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Research Article

Genetic studies on chickpea genotypes grown in late sown under rice fallow conditions of Madhya Pradesh

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Abstract
Genetic variability, heritability, interrelationships and diversity analysis for seed yield and its components were estimated in 31 genotypes of chickpea grown under rice fallow conditions. Highly significant differences existed among the genotypes tested for all the traits. Traits such as seed yield per plant, biological yield, number of effective pods, total number of pods, 100-seed weight, harvest index and number of secondary branches showed high phenotypic and genotypic coefficient of variation, heritability and genetic advance as percentage of mean. Significant and positive correlations were found between seed yield and biological yield, total number of pods per plant, harvest index, number of effective pods, 100-seed weight, number of secondary branches, number of primary branches and number of seeds per plant, while negative with phenological traits. Protein content showed significant negative correlation with 100-seed weight. Ideal plant type in late sown under rice fallows would be early in phenological traits having high biomass, harvest index and more number of effective pods. D^2 analysis grouped 31 promising lines into thirteen clusters. Genotypes JSC55, AKG 70, BGD 1064, BG 256, RVSSG 8, H 07-120, Phule G 00-108, BG 3005, JG 92-3974, CSJ 313 and BGD-1056 were identified as promising donor lines which may be utilized for chickpea improvement.

Key words
Chickpea, Phenological, heritability, variability, rice-fallow

Introduction

Chickpea is the third leading grain legume in the world and first in the South Asia. The introduction of chickpea in a cereal-based rotation, which is used particularly in developing countries, can break the disease and pest cycle, and increase the productivity of the entire rotation. Rice fields are mostly vacated late up to the end of November making the available varieties of chickpea unfit for sowing under late conditions (rice-fallow). Early maturing lines of chickpea, however, can be grown under rice fallow when availability of water is not enough for wheat cultivation. Inclusion of chickpea in rice-wheat system not only brings qualitative change in the production base for long term sustainability, but also protects the environment from risks associated with high input agriculture. The late sown conditions are characterized by low temperature at seedling and high temperature at the time of grain development. Low temperature at initial stage of crop growth results in poor and slow vegetative growth, whereas high temperature at the end of season leads to forced maturity. The purpose of this study was to estimate the genetic variability and to identify suitable plant type for selection for improving yield in late-sown chickpea cultivar under rice fallow situations.

Materials and Methods

Thirty one genotypes of chickpea were sown in randomized block design replicated thrice at the Seed Breeding Farm, College of Agriculture, Jabalpur in rice fallow under late sown conditions during first fortnight of December 2010. Each entry was accommodated in four row of 4.0 m length with a spacing of 30 cm between rows and 8-10 cm between plants. The recommended agronomical and plant protection practices were adopted for good crop growth. Observations were recorded for fourteen quantitative traits *viz*., days to flower initiation, days to 50% flowering, days to pod initiation, days to maturity, plant height (cm), number of primary branches, number of secondary branches, total number of pods, number of effective pods, number of seeds per pod, 100-seed weight (g), biological yield (g), harvest index (%), seed yield per plant (g) and two biochemical traits *viz*., carbohydrate (%) and protein (%).The standard statistical procedure were used for estimation of genetic parameters of variability, correlation, path and D^2 analysis.

Results and Discussion

In the present study, evaluation of genotypes of chickpea grown under late sown in rice fallow revealed presence of highly significant differences among them for all the traits, suggesting ample scope of exploiting such variability through selection. The estimates of various genetic parameters are presented in Table 1. Seed yield per plant had highest phenotypic and genotypic coefficient of variation, followed by biological yield, number of effective pods, total number of pods, 100- seed weight, harvest index and number of secondary branches, while days to flower initiation, days to 50 % flowering, days to pod initiation and days to maturity exhibited low phenotypic and genotypic coefficient of variation. High heritability coupled with high genetic advance as % of mean was recorded for the characters viz., 100-seed weight, number of effective pods, total number of pods, biological yield and seed yield per plant indicated that additive gene effect is predominant for these characters. Selection of these traits in early generation may be rewarding. Present results are similar to the findings of Pratap *et al*. (2004), Saleem *et al*. (2005), Ali *et al*. (2009), Jeena *et al.* (2005) and Atta *et al.* (2008). Sidramappa *et al*. (2008), Vaghela *et al*. (2009), Sharma and Saini (2010) and Akhtar *et al*. (2011) reported high heritability estimates coupled with high genetic advance for seed yield per plant, number of pods per plant, 100-seed weight and biological yield.

