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Genotype x Environment Interaction and Stability Analyses for Yield and Yield Attributing Traits of Different Genotypes in Chickpea (*Cicer arietinum* L.)

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ABSTRACT**:** The present investigation Genotype x Environment interaction and Stability analysis study in Chickpea (*Cicer arietinum* L.)" was carried out with forty one genotypes in RBD design with three replications at three locations viz. Rajendra Agricultural University at Pusa, TCA, Dholi, Muzaffarpur and KVK, Gaya during Rabi 2005-06 and 2006-07. Thirteen quantitative as well as qualitative traits were included in the investigation to estimate genetic variability, character association, direct and indirect effects, genetic divergence and G x E interaction along with stability parameters. The analysis of variance revealed considerable variability among the treatments for ten characters except number of primary branches. Analysis of variance for stability pooled over environments exhibited significant differences among genotypes for all the characters except insoluble protein. The linear component of environment and G x E interaction was found to be highly significant for number of primary and secondary branches, number of pods per plant and grain yield, which might be responsible for high adaptation in Chickpea genotypes. Among the forty one genotypes in stability study, seven genotypes namely IPC 2003-55, SAKI 95-16, IPC 2003-57, ICCV 10, IPC 2003-10, IPC 2003-66 and IPC 2003-68 appeared to be more adapted as they exhibited non significant deviation from regression, linear components (bi) value less than unity and high mean for grain yields as compare to the population mean, indicating that, these genotypes may give similar response in poor as well as good environments.

Keywords: Stability analysis, genotype x environment, Chickpea, (*Cicer arietinum* L.)

INTRODUCTION

Pulses production in the country during the last five decades, has increased from 9.5 to 15.11 million tonnes, attributable to area expansion from 20.27 million hectare in 1951 to 23.81 million hectare at present and yield gain from 470 to 635 kg/ha hectare. In Bihar state area under chickpea cultivation was 311 thousand hectares in 1966-70 but present area under cultivation is only 66 thousand hectares (2005-06). The total production of chickpea in Bihar State was 202 thousand tonnes with the productivity of 639 kg/ha in sixties while at per cent it is 59 thousand tonnes with the productivity level of 894 kg/ha (Agricultural statistics at a glance 2006-07). The main reason for this reduction in Chickpea area in the Northern States of the country as well as in the Bihar is the development of high yielding and fertilizer responsive semi dwarf varieties of wheat which replaced the chickpea. The expansion in area under irrigated cultivation of wheat and other irrigated crops became more profitable as compared to chickpea. As per the World Health Organization (WHO) standard per capita per day availability of the pulses should be 50 g while at national level it is only 37 g and that of state level only 19 g. Grain yield is a complex multigeneic group of characters with great genetic morph-physiological and pathological dependence. Genotype x environment interaction provides estimates to identify varieties stable over a wide range of environments and also helps to develop stable high yielding genotypes through breeding programme. In order to evolved stable and highly desirable chickpea variety in a wide range of environments, multi location testing for yield, its components and quality has been found to be highly effective and useful. Eberhart and Russell (1966) have given a model based on different parameters which have better resolving power among the genotype for testing stability. Keeping in view the present investigation was carried out to study Genotype x Environment interaction and stability analyses for yield and yield attributing traits of different genotypes of chickpea.

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MATERIALS AND METHODS

The present investigation Genotype x Environment interaction and Stability analysis study in Chickpea (*Cicer arietinum* L.)" was carried out with forty one genotypes in RBD design with three replications at three locations in Rabi 2005-06 and Rabi 2006-07. Spacing was maintained at 30 cm between rows and 10 cm between plants within a row. The plot size of an entry within a replication for the experiment was 6 m^2. The experimental materials for the present investigation comprised of 41 different genotypes of chickpea, *Cicer arietinum* L. are presented in Table 1. These genotypes exhibited wide range of variation with respect to height, days to 50% flowering, number of primary branches, number of secondary branches, number of pod per plant, number of seed per pod and 100 seed weight. The experiment s were carried at three different locations of Bihar and all locations were considered individual environment i.e. E1: RAU, Pusa, E2: TCA, Dholi and E3: Gaya KVK Farmer's field. Good agricultural practices were followed to raise the crops. Data were recorded on thirteen characters namely days to 50% flowering, plant height (cm), number of primary branches, number of secondary branches, number of pod per plant, number of grain per pod, 100-seed weight (g), per cent infestation of pod borer, Score of wilt infestation, total protein (%), soluble protein (%) insoluble protein (%) and grain yield (Kg/ha).

