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Genetic competition of lentil genotypes in different environmental condition

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Abstract
An experiment to evaluate performance of newly developed candidate lines of lentil (*Lens culinaris*) was conducted at Krishi Vigyan Kendra, Saraiya during 2013-14, 2014-15 and 2015-16. Genetic variability and Heritability were evaluated for yield and its attributing traits. The combined analysis of variance indicated that genotype and genotype x environment interaction showed significant mean sum of squares for all the character in the entire environment. The genotype PL-6 was earliest to reach days to 50% flowering. The phenotypic coefficient of variance (PCV) was significantly higher than genotypic coefficient of variance (GCV). High heritability with low genetic advance was observed for most of the traits indicating the presence of additive gene effect for these traits.

Keywords: lentil, variability, heritability, genetic advance

Introduction
Lentils are one of the oldest and cool season *rabi* crops grain legume crops, cultivated as human food worldwide. Legumes are important components in farming systems for environmental and ecological benefits through crop rotation, ability to fix atmospheric nitrogen (N) and thus improve soil fertility (Khazaei *et al*., 2016) [8]. It is a self-pollinated diploid (2n=14), autogamous species and oldest crop i.e. originated in near east (Zohary, 1972) [16]. Medicinal and therapeutic studies suggested that the crop has potential to fight against some important chronic diseases due to presence of antioxidant, anticancerous, probiotic activity and anti-nutritional factors, like trypsin inhibitors and relatively high phytate content (Madina *et al*., 2013) [9].

During recent days' agricultural scientists are facing complex and urgent task of bringing the "population-food supply" equation into rational balance. The past trend of government effort in research and development has been the focus mostly on Rice and wheat. Similar attention was overdue for the pulse crops (also k/n as poor man's meat) (Sarker and Erskine, 2008). Pulses crop has ability to enhance the soil fertility and contribute significantly to achieve the twin objectives of increasing productivity and enhance the sustainable potential of cropping system in the Indo Gangetic plain (Singh *et al*., 2013) [13]. It has been reported that there is a scope of increasing area under lentil during the *rabi* season, as its cost per hectare is less with higher net returns than the competing cereal crops under drought and minimal resource conditions. Globally India ranked first in area and second in production contributing 39.79% and 22.79% of world area and production respectively. Lentil occupies 14.79 lakh ha total area under pulses with production of 10.38 lakh tonnes annually having low productivity (663 kg/ha) as compared to other countries like Australia, Canada etc.

The total production and productivity could be enhanced either by making horizontal expansion in area of lentil, which is not possible due to high population growth, apart from that the other option were vertical expansion, which could possible by opting a suitable breeding method. Genetic variation between and within populations is a major interest of plant breeders and geneticists because it facilities the efficient sampling and utilization of germplasm resource. The breeders must have knowledge of choosing the accession that most likely possesses the trait of interest and its knowledge of genetic variation and relationships between populations is important to understand the available genetic variability and its potential use in breeding programs. Its maintenance is necessary to protect plant genetic resource, maintain genotype environment interaction and provide greater production stability.

Lentil breeding has relatively short methodology based on bulk population method with single plant selection at F_5 and in this lines are evaluated for morpho-agronomic traits to develop cultivar capable of producing high yield. The simultaneous improvement depends on availability of genetic variation present for the traits. The considering the importance of crop, and the need to enhance the availability, utilization of its genetic resources and selection of high yielding genotype based on environmental performance. The present experiment was conducted to assess the performance of genotype based on three environments to estimate variability, heritability of yield and its yield contributing traits.

Material and Methods

The experiment was conducted at Krishi Vigyan Kendra, research and demonstration farm Saraiya muzaffarpur. The twelve diverse genotypes were sown in completely randomized bloc design with three replications at spacing of 30cm row-row and plant to plant spacing of 10cm in three consecutive year *i.e.* early October (2012-13), mid-October (2013-14) and late October (2014-15). All the recommended agronomical practices and plant protection measures were endorsed to raise good crop. Observations were recorded for five diverse characters viz., days to 50% flowering, plant height, number of nod/plant, 1000 grain weight and yield/plant. The data were analysed to estimate genotypic and phenotypic co-efficient of variations, heritability in broad sense (Burton and De Vane, 1953) [3] and genetic advance in per cent of mean. The data were analysed using the software SPSS.

