-888	IRG	1.77±0.10	1.65±0.09	1.66±0.10	1.68±0.07	1.45±0.07
	RF	1.80±0.08	1.65±0.07	1.79±0.06	1.75±0.01	1.55±0.06
RSG-888 x ICC-4958	IRG	1.68±0.09	1.30±0.08	1.45±0.08	1.47±0.08	1.28±0.07
	RF	1.70±0.06	1.32±0.08	1.58±0.03	1.55±0.05	1.36±0.05
IPC-94-94 x RSG-888	IRG	1.57±0.08	1.67±0.10	1.77±0.09	1.67±0.09	1.88±0.08
	RF	1.49±0.07	1.73±0.07	1.55±0.06	1.65±0.07	1.78±0.06
CSJD-901 x RSG-931	IRG	1.97±0.06	1.67±0.08	1.71±0.08	1.79±0.07	1.59±0.07
	RF	1.73±0.10	1.68±0.07	1.71±0.05	1.72±0.05	1.54±0.06
BG-362 x RSG-931	IRG	1.79±0.10	1.66±0.09	1.68±0.10	1.71±0.06	1.55±0.05
	RF	1.80±0.07	1.67±0.06	1.59±0.08	1.61±0.06	1.49±0.06
Biological yield per plant (g)						
RSG-895 x RSG-888	IRG	34.92±1.32	39.74±1.09	43.41±1.33	41.11±1.11	34.52±1.30
	RF	34.77±1.03	30.13±1.23	37.44±1.31	35.68±1.02	30.41±1.23
RSG-888 x ICC-4958	IRG	39.41±1.47	44.99±1.39	50.56±1.74	48.32±1.09	40.72±1.50
	RF	30.07±1.07	34.68±1.61	41.61±1.49	39.29±0.92	42.52±1.00
IPC-94-94 x RSG-888	IRG	35.30±1.01	39.39±1.27	44.71±1.21	43.27±0.92	36.46±1.01
	RF	34.44±0.72	30.41±1.01	38.91±1.62	35.82±0.71	37.94±0.71
CSJD-901 x RSG-931	IRG	34.51±1.37	38.28±0.85	42.38±1.17	38.11±1.25	41.35±0.97
	RF	29.09±0.81	34.55±1.13	32.49±1.30	35.52±0.95	28.43±0.76
BG-362 x RSG-931	IRG	34.63±1.20	39.00±1.34	43.26±1.37	44.46±1.25	47.61±1.25
	RF	38.35±1.51	33.38±1.45	40.92±1.58	38.27±1.59	42.91±0.85
Seed yield per plant (g)						
RSG-895 x RSG-888	IRG	14.02±0.64	17.31±0.56	20.14±0.54	18.63±0.66	20.43±0.72
	RF	11.25±0.72	13.35±0.65	16.35±0.68	14.60±0.48	10.98±0.58
RSG-888 x ICC-4958	IRG	17.85±0.89	15.58±0.58	22.44±0.57	20.73±0.67	22.43±0.67
	RF	12.67±1.40	15.87±0.65	20.89±0.92	19.19±0.57	21.49±0.62
IPC-94-94 x RSG-888	IRG	15.43±0.65	17.98±0.72	20.24±0.52	19.08±0.47	15.98±0.54
	RF	16.38±0.49	12.53±0.72	18.63±0.97	16.63±0.43	18.91±0.46
CSJD-901 x RSG-931	IRG	13.93±0.75	16.14±0.62	18.50±0.52	15.09±0.72	13.95±0.60
	RF	11.01±0.37	12.93±0.67	13.76±0.75	14.23±0.55	11.26±0.43
BG-362 x RSG-931	IRG	15.04±0.53	16.87±0.62	20.95±0.63	20.00±0.61	21.91±0.65
	RF	15.63±0.77	12.74±0.82	19.73±0.75	18.21±0.86	20.50±0.51
Harvest index (%)						
RSG-895 x RSG-888	IRG	39.03±1.13	44.67±1.17	48.64±1.42	46.45±1.83	51.70±1.36
	RF	34.33±1.22	41.55±1.34	46.14±1.44	43.35±1.17	37.33±1.00
RSG-888 x ICC-4958	IRG	45.29±1.13	38.96±1.55	49.25±0.94	47.85±1.68	52.50±1.34
	RF	41.44±1.13	46.43±1.80	52.74±1.03	50.12±1.02	53.04±0.94
IPC-94-94 x RSG-888	IRG	41.35±0.86	44.14±0.72	47.68±1.16	47.08±1.11	41.15±1.32
	RF	47.56±1.66	41.21±1.44	51.88±0.80	49.17±0.66	52.62±0.92
CSJD-901 x RSG-931	IRG	40.36±1.41	42.16±1.37	45.82±1.04	44.24±0.63	40.61±0.57
	RF	40.64±0.86	37.42±1.38	42.35±0.68	40.06±0.78	42.60±0.59
BG-362 x RSG-931	IRG	39.97±1.43	43.26±1.17	48.43±1.37	46.02±0.94	48.04±0.73
	RF	44.22±1.04	38.17±0.91	50.70±1.06	48.86±0.68	51.37±0.66
100-seed weight (g)						
RSG-895 x RSG-888	IRG	17.44±0.54	15.86±0.44	17.20±0.48	17.00±0.47	18.20±0.51
	RF	16.28±0.45	15.76±0.76	17.30±0.66	16.60±0.46	17.80±0.44
RSG-888 x ICC-4958	IRG	15.87±0.48	28.72±0.58	26.25±0.63	25.46±0.54	26.48±0.65
	RF	15.68±0.73	27.19±0.89	24.13±0.61	23.93±0.42	24.86±0.36