Correlation studies provide a clear picture of the extent of association between a pair of traits, which is generally due to linkage and pleiotropy. Correlations among characters are of much interest, because the changes brought about by selection for one trait may bring about simultaneous changes in other characters. In present investigation, seed yield per plant was positively and significantly associated with biological yield, plant height, total number of pods, harvest index, number of effective pods, 100 seed weight, number of secondary branches, number of primary branches and number of seeds per pod, while negatively associated with days to flower initiation, days to 50% flowering and days to pod initiation (Table 2). Similar results were reported in the earlier studies of Babbar and Patel (2005), Yucel *et al*. (2006), Talebi *et al*. (2007), Malik *et al*. (2010), Meena *et al*. (2010), Thakur and Sirohi (2010), Ali *et al*., (2011), Akhtar *et al*. (2011) and Gul *et al*. (2013). Yadav and Haquae (2001) showed that days to 50% flowering was negatively correlated with seed yield per plant which confirmed the present finding. Hence, selection of these characters will be effective for improvement of seed yield. Number of seeds per pod showed significant positive correlation with number of effective pods. Total number of pods showed significant positive correlation with number of effective pods, number of seeds per pod, biological yield and harvest index. These traits also showed strong positive association with seed yield per plant. Thus these traits should be given due importance, while formulating the selection procedure for improving the seed yield.

Correlation coefficients were estimated for yield and quality traits (Table 3). Protein content had significant negative correlation with 100-seed weight, while yield attributing traits showed non-significant correlation with carbohydrate content. Effective pods per plant and harvest index had significant positive correlations with seed yield. Effective pods per plant, total pods per plant and number of seeds per pod were positively correlated with each other and significant negative correlation with 100-seed weight. These findings indicated that small seeded genotypes will have more protein content than large seeded types and selection pressure for effective pods in small seeded types will improve the yield.

An attempt has been made to understand the component factors influencing seed yield per plant, biological yield and harvest index separately using path analysis as dependent characters (Table 4). The path coefficients at genotypic level revealed that days to 50% flowering, biological yield and number of secondary branches showed high positive direct effect and harvest index and flower initiation had high negative direct effect on seed yield per plant. On the other hand, days to flower initiation and 100 seed weight showed high positive direct effect, while days to 50 % flowering, total number of pods, number of secondary branches, days to pod initiation and seed yield per plant had high negative direct effect on biological yield. In this study, direct and indirect effects on harvest index were also observed and found that days to flower initiation had high positive direct effect, whereas high indirect effect was exhibited by days to flower initiation *via* plant height, seed yield per plant, biological yield, seeds per pod and number of primary branches; days to 50 % flowering *via* days to flower initiation, days to pod initiation and days to maturity. The residual effect of the genotypes on biological yield, harvest index and seed yield per plant was 3.124, 1.122 and 0.538, respectively indicated that some more characters should be included in the present study. Phenological traits *viz*., days to flower initiation, days to 50 % flowering , days to pod initiation and days to maturity showed negatively significant correlation with seed yield per plant, biological yield and harvest index and their negative direct and indirect effects were also high. It is also observed that these phenological traits had strong positive correlation with each other, indicating that earliness is the important trait for constructing of plant ideotype in chickpea. The present findings are in conformity with the findings of Kumar *et al*. (2002), Choudhary and Sharma (2003), Kumari *et al*. (2003) and Mushtaq *et al*. (2013). The results obtained are in accordance with the findings of Jain and Sharma (1991) for days to 50% flowering and days to maturity; Sontakey *et al*. (1991) for 100-seed weight; Dasgupta *et al*. (1992) for 100-seed weight; Khorgade *et al*. (1995) for biological yield and harvest index; Sandhu and Mangat (1995) for 100-seed weight and harvest index; Ozdemir (1996) for number of secondary branches; Gupta and Krishna (1997) for days to flowering, biological yield, 100-seed weight and harvest index; Babbar and Patel (2005) for biological yield, days to 50% podding and harvest index; Talebi *et al*. (2007) for harvest index and Ali *et al*. (2011) for 100-seed weight, number of pods and number of seeds per pod. On the basis of correlation and path analyses, traits suitable for ideal plant type would be earliness, high biological yield and harvest index. Therefore, in late planting under rice fallow condition the ideal plant should be early in flowering and maturity having high biomass, harvest index, more number of effective pods with optimum size of seeds.