Table 1 : List of genotypes, pedigree and source of the experimental materials

Sl. No.	Genotype	Pedigree	Source
1.	IPC 2000-33	L 412 x KPT 1	IIPR Kanpur
2.	IPC 2001-02	ICCV 10 x PDG 84-16	IIPR Kanpur
3.	ICP 2001-21	Selection from 84396	IIPR Kanpur
4.	IPC 2002-26	NARC 9004 x C 235	IIPR Kanpur
5.	IPC 2002-35	PG 5 x IPC 92-39	IIPR Kanpur
6.	IPC 2002-51	DCP 95-3 x KTP 1	IIPR Kanpur
7.	IPC 2002-71	Phule G 5 x H 82-2	IIPR Kanpur
8.	IPC 2002-75	Phule G 5 x H 82-80	IIPR Kanpur

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9.	IPC 2003-06	ICCV 10 x JG-315	IIPR Kanpur
10.	IPC 2003-07	DCP 92-3 x BG 256	IIPR Kanpur
11.	IPC 2003-10	NARC 9004 x C 235	IIPR Kanpur
12.	IPC 2003-27	L 411 x BG 256	IIPR Kanpur
13.	IPC 2003-31	ICC x 490220	IIPR Kanpur
14.	IPC 2003-35	IXCC x 94049	IIPR Kanpur
15.	IPC 2003-37	Phule G 5 X IPC 92-39	IIPR Kanpur
16.	IPC 2003-45	PG 5 x IPC 92-1	IIPR Kanpur
17.	IPC 2003-46	BG 364 x PDG 84-16	IIPR Kanpur
18.	IPC 2003-51	IPC 71 x ICCV 10	IIPR Kanpur
19.	IPC 2003-52	DCP 92-1 x KPT 1	IIPR Kanpur
20.	IPC 2003-54	PG 5 x H 82-2	IIPR Kanpur
21.	IPC 2003-55	ICCV2 x ICC 202	IIPR Kanpur
22.	IPC 2003-56	PG 5 x L 144	IIPR Kanpur
23.	IPC 2003-57	(ICC 4958 x ICC 11322) x ICCV 10	IIPR Kanpur
24.	IPC 2003-60	(IPC 6 x ICCV 10) x ICC 4958	IIPR Kanpur
25.	IPC 2003-66	ICC 4958 x BG-364	IIPR Kanpur
26.	IPC 2003-68	IPC 94-37 x KWR 108	IIPR Kanpur
27.	IPC 2003-69	PG 5 x KWR 108	IIPR Kanpur
28.	IPC 2003-71	KPG 59 x KPT 1	IIPR Kanpur
29.	ICP 2004-63	NARC 9008 x C 235	IIPR Kanpur
30.	ICP 2004-64	PG 5 x ICC 4958	IIPR Kanpur

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31.	SAKI-9516	ICCC 42 x ICCV 10	Jabbalpur (MP)
32.	DCP-92-3	Selection from germplasm	IIPR Kanpur
33.	ICCV-10	P 1231 x P 1265	ICRISAT
34.	BG-2019	Pusa 362 x (Avrodhi X Pusa 212)	IARI New Delhi
35.	BG 2032	(BG 361 x ICC 14309) X ICCV 89230	IARI New Delhi
36.	BG-2024	(BG 261 x ICC 88503) x (GL 920 x BG 1003)	IIPR Kanpur
37.	IPC 2003-11	IPC 9511 X PDG 84-16	IIPR Kanpur
38.	IPC 99-18-6	Selection from ICCV 940253	IIPR Kanpur
39.	BG 256	(BG 62 x K 850-3/127) x (L 280 x H 75-35)	IARI New Delhi
40.	BG 362	(Pusa 303 x P 179) x Pusa 303	IARI New Delhi
41.	BG 372	P 1231 x P 1265	IARI New Delhi