Results and Discussion

All the genotype showed significant mean sum of squares for all the character in the entire environment (E_1, E_2 and E_3: Table 1.1). The combined analysis of variance of twelve genotypes over three years for the concerned character indicated that year, genotype and genotype x environment interaction showed significant mean sum of squares for all the character in the entire environment (E_1, E_2 and E_3:Table 1.2). Bycer and Tuba (2004) reported that there was significant variation in plant height and grain yield among the entire environment. This specified the existence of considerable amount of variation among the genotypes to carry out further genetic analysis i.e. necessary for formulating an effective breeding program. This variation may be phenotypic, genotypic and environmental which gives an idea of magnitude of variability. This result had an agreement of Crippa *et al.*, 2009 [5] and Singh *et al.*, 2017 [14]. The highest pcv and gcv were observed for grain yield/plot (4.53 and 2.93) whereas lowest was observed for days to 50% flowering. Similar results were also reported by Hussain *et al.* (2014) [7] and showed that remarkable difference was observed between PCV and GCV for the given characters which confirms high influence of environmental factors for expression of these traits.

Table 1.1: Analysis of variance (Mean sum of square) for twelve parents with five characters of Lentil

S. No.	Character	Source of Variation								
		2013-14			2014-15			2015-16		
		R	T	E	R	T	E	R	T	E
	Degree of Freedom	2	11	22	2	11	22	2	11	22
1.	Days of 50%flowering	0.03	15.60**	9.18	3.77	41.65**	4.14	4.94	14.46**	4.50
2.	Plant height (cm)	13.86	21.97**	5.29	0.26	7.86*	3.57	5.33	21.44**	7.83
3.	No. of pod/plant	39.08	363.64**	60.72	0.34	539.79**	17.47	8.09	362.43**	92.00
4.	1000 grain weight	0.25	38.69**	3.61	0.60	40.64**	1.60	0.02	49.38**	4.04
5.	Grain yield /plot	0.02	0.10	0.03	0.02	0.26	0.06	0.05	0.33	0.06

Table 1.2: Pooled analysis of variance (Mean sum of square) for twelve parents with five characters of Lentil

Variation Sources	Degree of Freedom	Days of 50%flowering	Plant height (cm)	Number of pod/plant	1000 grain weight	Grain yield /plot
Genotype	11	8.79	13.32	3139.82	371.11	1.77
Environment	2	6.12	0.95	873.14	0.99	42.95
G × interaction	22	7.56	1.90	328.89	14.34	0.16
Pooled error	66	6.20	1.57	56.73	3.08	0.05
CV	-	3.49	4.69	4.54	6.28	6.14

Table 1.3: Estimates of range, grand mean, phenotypic, genotypic, environmental, coefficient of variation, heritability in broad (h2bs) sense and genetic advance in per cent of mean (GA) eleven characters in bottle gourd genotypes

Traits	Days of 50%flowering				Plant height (cm)				No. of pod/plant				1000 grain weight			
S. No.	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1.NDL-1	81.00	75.00	75.22	77.07	31.33	30.00	33.67	31.67	401	343	445	396.33	79.52	77.08	78.78	78.46
2.PL-6	74.00	76.00	80.00	76.67	28.67	31.33	28.00	29.33	423	395	407	408.57	47.14	49.45	49.45	48.68
3.IPL-406	75.00	78.00	78.33	77.11	24.67	30.24	25.10	26.67	451	452	462	455.00	49.47	52.26	58.59	53.44
4.Noori	79.00	82.00	82.00	81.00	29.67	29.63	29.67	29.65	368	367	373	369.44	74.98	76.53	79.32	76.94
5.Arun	76.33	86.00	80.26	80.86	27.33	27.77	26.67	27.26	396	390	400	395.33	68.40	75.60	61.50	68.50
6.PL-8	79.67	76.00	76.44	77.37	28.00	30.00	29.33	29.11	378	376	384	379.33	49.11	53.03	56.30	52.81
7.HUL-57	80.00	80.33	79.77	80.04	25.00	25.77	24.67	25.15	354	378	394	375.33	62.27	58.40	62.27	60.98
8.Shivalika	80.33	72.33	77.97	76.88	30.67	28.74	29.67	29.69	352	348	366	355.44	79.50	72.83	64.90	72.41
9.Moittree	80.00	76.00	80.00	78.67	33.67	31.19	30.67	31.84	396	446	410	417.33	48.41	50.69	52.17	50.42
10.PusaVaibhav	79.00	78.33	81.70	79.68	28.67	30.00	29.40	29.36	450	465	469	461.25	49.21	46.87	48.90	48.33
11.KLS-218	80.00	79.73	82.07	80.60	30.67	30.05	30.93	30.55	379	370	394	381.00	58.48	59.34	61.42	59.75
12.Titua(local)	80.00	74.64	77.67	77.44	32.00	31.48	32.00	31.83	380	403	403	395.55	52.87	52.48	52.26	52.54
13.GCV	1.86	4.54	3.53	0.86	8.08	4.03	8.08	2.07	7.65	10.03	6.96	2.39	17.74	18.00	18.55	3.21
14.PCV	4.28	5.24	2.29	3.28	11.28	7.53	11.28	3.22	9.68	10.53	9.90	3.04	20.29	19.07	20.88	4.34