Mahalanobis D^2 Statistics is a powerful tool in quantifying the degree of divergence. In the present study, 31 chickpea genotypes were grouped into 13 clusters. Highest Intra-cluster distance was found in cluster I (83.74) having 16 genotypes, the most diversified cluster, followed by cluster II (81.00) having 4 genotypes and other clusters had one genotype each (Table 5). The highest inter cluster divergence was observed between genotypes of cluster XI and XII, followed by cluster XI and XIII, cluster V and XI, cluster II and cluster XIII, cluster VIII and XII, cluster VII and cluster XIII, cluster IX and cluster XII and Cluster II and cluster VI, suggesting the presence of high variability in genetic make-up of genotypes included in these clusters.

Cluster I consisted of 16 genotypes, H07-157, NDG10-12, BG372, IPC 2006-77, PG064, RSG957, CSJ313, IPC2006-84, JSC55, RVSSG8, JG-17, GNG1995, JG14, BG256, BGD 1055, BG 3017 which suggested that there is lack of substantial divergence amongst them (Table 6). Genotypes grouped in this cluster indicated overall genetic similarity amongst them, whereas cluster II consisted of 4 genotypes, JG 21, H07 120, Phule G00 108, JG92 3974. Rest of the clusters namely cluster III (BGD1064), cluster IV (PG065), cluster V (IPC 2006-77), cluster VI (PG064), cluster VIII (BG372), cluster IX (RSG957), cluster VIII (BG 379), cluster X (H07 157), Cluster IX (AKG70), cluster XII (BGD 1063) and cluster XIII (GL26074) had one genotype each. In this context, the genotypes from these clusters should be selected as parents in hybridization programme for yield improvement in chickpea. Concomitant result has been reported by Dwevedi and Lal (2009), Syed *et al*. (2012) and Asghar *et al*. (2010).

The genotypes belonging to the clusters separated by high statistical distance could be used in hybridization programme for obtaining a wide spectrum of variation amongst the segregates. In this context, the genotypes from clusters III, IV, V, VI, VII, VIII, IX, X, XI, XII and XIII should be selected as parents in hybridization programme for yield improvement in chickpea. The variation in cluster mean of plant height, number of secondary branches, number of seeds per pod, 100-seed weight and seed yield per plant reflected the genetic difference in the cluster. The cluster mean for different yield attributing traits are presented in Table 7. Cluster II exhibit high harvest index, cluster VI for highest 100-seed weight, cluster VIII for low mean value for plant height, cluster IX was high in number of primary branches, cluster X was high in seed yield per plant, biological yield, cluster XIII for maximum number of effective pods, total number of pods, days to pod initiation, number of secondary branches, cluster XI was for maximum number of seeds per pod and cluster II for highest harvest index. Therefore, intercrossing of genotypes involved in these clusters could be practiced for inducing variability in the respective characters and their rationale improvement for increasing grain yield. Jethara *et al*. (1996) observed that seed yield, number of pods and 100-seed weight contributed most to divergence, while Darshanlal *et al*. (2001) reported that grouping of genotypes in different clusters was due to the traits *viz*., plant height, seed yield per plant, number of primary branches, number of secondary branches, number of seeds per pod, number of pods and 100 seed weight as these were the main contributing characters to genetic divergence in chickpea. Previous study of Nimbalkar and Harer (2001) supported the results of the present investigation that plant height, maturity duration, yield per plant, seeds per pod, 100-seed weight and secondary branches per plant were important in diversification of genotypes.