RESULTS AND DISCUSSION

Minimum days to 50% flowering was observed in IPC 2003-06 and IPC 2003-52 (74 days) followed by IPC 2003-07 and IPC 2003-27 (75 days), IPC 2004-63 (76 days) indicating that these genotypes may be selected for cultivation after early and mid early rice in Bihar condition with the mean yield potential of 800 kg/ha. BG 2019 and IPC 2000-33 were having the minimum plant height i.e. 44 cm followed by IPC 2003-55 (46 cm), where as DCP 92-03 and ICCV 10 were having (47 cm) of height having maximum yield as compared to other test entries; suggesting that to have the higher yield of chickpea dwarf plant may be selected. Maximum number of primary branches was observed in IPC 2002-51, IPC 2003-56, IPC 2000-33, IPC 2001-02 and IPC 2001-21 (6 branches) along with the mean grain yield of 850 kg/ha; however, IPC 2003-56 had given the maximum yield (1283 kg/ha) suggesting that more number of primary branches is also enhancing the grain yield. Maximum number of secondary branches obtained in IPC 2003-37 (29 branches) followed by IPC 2002-71 (26 branches), IPC 2003-46 (25 branches), BG 256 and IPC 2003-54 (24 branches), along with the mean grain yield of 800 kg/ha indicating that number of secondary branches

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is not as responsive as number of primary branches to have the higher grain yield. Highest numbers of pods per plant was obtained in BG 362 (94 pods/plant) followed by BG 372 (75 pods/plant). IPC 2003-51 (71 pods/plant), BG 256 (61 pods/plant) and IPC 2002-71 (57 pods/plant) along with the mean grain yield of 800 kg/ha; but a perusal of the table revealed that inspite of the very high number of pods per plant yield has gone down due to the higher per cent of the pod borer infestation as well as high wilt infestation score. The maximum 100-seed (g) weight was observed in IPC 2003-51 (32.03) followed by IPC 2003-60 and IPC 2003-35 (31 g), IPC 2004-63 (26.5 g) and IPC 2000-33 (25.62 g) exhibiting the mean grain yield 820 kg/ha. The minimum per cent of pod borer infestation was obtained in IPC 2003-07 and IPC 2003-27 (8%) followed by IPC 2003-10 (9%), where as IPC 2002-75, IPC 2002-51 and IPC 2001-21 (9.5%) with the mean grain yield of 850 kg/ha.IPC 2003-55, SAKI 9516 and IPC 2003-56 were found resistant to wilt along with the infestation score of (1.00); where as IPC 2003-57, DCP 92-3 and ICCV-10 exhibited higher score of wilt infestation (1.6) suggesting that they are tolerant to wilt infestation as well as they are the highest yielder among all the forty one genotypes. All the six experimentation locations were highly prone to wilt infestation that's why the entries which could not been infested by wilt exhibited the highest mean grain yield (1272 kg/ha). The maximum total protein was estimated in DCP 92-3, BG 256, IPC 2003-55, IPC 2003-71 and BG 2019 lower per cent of insoluble protein (20.5%) along with the higher per cent of soluble protein and having the mean grain yield of 1067 kg/ha. Indicating that these above five genotypes are good yielder as well as having the higher protein percentage, may be recommended for cultivation in rice fallow in North Bihar, to over come the malnutrition problem of poor among the poorest those residing in the remote of the remotest area of the Bihar State. IPC 2003-55 exhibited the highest yield (14.38 kg/ha) along with the high protein per cent and least infestation of wilt having the plant height (45.6 cm) followed by SAKI 9516 (1384 kg/ha), also exhibited the resistance against wilt infestation, DCP 92-3 (1271 kg/ha) with highest protein percentage (20.5%) and moderately resistant to wilt, IPC 2003-45 (1224 kg/ha) and IPC 2003-57 (1169 kg/ha). (Table 2).