15.ECV	3.85	2.61	2.67	3.17	7.87	6.36	7.87	2.46	5.93	3.18	7.03	1.89	9.86	6.30	9.58	2.91
16.h^2 (%)	43.49	86.68	65.16	26.07	71.60	53.51	60.58	64.48	79.02	95.33	70.35	78.44	87.41	94.38	88.84	74.11
17.GA	1.59	1.94	1.31	4.59	11.85	2.79	4.18	2.79	3.59	3.90	3.67	3.82	7.52	7.07	7.74	4.82
18.GM	78.69	77.86	79.29	78.62	29.19	29.68	29.19	88.07	131.33	131.49	136.35	399.16	19.28	20.03	20.96	60.27
19.Lowest range	74.00	72.00	75.22	76.67	24.67	77.32	74.00	75.77	352.00	343.00	469.00	369.44	47.14	52.06	48.90	48.33
20.Highest range	81.00	86.00	82.00	81.00	33.67	94.45	101.00	98.52	450.00	465.00	366.00	461.25	79.52	77.08	79.32	78.46
21.CV	3.85	2.61	2.67	3.49	7.87	6.36	7.87	4.36	5.93	3.17	7.03	4.54	9.86	6.30	9.58	6.28
22. CD (5%)	2.96	1.99	2.07	2.43	2.25	1.84	2.24	2.04	7.61	4.08	9.38	7.09	1.86	1.23	1.96	1.65
(1%)	4.03	2.70	2.82	3.11	3.05	2.51	3.09	2.71	10.35	5.55	12.75	9.42	2.52	1.68	2.67	2.19
23.S.Em±	1.43	0.96	0.99	1.17	1.08	0.89	1.08	1.02	3.67	1.97	4.52	3.55	0.89	0.59	0.95	0.83

Cont…

Traits	**Grain Yield/Plant**			
S. No.	**E_1**	**E_2**	**E_3**	**Pooled**
1.NDL-1	5.33	8.78	7.47	7.19
2.PL-6	4.94	8.39	6.96	6.76
3.IPL-406	4.54	9.08	7.48	7.03
4.Noori	3.88	7.15	6.09	5.71
5.Arun	3.55	7.2	5.65	5.47
6.PL-8	4.42	7.63	7.67	6.57
7.HUL-57	4.31	7.5	5.82	5.88
8.Shivalika	3.86	7.53	6.14	5.84
9.Moittree	4.72	8.17	7.29	6.73
10.PusaVaibhav	5.24	10.13	9.25	8.21
11.KLS-218	4.90	8.77	7.32	7.00
12.Titua(local)	4.26	7.99	7.35	6.53
13.GCV	10.32	9.46	12.81	2.92
14.PCV	15.75	13.06	16.70	4.53
15.ECV	11.90	9.01	10.71	3.46
16.h2 (%)	65.52	72.39	76.73	64.57
17.GA	5.84	4.84	6.19	3.83
18.GM	1.49	2.73	2.35	6.58
19.Lowest range	3.55	7.20	5.82	5.47
20.Highest range	5.33	10.13	9.25	8.21
21.CV	11.90	9.01	10.71	6.14
22. CD (5%)	0.17	0.24	0.25	0.21
(1%)	0.24		0.33	0.28
23.S.Em±	0.08	0.33	0.25	0.23