The results on the contribution of individual characters towards the total divergence suggested that the percent contribution was highest for days to pod initiation, followed by 100-seed weight, days to 50% flowering, biological yield, harvest index and seed yield per plant (Table 8). These traits should be given prime importance during selection. The clustering pattern obtained in the present study revealed that the genotypes from the extreme divergent groups with better values for yield and its components may yield superior segregates. Overall, chickpea genotypes, Phule G 0714, RSG 957, PG 064, BG 3005, BG 1056, BG 3018, JG 14, JG 92-3974 and JG 21 were found promising for suitable for late planting under rice fallow condition and could be utilized in the breeding programme to incorporate terminal heat tolerance.

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Table 1. Genetic parameters of variability for yield and its components traits of chickpea genotypes grown in late sown condition under rice fallow

Characters	Range		Mean	Variance		Coefficient of variation		h^2 B (%)	Genetic advance	GA as % of mean
	Min.	Max.		Phenotypic	Genotypic	Phenotypic	Genotypic			
FI	40.7	61.7	52.9	33.7	29.3	11.0	10.2	87	10.4	19.7
50% F	45.7	68.3	58.8	36.1	34.2	10.2	1.0	95	11.7	20.0
PI	56.7	78.7	68.1	32.2	31.1	8.3	8.1	97	11.3	16.6
DM	101.7	108.0	105.4	4.5	1.4	2.0	1.1	32	1.4	1.3
PH (cm)	23.9	61.1	45.6	112.7	52.0	23.3	15.8	46	10.1	22.1
PB	1.4	2.7	2.3	0.3	0.0	23.1	6.2	07	0.1	3.5
SB	3.9	7.8	5.7	2.3	1.0	27.0	17.2	41	1.3	22.5
TP	19.0	101.3	53.1	399.3	265.5	37.7	30.7	67	27.4	51.6
EP	15.8	90.2	47.7	340.7	236.6	38.7	32.3	69	26.4	55.4
S/P	0.6	1.3	1.0	0.0	0.0	21.3	8.9	18	0.1	7.7
100-SW (g)	8.6	34.0	19.9	52.6	40.0	36.5	31.8	76	11.4	57.2
BY (g)	19.7	65.4	34.3	188.5	119.8	40.1	32.0	64	18.0	52.4
HI (%)	15.2	55.2	34.0	107.9	45.6	30.6	19.9	42	9.1	26.6
SY (g)	5.6	22.9	11.0	19.6	11.2	40.2	30.4	57	5.2	47.2

FI=days to flower initiation, 50% F= days to 50% flowering, PI=days to pod initiation, DM=days to maturity, PH (cm)= plant height (cm), PB=number of primary branches, SB= number of secondary branches, TP=total number of pods, EP= number of effective pods, S/P= number of seeds per pod, 100-SW (g)=100-seed weight (g), BY (g)=biological yield (g), HI (%)= harvest index (%), SY (g) =seed yield per plant (g)

Table 2. Estimation of genotypic (lower diagonal) and phenotypic (upper diagonal) correlation coefficient for yield and its component traits in late sown condition under rice fallow