The minimum G x E interaction was observed to be highly significant for plant height, number of primary branches, number of secondary branches, number of pods per plant, pod borer infestation and grain yield kg per ha where as Genotype x Environment (linear) was found to be highly significant for number of primary branches, number of secondary branches, number of pods per plant and grain yield. It

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revealed that the average performance of the genotypes with respect to yield and other characters varied significantly. Similar results were reported by Singh *et al*.(1988), Singh *et al*. (1990), Singh *et al*. (1993), Rao and Rao (2004). The variance due to pooled deviation (non linear) was significant for plant height number of secondary branches, number of pods per plant, and pod borer infestation, indicating considerable genetic diversity in the material as also reported by Naidu *et al*. (1988) and Muhammad *et al*. (2003). The highest magnitude of pooled deviation (non-linear) was observed for number of pods per plant followed by plant height, pod borer infestation and number of secondary branches based on over all performance of genotypes. Such non-linear deviation might be of practical value to construct and test the utility of multiple regression models to know more critically the complex mechanism of adaptation. High magnitude of environment (linear) effect in comparison to genotype environment (linear) were observed for six traits, which may be responsible for high adaptation in relation to yield attributing traits (Table 3)

When the individual genotypes was considered, it was found that the pooled deviation was highly significant in IPC 2000-33 for plant height, number of pods per plant, pod borer infestation per cent and grain yield. High significant deviation was observed in IPC 2001-02 for plant height, number of secondary branches, number of pods per plant, pod borer infestation and grain yield per hectare. IPC 2001-21 exhibited highly significant deviation for all six traits. IPC 2002-26 had shown highly significant pooled deviation for number of secondary branches, number of pods per plant and grain yield kg per hectare and significant for pod borer infestation per cent. IPC 2002-35 exhibited highly significant pooled deviation for all characters except number of primary branches. IPC 2002-51 revealed highly significant pooled deviation for all the characters except grain yield. Pooled deviation was highly significant in IPC 2002-71 for all the characters except number of primary branches. High significant deviation observed in IPC- 2002-75 for plant height, number of secondary branches, number of pods per plant, pod borer infestation per cent and yield. IPC 2003-06 exhibited high significant deviation for all the characters except yield. IPC 2003-07 had shown highly significant deviation for plant height, number of primary branches, number of pods per plant, pod borer infestation per cent and grain yield. IPC 2003-10 exhibited highly significant deviation for all the character except number of primary branches and grain yield. IPC 2003-27 revealed highly significant pooled deviation for plant height, number of secondary branches, number of pods per plant, pod borer infestation per

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cent and yield. IPC 2003-31 had shown highly significant pooled deviation for plant height, number of secondary branches, number of pods per plant, pod borer infestation per cent and grain yield. Pooled deviation was highly significant in IPC 2003-35 for number of secondary branches, number of pods per plant and pod borer infestation per cent. High significant deviation observed in IPC 2000-37 for number of secondary branches, number of pods per plant, pod borer infestation and yield kg/ha. High significant deviation observed in IPC 2003-45 for number of secondary branches, number of pods per plant, pod borer infestation per cent and grain yield. IPC 2003-46 revealed highly significant deviation for plant height, number of pods per plant, pod borer infestation per cent and grain yield. IPC 2003-51 exhibited highly significant pooled deviation for plant height, number of pods per plant, pod borer infestation and grain yield. Highly significant pooled deviation was observed in IPC 2003-52 for all the characters except yield . IPC 2003-54 had shown highly significant pooled deviation for all the characters except number of primary branches and grain yield. IPC 2003-55 exhibited highly significant pooled deviation for plant height, number of secondary branches, pods per plant, pod borer infestation per cent and grain yield. IPC 2003-56 revealed highly significant pooled deviation for plant height, number of primary, secondary branches, pods per plant, pod borer infestation per cent and grain yield. Highly significant deviation observed in IPC 2003-57 for all characters except number of primary branches. IPC 2003-60 had shown highly significant deviation for plant height, number of secondary branches, number of pods per plant, pod borer infestation. IPC 2003-66 and IPC 2003-68 exhibited highly significant pooled deviation for plant height, number of secondary branches, number of pods per plant, pod borer infestation and grain yield . Highly significant deviation observed in IPC 2003-69 for plant height, number of secondary branches, number of pods per plant, pod borer infestation per cent. IPC 2003-71 exhibited highly significant deviation for plant height and pod borer infestation per cent. IPC 2004-63, IPC 2004-64, SAKI-19516, DCP 92-3, ICCV-16, BG 2019, BG 2032 and BG 2024 revealed highly significant pooled deviation for plant height, number of secondary branches, number of pods per plant, pod borer infestation and grain yield. Highly significant deviation observed in IPC 2003-11 for plant height, number of pods per plant, pod borer infestation per cent and grain yield but in IPC 99-18-6 had observed highly significant deviation for above mention character except grain yield. BG 256 had observed highly significant deviation for plant height, number of secondary branches, number of pods per plant, pod borer infestation and grain yield. It was found that the pooled deviation was highly significant in BG 362 and BG 372 for plant height, number of pods per plant, pod borer infestation and grain yield.