Seasonal variation of genotype based on environment

The overall mean for days to 50% flowering were earliest among genotype PL-6 74.00in E_1, Titua (local-74.64) in E_2, NDL-22(75.22) in E_3 and PL-6 for pooled (76.67), respectively. The grand mean for this character was highest in E_3 (79.29) and lowest in E_2 (77.86) respectively. Maximum Plant height was recorded among the genotypes Moittree in E_1 (33.67) and E_3 (31.84) whereasNDL-1 in E_2 (94.45) and pooled mean. Maximum number of pods/plant was recorded among genotype IPL-406 in E_1 (451), Pusa Vaibhav in E_2 (465) and E_3 (469) and Pooled (461.25) respectively. The 1000 grain weight was observed highest among genotype NDL-1 in E_1 (79.52), E_2 (77.08), E_3 (78.08) and in pooled (78.46) respectively. The genotype NDL-1 in environment E_1 (1.78) was observed highest grain yield/plot followed by Pusa Vaibhav in E_2 (3.38) and E_3 (3.08) respectively whereas pooled analysis shows that gran yield /plot was observed highest in Pusa Vaibhav (8.21). The comparison of mean performance of twelve genotypes in three environments and pooled performance revealed existence of very high level of variability in the germplasm. The genotypes showing high mean performance in desirable direction for few traits were listed in Table 1.3, which may also be used as donors for improving the characters. Similar results in various lentil genotypes have also been reported by Ayub *et al*., 2004 [2], Roy *et al*., 2013 and Hamdi *et al*., 2004.

Variability for yield attributing traits in different environment

The phenotypic coefficient of variance (PCV) was significantly higher than genotypic coefficient of variance (GCV) or environmental coefficient of variance for days to 50% flowering ranging from 2.24 to 5.29 for PCV and 1.86 to 4.56 for GCV with low pcv and gcv among the entre environments. The phenotypic and genotypic coefficients of variance were closer to each other for the traits which reveals that the influence of the environment on this character is negligible and the role of the genotypic performance for the full expression of the phenotype. The phenotypic and genotypic coefficients of variance were closer to each other for plant height and it ranges from 2.51 to 3.59 for PCV and 1.30 to 2.47 for GCV. The phenotypic and genotypic coefficients of variance for number of nods/plant ranges from 9.68 to 10.53 for PCV and from 6.96 to 10.03 for GCV among all the environment whereas for pooled GCV (2.39) was lower than PCV (3.04). PCV for 1000 grain weight ranges from 19.07 to 20.88 whereas than 17.74 to 18.55 for GCV. The Phenotypic coefficient of variance for grain yield/plant ranges from 15.76 to 19.08 whereas for GCV it was ranges from 10.32 to 18.01. The results are in conformity with findings of Al-Ghzawi *et al* (2011) [1] and Chakraborty and Haque (2000) [4] and reported that there was variation in yield performance of lentil genotypes among different environment.

Effects of season on heritability for yield attributing traits

Heritability in broad sense (h^2bs) for days to 50% flowering ranges from 43.49 to 65.16% grouped as moderate to high heritability among the entire environments whereas highest estimate of heritability was observed in $E_2$with very less genetic advance as percent of mean of 1.86(E_2). The heritability in broad sense for plant height ranged from53.51 to 71.60 whereas highest heritability was observed in E_1 with moderate to less genetic advance as percent of mean. High heritability with low genetic advance was rendering them unsuitable for improvement through selection. The results are in conformity with finding of Rathi *et al.* 2002 [11] and Tyagi and Khan 2010 [15].

The heritability for number of pod/plant range from 70.35 to 95.33 whereas highest heritability was observed in E_2 with very less genetic advance as percent of mean of 3.90. The heritability for 1000 grain weight ranges from 87.41 to 94.38 whereas highest heritability was observed in $E_2$with less genetic advance as percent of mean of 7.41. The heritability for grain yield ranges from 65.52 to 94.38 whereas highest heritability was observed in $E_3$with less genetic advance as percent of mean of 6.19. The higher estimates of heritability indicate the minimum environmental effect on these traits suggested that any traits can be used for selection. High heritability with low genetic advance indicates non-additive gene action. Though, high heritability may not necessarily lead to increased genetic gain, unless sufficient genetic variability existed in the germplasm. The results are in conformity with finding of Oligganayan and Olakojo 2014 [10], Eid 2009 [6] and Hussain *et al*., 2014 [7].

Conclusions

Considerable variation was observed among genotypes in different environment. In this all the traits show high heritability except days to 50% flowering and plant height indicating low environmental effects for these characters. The magnitudes of PCV were higher than GCV indicating there was effects of environment. A noticeable difference between PCV and GCV, higher estimates of heritability was observed for various traits which indicate there was high influence of environmental factors for expression of these traits.

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