Characters	FI	50% F	PI	DM	PH (cm)	PB	SB	TP	EP	S/P	100-SW (g)	HI (%)	SY (g)	BY (g)
FI	1.0000	0.9111***	0.8423***	0.3274**	-0.3574***	-0.1179	0.2468*	-0.2126*	-0.1996	-0.2308*	-0.1712	-0.2665**	-0.3943***	-0.4785***
50% F	0.9408	1.0000	0.9138***	0.3973***	-0.3492***	-0.0884	0.2177*	-0.1682	-0.1683	-0.2292*	-0.1110	-0.2882**	-0.3767***	-0.4638***
PI	0.9081	0.9432	1.0000	0.4531***	-0.2250*	-0.0597	0.2898**	-0.0941	-0.1076	-0.2074*	-0.0003	-0.2663**	-0.3051**	-0.3307**
DM	0.4843	0.5970	0.7469	1.0000	0.1124	0.2408*	0.2481*	0.1211	0.0915	0.0889	0.0837	-0.0092	0.0569	-0.449
PH (cm)	-0.4994	-0.4808	-0.3092	0.0444	1.0000	0.6363***	0.4370***	0.4707***	0.4463***	0.6249***	0.6483***	0.5476***	0.6144***	0.5997***
PB	-0.4946	-0.3869	-0.1284	0.9474	0.5630	1.0000	0.6207***	0.4296***	0.4236***	0.7100***	0.3910***	0.4602***	0.3888***	0.3955***
SB	0.4539	0.3714	0.4905	0.5589	-0.1050	0.2552	1.0000	0.6093***	0.6031***	0.5850***	0.1921	0.2786**	0.4006***	0.4192***
TP	-0.2640	-0.1895	-0.0772	0.1295	0.2975	0.3512	0.5211	1.0000	0.9408***	0.5142***	0.0441	0.4884***	0.5869***	0.5099***
EP	-0.2740	-0.2016	-0.0940	0.1067	0.2573	0.3468	0.5056	0.9806	1.0000	0.5346***	-0.0150	0.4691***	0.5856***	0.4979***
S/P	-0.5384	-0.5197	-0.4473	-0.3030	0.1759	0.8419	0.1370	0.4005	0.5107	1.0000	0.2750**	0.5990***	0.4615***	0.4045***
100-SW (g)	-0.1420	-0.0903	0.0121	0.0837	0.5738	0.4244	-0.1543	-0.1658	-0.2447	-0.1882	1.0000	0.3226**	0.4709***	0.4625***
HI (%)	-0.4293	-0.4135	-0.3718	-0.1467	0.2555	0.2589	-0.3687	0.2514	0.2315	0.1923	0.1540	1.0000	0.5253***	0.2816**
SY (g)	-0.5480	-0.4930	-0.3899	-0.1781	0.4736	-0.0812	0.0108	0.4729	0.4687	0.0489	0.3917	0.2641	1.0000	0.7376***

FI=days to flower initiation, 50% F= days to 50% flowering, PI=days to pod initiation, DM=days to maturity, PH (cm)= plant height (cm), PB=number of primary branches, SB= number of secondary branches, TP=total number of pods, EP= number of effective pods, S/P= number of seeds per pod, 100-SW (g)=100-seed weight (g), BY (g)=biological yield (g), HI (%)= harvest index (%), SY (g) =seed yield per plant (g)

Table 3. Correlation coefficients of yield components and quality traits of chickpea in late sown condition under rice fallow

Characters	EP	TP	S/P	100-SW(g)	HI (g)	SY(g)	Carbohydrate (%)	Protein (%)
EP	1.00000	0.53776***	0.41039*	-0.35962*	0.31463	0.52722***	0.02589	0.13867
TP		1.00000	0.46748**	- 0.45422*	0.31019	0.26690	-0.10434	0.26177
S/P			1.00000	-0.46372**	0.27659	0.18163	-0.16505	0.18621
100-SW(g)				1.00000	-0.00480	0.28067	0.33592	-0.46514**
HY(g)					1.00000	0.39314*	-0.00235	-0.27981
SY(g)						1.00000	0.09044	-0.08913
Carbohydrate %							1.00000	-0.29061
Protein %								1.00000

EP= number of effective pods, TP=total number of pods, S/P= number of seeds per pod, 100-SW (g)=100-seed weight (g), BY (g)=biological yield (g), HI (%)= harvest index (%), SY (g) =seed yield per plant (g)

Table 4. Path coefficient analysis of different traits on seed yield, biological yield and harvest index in late sown condition under rice fallow at genotypic level