High mean grain yield and deviation from regression was further taken as a basis to select the stable varieties. In the above average stable group maximum mean grain yield was observed in the genotype IPC 2003-55, SAKI 9516, IPC 2003-57, ICCV-16, IPC 2003-10, IPC 2003-66 and IPC 2003-68. They were found to be above average stable with non significant deviation from non linear component, suggesting that these above varieties are specifically suited for the poor environments as well as they will give the similar response also in good environment. In the average stable group maximum mean grain yield was observed by BG 256, followed by BG 2019 and BG 372 along with the non significant deviation from non-linear components indicating that these genotypes may get adapted in poor as well as good environment. Whereas, in the below average stable group maximum yield was obtained by DCP 92-3 followed by IPC 2002-75, IPC 2003-07, IPC 2003-37, IPC 2003-46 and BG 2024 along with the non-significant deviation from non-linear components, suggesting that these genotype will be specifically adapted to favourable environment and they will give poor yield in poor environment. Similar results were also obtained by Naidu *et al*. (1988), Muhammad *et al*. (2003). In all the above stable groups IPC 2003-55 exhibited maximum grain yield having the regression value less than one (above average stability) and non significant deviation from non-linear components proving that this would be the ideal variety with regard to yield and stability in the present study. For the character pod borer infestation percentage, IPC 2002-26, IPC 2003-37, IPC 2003-71, IPC 2004-63, IPC 2003-11 and IPC 99-18-6 exhibited above average stability along with the non-significant deviation from non-linear components having the average pod borer infestation percentage, only one genotype namely IPC 2003-71 was found above average stability along with the non-significant deviation from non-linear components comprising the average number of pods per plant BG 362 and BG 372 were having the highest number of pods per plant having the above average stability along with the significant deviation from non-linear components suggesting that in these varieties positive improvement in the environment can be exploited. BG 362 exhibited above average stability along with the non-significant deviation from regression comprising the above average number of secondary branches per plant. Four genotypes namely IPC 2002-71, IPC 2003-56, IPC 2003-66 and IPC 2003-60 were having the above average stability along with non-significant deviation from non-linear component comprising the above average number of primary branches. Three genotypes namely IPC 2002-26 and IPC 2003-31 and IPC 2003-35 exhibited above average stability along with the non significant deviation from regression comprising the average plant height (Table 4). Among the forty one (41) genotypes in stability study, seven genotypes namely IPC 2003-55, SAKI 9516, IPC 2003-57,

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ICCV 10, IPC 2003-10, IPC 2003-66 and IPC 2003-68 appeared to be more adapted as they exhibited non-significant deviation from regression, linear component (b_i) value less than unity and high mean for grain yield as compare to the population mean. Suggesting that these above genotypes are specially suited for the poor environments as well as they will give the similar response also in good environment.