IPC-94-94 x RSG-888	IRG	25.56±0.70	15.99±0.47	23.32±0.65	22.56±0.65	23.41±0.40
	RF	23.55±0.49	15.74±0.71	22.50±0.76	22.20±0.31	21.63±0.35
CSJD-901 x RSG-931	IRG	16.79±0.42	15.41±0.37	17.50±0.27	17.14±0.37	17.80±0.27
	RF	14.38±0.68	15.99±0.58	16.68±0.62	16.48±0.27	17.43±0.50
BG-362 x RSG-931	IRG	23.65±0.52	15.71±0.75	24.83±0.43	24.22±0.38	24.47±0.21
	RF	23.01±0.73	15.82±0.52	24.01±0.61	23.56±0.37	22.86±0.40
Protein content (%)						
RSG-895 x RSG-888	IRG	18.56±0.14	17.19±0.14	17.58±0.14	17.29±0.10	16.99±0.14
	RF	18.69±0.14	17.22±0.14	18.19±0.14	17.99±0.10	17.60±0.10
RSG-888 x ICC-4958	IRG	17.13±0.14	18.50±0.15	19.38±0.14	18.38±0.10	18.43±0.10
	RF	17.44±0.14	18.91±0.14	19.09±0.14	18.59±0.10	18.70±0.10
IPC-94-94 x RSG-888	IRG	20.63±0.14	17.50±0.15	18.56±0.15	18.25±0.10	17.50±0.10
	RF	20.69±0.14	17.69±0.14	18.66±0.15	18.38±0.10	18.51±0.10
CSJD-901 x RSG-931	IRG	20.00±0.14	17.50±0.14	18.44±0.14	18.19±0.13	18.63±0.10
	RF	19.82±0.13	19.18±0.14	18.43±0.14	18.60±0.10	18.80±0.10
BG-362 x RSG-931	IRG	19.69±0.14	17.75±0.14	18.98±0.14	18.63±0.10	18.19±0.12
	RF	19.50±0.14	19.09±0.14	19.17±0.14	19.25±0.10	18.93±0.10

Table 4: Percent decrease in the mean performance of different characters under rainfed condition as compared to irrigated condition

Characters	P_{1S}	P_{2S}	F_{1S}	F_{2S}	F_{3S}
Days to 50% flowering	4.41	5.04	9.80	9.94	8.26
Days to maturity	5.91	3.47	3.04	4.52	5.34
Plant height (cm)	4.87	11.77	7.74	9.77	10.99
Fruiting branches per plant	10.73	11.95	21.15	18.27	4.44
Pods per plant	19.83	25.79	18.02	14.43	9.74
Seeds per pod	2.98	-1.3	0.63	0.44	0.42
Biological yield per plant (g)	6.74	18.99	14.69	14.26	9.19
Seed yield per plant (g)	12.23	19.62	12.62	11.41	12.21
Harvest index (%)	-1.06	3.95	-1.66	0.04	-1.26
100-Seed weight (g)	6.45	1.30	4.11	3.39	5.24
Protein content (%)	-0.14	-4.13	-0.65	-2.29	-3.12

Note:- Minus (-) indicates that there was slight increase in the mean values of these characters

4. Conclusion

On the basis of the findings of this experiment it is concluded that there is differential influence of moisture stress on different quantitative characters because characters like seeds per pod and 100-seed weight were not affected significantly whereas pods per plant, seed yield per plant, biological yield per plant, fruiting branches per plant were affected the most by moisture stress. Therefore it is suggested that more consideration should be given to the characters like pods per plant, fruiting branches per plant, biological yield per plant and plant height given while deciding selection criteria for rainfed condition while selection for seed weight and seeds per pod can be exercised at any stage of generation advancement due to their stable nature and high heritability. The highest seed yield and harvest index were recorded in bold seeded parents IPC-94-94, ICC-4958 and BG-362 even in rainfed condition indicated that bold seeded genotypes generally showed higher degree of drought tolerance in comparison to medium seeded genotypes.

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