Characters		FI	50% F	PI	DM	PH (cm)	PB	SB	TP	EP	S/P	100 SW (g)	BY (g)	HI (%)	SY (g)
	BY	**25.193**	23.702	22.876	12.199	-12.582	-12.461	11.436	-6.649	-6.904	-13.563	-3.577		-10.816	-13.806
FI	HI	**4.321**	4.065	3.924	2.092	-2.158	-2.137	1.961	-1.141	-1.184	-2.326	-0.614	-2.542		-2.368
	SY	**-1.545**	-1.454	-1.403	-0.748	0.772	0.764	-0.702	0.408	0.424	0.832	0.219	0.909	0.664	
	BY	-21.275	**-22.613**	-21.329	-13.501	10.873	8.748	-8.399	4.285	4.559	11.752	2.042		9.351	11.148
50% F	HI	-3.085	**-3.279**	-3.093	-1.958	1.577	1.269	-1.218	0.621	0.661	1.704	0.296	1.856		1.617
	SY	1.885	**2.004**	1.890	1.196	-0.964	-0.775	0.744	-0.379	-0.404	-1.041	-0.181	-1.134	-0.829	
	BY	-7.290	-7.573	**-8.028**	-5.996	2.458	1.031	-3.938	0.619	0.755	3.591	-0.097		2.985	3.130
PI	HI	-1.235	-1.283	**-1.359**	-1.016	0.416	0.175	-0.667	0.105	0.128	0.608	-0.017	0.560		0.530
	SY	-0.271	-0.282	**-0.299**	-0.223	0.091	0.038	-0.147	0.023	0.028	0.134	-0.004	0.123	0.111	
	BY	1.949	2.404	3.007	**4.026**	0.179	3.815	2.251	0.521	0.430	-1.220	0.337		-0.591	-0.717
DM	HI	0.319	0.393	0.492	**0.658**	0.029	0.623	0.368	0.085	0.070	-0.199	0.055	-0.141		-0.117
	SY	-0.098	-0.120	-0.150	**-0.201**	-0.009	-0.191	-0.113	-0.026	-0.022	0.061	-0.017	0.043	0.030	
	BY	4.273	4.114	2.619	-0.379	**-0.856**	-4.817	0.898	-2.545	-2.202	-1.505	-4.909		-2.186	-4.053
PH (cm)	HI	0.577	0.556	0.354	-0.051	**-1.156**	-0.651	0.121	-0.344	-0.297	-0.203	-0.663	-0.489		-0.547
	SY	-0.289	-0.279	-0.178	0.026	**0.581**	0.327	-0.061	0.173	0.149	0.102	0.333	0.246	0.148	
	BY	-1.460	-1.142	-0.379	2.797	1.662	**2.952**	0.753	1.037	1.024	2.485	1.253		0.764	-0.240
PB	HI	-0.259	-0.203	-0.067	0.497	0.295	**0.524**	0.134	0.184	0.182	0.442	0.223	-0.114		-0.043
	SY	0.100	0.078	0.026	-0.192	-0.114	**-0.202**	-0.052	-0.071	-0.070	-0.170	-0.086	0.044	-0.052	
	BY	-5.781	-4.731	-6.247	-7.118	1.337	-3.249	**-12.736**	-6.637	-6.439	-1.745	1.966		4.696	-0.138
B	HI	-0.939	-0.768	-1.015	-1.156	0.217	-0.528	**-2.069**	-1.078	-1.046	-0.283	0.319	-0.296		-0.022
	SY	0.378	0.309	0.408	0.465	-0.087	0.212	**0.832**	0.434	0.421	0.114	-0.128	0.119	-0.307	
	BY	5.059	3.632	1.479	-2.481	-5.701	-6.730	-9.987	**-19.164**	-18.792	-7.675	3.178		-4.819	-9.062
TP	HI	0.316	0.227	0.092	-0.155	-0.356	-0.419	-0.623	**-1.196**	-1.173	-0.479	0.198	-0.559		-0.565
	SY	0.140	0.101	0.041	-0.069	-0.158	-0.186	-0.277	**-0.531**	-0.520	-0.213	0.088	-0.248	-0.133	
	BY	-11.055	-8.134	-3.792	4.303	10.381	13.989	20.395	39.555	**40.338**	20.601	-9.873		9.339	18.908
EP	HI	-1.096	-0.806	-0.376	0.427	1.029	1.387	2.022	3.921	**3.998**	2.042	-0.979	1.836		1.874
	SY	0.088	0.065	0.030	-0.034	-0.082	-0.111	-0.162	-0.314	**-0.320**	-0.164	0.078	-0.147	-0.074	
	BY	4.715	4.551	3.917	2.654	-1.541	-7.373	-1.199	-3.507	-4.473	**-8.758**	1.648		-1.684	-0.429
S/P	HI	0.452	0.436	0.375	0.254	-0.148	-0.706	-0.115	-0.336	-0.428	**-0.839**	0.158	0.023		-0.041
	SY	-0.121	0.117	-0.100	-0.068	0.039	0.189	0.031	0.089	0.115	**0.224**	-0.042	-0.006	0.043	
	BY	-1.727	-1.098	0.147	1.018	6.978	5.161	-1.877	-2.017	-2.976	-2.288	**12.161**		1.873	4.764
100-SW (g)	HI	-0.204	-0.129	0.017	0.120	0.824	0.609	-0.222	-0.238	-0.351	-0.270	**1.436**	0.498		0.563
	SY	0.043	0.027	-0.004	-0.025	-0.174	-0.129	0.047	0.050	0.074	0.057	**-0.303**	-0.105	-0.047	
	BY														
BY (g)	HI	0.239	0.230	0.168	0.087	-0.172	0.089	-0.058	-0.190	-0.187	0.011	-0.141	**-0.407**		-0.313
	SY	-0.549	-0.528	-0.384	-0.199	0.395	-0.203	0.133	0.436	0.428	-0.026	0.324	**0.933**	-0.007	
	BY	3.052	2.939	2.643	1.043	-1.816	-1.841	2.621	-1.788	-1.646	-1.367	-1.095		-7.109	-1.878
HI (%)	HI														
	SY	-0.308	-0.297	-0.267	-0.105	0.184	0.186	-0.265	0.181	0.166	0.138	0.111	-0.006	**0.718**	
	BY	3.758	3.381	2.674	1.221	-3.248	0.557	-0.074	-3.243	-3.215	-0.336	-2.686		**-1.811**	**-6.858**
SY (g)	HI	0.166	0.149	0.118	0.054	-0.143	0.025	-0.003	-0.143	-0.142	-0.015	-0.118	-0.233		**-0.302**
	SY														