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Table 2 : Pooled mean performance of 41 genotypes for twelve quantitative traits

Sl. No.	Genotypes	Days to 50% flowering	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pods per plant	100 seed weight (cm)	Pod borer infestation	Score of wilt infestation	Total protein (%)	Soluble protein (%)	Insoluble protein (%)	Yield (kg/ha)
		1	2	3	4	5	6	7	8	9	10	11	12
1	IPC 2000-33	80.39	43.97	5.60	19.39	47.93	25.56	15.23	4.11	17.42	14.80	2.42	724.22
2	IPC 2001-02	80.56	59.00	5.58	19.77	44.08	21.81	9.96	3.72	17.41	14.88	2.61	558.83
3	ICP 2001-21	82.56	54.42	5.59	17.55	39.22	22.71	9.52	3.37	18.32	15.42	2.44	880.17
4	IPC 2002-26	83.50	60.25	4.53	19.25	49.88	19.51	11.88	3.83	19.41	16.47	2.72	693.28
5	IPC 2002-35	81.89	55.23	5.35	21.59	57.01	21.19	15.23	3.94	18.32	15.81	2.58	714.44
6	IPC 2002-51	76.00	56.70	6.19	23.32	54.72	20.96	9.51	3.94	18.54	15.65	2.67	587.28
7	IPC 2002-71	82.17	55.65	5.22	25.55	57.15	21.61	13.03	4.22	17.74	15.26	2.41	728.94
8	IPC 2002-75	82.56	58.61	5.41	16.93	44.37	20.83	9.51	3.72	19.46	24.13	2.46	862.67
9	IPC 2003-06	73.75	51.34	5.09	19.58	41.94	19.51	9.25	4.28	18.51	16.19	2.50	667.22
10	IPC 2003-07	74.67	48.21	4.34	16.95	33.68	23.42	7.70	3.72	19.39	16.45	2.50	763.78
11	IPC 2003-10	76.17	50.78	4.48	13.66	45.70	23.11	8.81	2.11	17.41	15.08	2.78	1068.61
12	IPC 2003-27	75.22	55.66	4.33	20.87	41.27	17.09	7.88	2.56	19.46	16.42	2.50	1019.11
13	IPC 2003-31	79.83	54.16	4.26	17.25	45.81	19.39	9.11	6.17	19.42	16.28	2.69	487.22
14	IPC 2003-35	82.83	55.43	4.48	15.52	45.59	31.01	11.56	3.61	18.35	15.99	2.53	487.22
15	IPC 2003-37	84.17	53.20	4.25	28.60	39.70	17.11	10.28	3.83	17.23	14.93	2.54	764.67
16	IPC 2003-45	79.94	47.43	4.65	15.90	33.61	20.41	10.06	1.83	19.35	16.29	2.50	1224.28
17	IPC 2003-46	88.28	47.82	4.17	17.58	51.39	22.53	13.02	4.22	17.37	14.99	2.71	755.94
18	IPC 2003-51	87.28	52.30	4.92	19.59	71.17	32.03	12.62	3.83	19.52	16.29	2.56	789.28
19	IPC 2003-52	74.33	54.81	5.45	24.91	42.59	25.33	11.17	4.44	18.43	16.24	2.50	699.89
20	IPC 2003-54	81.17	51.12	4.72	16.74	44.28	18.07	12.94	3.78	17.41	14.80	2.81	851.22

21	IPC 2003-55	86.78	54.64	4.79	17.93	53.12	19.66	10.99	1.00	20.47	17.37	2.41	1438.44
22	IPC 2003-56	88.83	56.36	5.76	23.52	49.57	22.10	15.05	1.28	19.14	16.86	2.56	1283.17
23	IPC 2003-57	79.56	55.84	4.53	15.74	39.36	19.82	12.21	1.50	17.53	14.73	2.72	1169.39
24	IPC 2003-60	88.89	56.92	5.30	17.36	50.64	31.46	13.96	2.06	18.51	15.90	2.48	1017.06
25	IPC 2003-66	82.11	57.49	5.39	16.63	46.76	22.54	13.88	1.94	19.32	16.75	2.49	1045.78
26	IPC 2003-68	89.78	50.89	4.76	14.46	49.05	21.62	14.60	1.94	17.48	14.55	2.54	1036.67
27	IPC 2003-69	89.00	56.04	4.35	13.99	47.93	20.57	12.43	2.49	13.36	15.87	2.37	983.11
28	IPC 2003-71	81.56	51.78	4.33	14.23	43.03	19.97	13.43	3.56	20.45	17.75	2.55	872.00
29	ICP 2004-63	75.61	47.17	4.95	13.91	53.26	26.54	12.61	2.05	17.41	14.88	2.62	1017.56
30	ICP 2004-64	77.72	50.55	4.51	18.14	53.28	18.31	13.23	3.44	19.49	16.57	2.82	800.61
31	SAKI-9516	87.67	55.21	4.71	16.44	41.73	20.49	11.82	1.00	18.62	16.31	2.50	1383.89
32	DCP-92-3	78.50	46.54	3.88	14.81	45.12	17.71	10.96	1.61	20.51	17.77	2.60	1271.17
33	ICCV-10	80.44	47.96	5.25	19.82	46.32	17.14	13.99	1.83	19.54	16.94	2.61	1093.28
34	BG-2019	84.33	43.53	4.55	18.11	41.90	22.17	13.03	3.17	20.41	17.63	2.30	867.72
35	BG 2032	89.28	54.6	3.86	13.68	40.26	21.49	11.69	3.61	19.40	16.45	2.61	824.83
36	BG-2024	86.78	48.46	3.94	12.12	35.38	22.04	11.65	4.31	18.37	15.46	2.55	737.22
37	IPC 2003-11	77.33	54.92	4.43	16.32	53.20	18.28	12.63	4.44	17.54	15.24	2.53	664.39
38	IPC 99-18-6	77.34	56.51	4.43	17.81	51.80	17.09	11.31	4.11	18.53	16.42	2.12	747.32
39	BG 256	89.50	56.02	4.73	17.50	60.96	22.69	10.93	3.28	20.49	17.41	2.67	883.50
40	BG 362	88.69	55.65	4.74	21.10	91.35	21.21	15.94	3.78	19.62	16.81	2.78	748.61
41	BG 372	87.17	51.70	4.75	23.70	74.83	19.19	16.12	3.50	19.57	16.96	2.80	841.11
	Mean ($\overline{X}$)	82.92	53.04	4.77	18.23	54.80	21.60	11.94	3.28	19.11	16.26	2.56	901.98

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Table 3: Analysis of variance of forty one chickpea genotypes for twelve traits across the six environments

Source of variation	d.f.	Days to 50% flowering	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pods/ plant	100 seed weight	Score of pod borer infestation	Wilt infesta -tion %	Total protein %	Soluble protein %	Insoluble protein %	Yield (kg/ha)
Genotype	40	137.54**	98.42**	2.071**	750.90**	715.80**	79.65**	27.82**	7.90**	6.33**	014.18**	0.15	30886.83**
Environment	5	44.07**	173.19**	21.05**	209.66**	802.59**	7.10**	222.50**	2.45**	1.13	10.22**	0.58	25929.81**
G x E	200	0.942	18.73**	0.403**	13.32**	148.34**	0.44	7.50**	0.29	0.016	8.69	0.14	1088.99**
Pooled Error	480	1.41	2.59	0.16	3.78	6.77	1.16	2.50	0.34	0.043	26.05	0.19	567.62

* Significant at P = 0.05
** Significant at P = 0.01

Table 4: Analysis of variance for G x E interaction across the six environment of forty one chickpea genotype

	d.f.	Plant height	No. of primary branches	No. of secondary branches	No. of pods per plant	Pod borer infestation	Yield (kg/ha)
Genotype	40	98.424**	2.071**	75.900**	715.899**	2781**	303886.83**
Environment	5	173.197**	21.052**	209.66**	802.582**	222.495**	25929.81**
Genotype x Environment	200	18.736**	0.413**	13.317**	148.333**	7.498**	1088.99**
Evt. + (G X E)	205	22.503	0.906	18.106*	164.291**	12.742**	1694.87**
Evt. (Liner)	1	866.025**	105.259**	1048.286**	4012.733**	1112.536**	129494.91**
G x E (Linear)	40	16.808	1.100**	100.350**	432.378**	8.284	3328.42**