Residual effect: biological yield = 3.1244, harvest index = 1.1216 and seed yield = 0.5376

FI=days to flower initiation, 50% F= days to 50% flowering, PI=days to pod initiation, DM=days to maturity,PH (cm)= plant height (cm), PB=number of primary branches, SB= number of secondary branches, TP=total number of pods, EP= number of effective pods, S/P= number of seeds per pod, 100-SW (g)=100-seed weight (g), BY (g)=biological yield (g), HI (%)= harvest index (%), SY (g) =seed yield per plant (g)

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Table 5. Inter and intra cluster D^2 values of various genotypes of chickpea grown in late sown condition under rice fallow

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX	Cluster X	Cluster XI	Cluster XII	Cluster XIII
Cluster I	83.74	215.75	115.72	142.96	116.81	217.67	142.09	210.92	183.16	191.14	351.47	296.62	349.82
Cluster II		81.00	294.56	401.91	441.52	510.72	430.11	158.52	132.95	361.73	156.96	653.97	794.12
Cluster III			0.00	62.36	158.80	46.96	231.94	295.21	300.88	231.15	517.36	125.66	427.77
Cluster IV				0.00	108.07	71.26	222.50	426.82	406.91	326.31	677.23	138.46	364.20
Cluster V					0.00	183.36	78.67	387.01	341.78	241.73	616.32	229.93	157.60
Cluster VI						0.00	304.28	438.12	478.03	345.97	810.70	91.88	413.44
Cluster VII							0.00	338.97	234.50	84.20	435.67	329.68	104.45
Cluster VIII								0.00	83.03	280.07	210.60	670.27	669.52
Cluster IX									0.00	165.44	88.32	655.25	546.83
Cluster X										0.00	302.03	422.91	249.64
Cluster XI											0.00	938.26	861.43
Cluster XII												0.00	414.13
Cluster XIII													0.00

Table 6. Distribution of various genotypes of chickpea in different clusters grown in late sown condition under rice fallow