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Pooled deviation	164	18.749**	0.223	13.793**	75.437**	7.123**	517.17
IPC 2000-33	4	147.81**	5.45	32.05**	475.41**	72.12**	9966.14**
IPC 2001-02	4	59.24**	3.49	24.49**	1024.52**	58.09**	2287.60**
IPC 2001-21	4	37.0**	17.35**	71.28**	431.94**	32.01**	75632.39**
IPC 2002-26	4	4.43	1.57	96.98**	634.51**	6.03*	16270.48**
IPC 2002-35	4	121.92**	5.77	37.12**	3406.39**	392.87**	3430.38**
IPC 2002-51	4	108.62**	37.03**	249.82**	227.24**	23.87**	785.83
IPC 2002-71	4	310.97**	2.53	96.67**	1151.72**	74.86**	11358.41**
IPC 2002-75	4	44.91**	5.39	57.70**	807.21**	30.07**	7855.63**
IPC 2003-06	4	544.49**	12.27**	49.49**	33.10**	15.33**	1319.34
IPC 2003-07	4	225.46**	9.64*	17.26	340.92**	33.70**	6086.69**
IPC 2003-10	4	324.52**	2.19	22.51*	429.59**	57.55**	380.01
IPC 2003-27	4	258.25**	0.91	233.49**	153.06**	67.28**	8850.93**
IPC 2003-31	4	11.53*	1.91	161.04**	121.42**	44.06**	14043.32**
IPC 2003-35	4	0.42	2.84	187.83**	138.69**	103.54**	322.02
IPC 2003-37	4	121.40	2.42	1163.71**	129.35**	22.92**	5737.78**
IPC 2003-45	4	54.13	5.92	147.62**	678.44**	35.95**	15052.31**
IPC 2003-46	4	49.86**	0.30	125.92**	4692.79**	206.32**	5024.95**
IPC 2003-51	4	92.68**	2.55	8.02	7932.69**	34.33**	3653.50**
IPC 2003-52	4	49.32**	15.74**	110.49**	148.24**	29.05**	274.64
IPC 2003-54	4	230.81**	7.93	21.26**	34.83**	43.62**	1036.50
IPC 2003-55	4	45.85**	1.46	35.54**	433.05**	43.45**	4488.00**

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IPC 2003-56	4	136.84**	2.42	49.98**	958.07**	58.41**	11863.27**
IPC 2003-57	4	140.81**	4.78	206.76**	232.82**	88.42**	2514.88**
IPC 2003-60	4	73.17**	1.75	44.38**	475.24**	159.78**	784.81
IPC 2003-66	4	51.41**	2.82	33.72**	938.98**	49.06**	1915.64**
IPC 2003-68	4	215.99*	2.08	105.00**	1057.30**	221.30**	4306.80**
IPC 2003-69	4	83.33**	1.16	31.01**	78.64**	93.62**	773.95
IPC 2003-71	4	141.89**	1.36	5.00	12.08	13.48**	1142.93
IPC 2004-63	4	94.19**	4.02	43.90**	327.94**	11.29**	685.78
IPC 2004-64	4	110.13**	1.62	29.64**	10.88**	43.90**	61910.61**
SAKI-9516	4	96.39**	0.95	20.10*	130.66**	39.65**	2552.23**
DCP-92-3	4	39.11**	0.94	17.33*	87.89**	25.86*	6042.39**
ICCV-16	4	64.97**	3.97	44.66**	78.47**	83.99**	807.11**
BG-2019	4	43.97**	2.19	36.40**	420.55**	9.16**	3773.95**
BG 2032	4	107.70**	0.99	17.12*	142.48**	44.95**	6201.94**
BG-2024	4	26.89**	0.91	20.58*	104.57**	30.52**	17453.75**
IPC 2003-11	4	125.41**	1.48	8.49	704.63**	14.05**	2716.17**
IPC 99-18-6	4	77.86**	2.17	6.16	606.24**	16.44**	1223.30
BG 256	4	34.39**	1.81	22.73*	1908.39**	33.12**	3458.84**
BG 362	4	36.86**	0.93	4.27	1211.83**	71.14**	19958.38**
BG 372	4	68.23**	2.87	14.21	730.92**	76.98**	3795.69**
Pooled error	480	2.592	3.77	6.769	2.447	2.50	567.628

* Significant at P = 0.05
** Significant at P = 0.01