Cluster No.	No. of genotypes	Genotypes included in the cluster
1	16	H 07-157, NDG 10-12, BG372 , IPC2006-77, PG 064, RSG 957, CSJ 313, IPC 2006-84, JSC 55, RVSSG 8, JG 17, GNG 1995, JG-14, BG256, BGD-1055 and BG 3017
2	4	JG 21, H 07-120, Phule G 00-108, and JG92-3974
3	1	BGD 1064
4	1	PG 065
5	1	GNG 1991
6	1	BG 3018
7	1	BGD 1056
8	1	JDSC56
9	1	RSG957
10	1	Phule G 0714
11	1	AKG 70
12	1	BGD 1063
13	1	GL 26074

Table 7. Cluster means for yield and its component traits of chickpea grown in late sown condition under rice fallow

Characters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX	Cluster X	Cluster XI	Cluster XII	Cluster XIII
Days to flower initiation	53.90	46.00	55.33	61.67	60.67	60.00	55.33	46.33	46.67	51.33	40.67	55.67	59.33
Days to 50% flowering	60.08	50.17	61.00	67.00	66.00	65.00	63.33	50.33	50.67	58.33	45.67	68.33	65.67
Days to pod initiation	68.81	60.00	71.00	73.33	75.67	75.67	71.67	62.33	63.00	68.67	56.00	75.00	78.67
Days to maturity	105.44	104.50	104.00	107.33	106.67	107.67	105.33	104.33	105.33	107.33	101.67	105.33	108.00
Plant height (cm)	41.20	54.87	50.33	49.00	39.07	49.37	43.00	38.60	51.07	61.13	56.73	48.00	48.27
Number of primary branches	2.30	2.45	2.20	2.40	2.53	2.40	2.33	2.47	2.60	2.47	2.00	2.27	2.47
Number of secondary branches	5.53	4.62	5.73	6.27	6.53	6.53	6.93	6.47	5.93	7.80	4.40	4.60	8.53
Total number of pods	48.53	51.22	42.20	27.93	45.73	38.60	73.80	63.27	52.53	98.13	72.33	47.93	101.27
number of effective pods	43.31	44.85	36.73	19.93	46.67	33.93	69.93	50.00	59.60	90.23	67.40	42.27	88.60
number of seeds/Pod	0.98	1.05	0.94	0.93	1.19	0.95	1.06	1.10	1.02	1.10	1.20	0.96	0.99
100-seed weight (g)	17.37	22.87	29.20	23.40	14.40	34.00	12.93	23.80	22.33	21.33	19.93	32.87	12.60
Biological yield (g)	28.35	37.42	38.67	27.67	25.00	42.67	38.47	57.53	54.33	65.37	49.07	25.33	35.33
Harvest index (%)	32.38	45.15	36.90	23.17	31.63	33.30	25.37	38.67	23.60	40.13	33.00	32.80	36.50
Seed yield per plant (g)	9.90	12.43	14.43	5.60	6.67	12.67	9.80	13.43	12.80	22.93	16.20	9.43	9.03

FI=days to flower initiation, 50% F= days to 50% flowering, PI=days to pod initiation, DM=days to maturity, PH (cm)= plant height (cm), PB=number of primary branches, SB= number of secondary branches, TP=total number of pods, EP= number of effective pods, S/P= number of seeds per pod, 100-SW (g)=100-seed weight (g), BY (g)=biological yield (g), HI (%)= harvest index (%), SY (g) =seed yield per plant (g)

Table 8. Contribution of different traits towards clustering in chickpea Genotypes grown in late sown condition under rice fallow

Source	Times ranked 1st	Contribution %
Days to flower initiation	14	3.01
Days to 50% flowering	66	14.19
Days to pod initiation	119	25.59
Days to maturity	1	0.22
Plant height (cm)	0	0.00
Number of primary branches	0	0.00
Number of secondary branches	11	2.37
Total number of pods	21	4.52
Number of effective pods	9	1.94
Number of seeds per pod	3	0.65
100-seed weight (g)	108	23.23
Biological yield (g)	56	12.04
Harvest index (%)	39	8.39
Seed yield per plant (g)	18	3.87

Toucher cut-off value = 104.45