Original Research Article

Genetic Variability and Character Association Study for Yield and attributing traits in Lentil (*Lens culinaris* Medikus.) under Terai Agro-Climatic Conditions of West Bengal

ABSTRACT

Aims: To evaluate the genotypes for different yield and yield attributing morphological traits by estimation of GCV, PCV, heritability (h^2) in broad sense and genetic advance as percent of mean. To study the character association between yield and yield attributes and further partitioning into their direct and indirect effect on yield for consideration of appropriate traits to facilitate the selection of desirable genotypes.

Place and duration of study: Lentil genotypes were evaluated in the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during the rabi season of 2019-20 and 2020-21.

Methodology: Forty lentil genotypes including two checks viz., WBL77 and IPL220 were evaluated in alpha lattice design with three replications following the standard cultural practices. The observations were recorded as the average of same in five randomly sampled plants in each plot for all the eleven attributes studied. Statistical analysis was carried out using the R v. 4.1.1 software.

Results: ANOVA revealed significant variation for all the characters among the genotypes and also for genotype vs. year interaction. Characters such as plant height (96.20%[1], 26.32%[2]), secondary branches plant^{-1} (91.79%[1], 28.59%[2]), number of pods plant^{-1} (97.98%[1], 89.67%[2]), pod weight plant^{-1}(g) (96.82%[1], 90.15%[2]), 100 seed weight (g) (98.13%[1], 40.92%[2]), yield plant^{-1}(g) (96.68%[1], 91.20%[2])and harvest index (%) (94.28%[1], 33.06%[2]) showed high heritability([1]) coupled with high genetic advance as percentage of mean(^{2}).Genotypic correlation study revealed that number of pods plant^{-1} (0.846), primary branches plant^{-1} (0.905), secondary branches plant^{-1} (0.416), pod weight plant^{-1}(0.992) and harvest index (0.432) were significantly and positively correlated with yield plant^{-1}. Path coefficient studies revealed that characters like pod weight plant^{-1}(0.699), primary branches plant^{-1} (0.241), harvest index (0.083), number of pods plant^{-1} (0.070), 100 seed weight (0.063) and days to 90% maturity (0.047) had positive direct effect on yield.

Conclusion: The present study revealed significant variability among the genotypes as far as the characters taken under study were concerned. Further the characters showing positive and significant correlation could be considered favourably for further selection of desirable genotypes.

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Keywords: Correlation, Genetic variability, heritability, Lentil

INTRODUCTION

Lentil (*Lens culinaris* Medikus) 2n=2x=14 is a low input *rabi* pulse crop grown mainly for its nutritional value. It is the fourth most important pulse crop in the world with India being a major lentil growing nation after Canada in terms of production. The crop is mainly grown in the states of Uttar Pradesh, Madhya Pradesh, Bihar and West Bengal which accounts for 95% of the acreage for the crop in India.The crop is a very important in having more than 25% protein and about 59% carbohydrate (Fredrick *et al*., 2006). Apart from these, it is also rich in iron, calcium and niacin among the others. Nevertheless the crop also plays an important role in the cropping system due to its ability to fix atmospheric nitrogen (101kg/hectare/annum) thereby enriching the soil (Anonymous, 1984). Worldwide the crop covers a total area of 6.10 million hectare with the production of about 6.33 million tones and an average yield of about 1068 kg/ha (FAOSTAT, 2020). In India the total area covered under the crop has been estimated to be about 1.32 million hectare with an overall production of about 1.18 million tones and an average yield of about 894 kg/ha (DAC&FW 2019-20). 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. And in this regard the availability of genetic resources of worth coupled with proper management practices is of primary importance. Genetic variability is the prerequisite for any plant breeding programme as it offers the scope for choosing superior lines for further crop improvement. Characters with high heritability and genetic variability will add to the potential of selection over multiple environments for wider adaptability. Genetic parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) could be used to detect the degree of influence of genetic architecture on the variability in the studied germplasm. The range GCV and PCV classified as suggested by Sivasubramanian and Madhavamenon (1973) helps to ascertain the extent of influence of genetic architecture on the expressed phenotype. Thus assessing the extent of variability for yield and its attributing traits enable to focus on the characters to be taken into consideration for further selection.The present investigation was aimed in that direction in a collection of forty lentil genotypes with the objective to identify potential genotypes with dominant characters to be reckoned for selection for future breeding programme.

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MATERIAL AND METHODS

The lentil genotypes including two checks viz., WBL77 and IPL 220 were grown in *rabi* season over two successive years viz., 2019-20 and 2020-21 in the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar located at 26^{0}24′09.1″ N latitude and 89^{0}23′08.3″E longitude and at 43 meter above the mean sea level. The genotypic details have been presented in **Table 1**.

Table 1: List of lentil genotypes used in the experiment

Sl.No.	Name of Genotypes	Sl.No.	Name of Genotypes	Sl.No.	Name of Genotypes	Sl.No.	Name of Genotypes
1	IC241067	**11**	IC78540	**21**	IC199779	**31**	IC614827
2	IC241090	**12**	EC223188	**22**	IC78486	**32**	IC201778
3	IC241119	**13**	IC78518	**23**	EC225484	**33**	EC223219
4	IC241072	**14**	IC78547	**24**	IC241071	**34**	EC267544
5	IC565035	**15**	WBL77	**25**	IC78513	**35**	EC267563
6	IC241082	**16**	IC78454	**26**	IC610426	**36**	EC267598
7	IC78535	**17**	IC78462	**27**	IC241097	**37**	EC267604
8	IC78531	**18**	EC33920	**28**	IC241061	**38**	EC267636
9	EC16391	**19**	EC223244	**29**	IC620839	**39**	IC78408
10	IC78545	**20**	EC225486	**30**	IC544556	**40**	IPL220

Alpha Lattice design after Alvardo *et al.* (2020) with three replications was used in the present experiment with a plot size of 2.0 m ×1.5 m and a plant to plant spacing of 10cm and row to row spacing of 25 cm. Standard recommended fertilizer doses were applied to the crop and intercultural operations were carried out as per schedule. The observations on various morphological characters were recorded as the average of same in five plants in each plot sampled randomly ; the eleven yield attributes for which observation were recorded were -days to 50% flowering, days to 90% maturity, plant height (cm), primary branches plant^{-1}, secondary branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, pod weight plant^{-1}(g),100 seed weight (g), yield plant^{-1}(g), and harvest index (%). Differences among the genotypes were ascertained by analysis of variance (ANOVA) after Panse and Sukhatme (1985) and genotypic variances Burton (1952), correlation Johnson *et al*. (1955), heritability in broad sense and path-coefficient analysis Dewey and Lu (1959) were performed to compute the result. The aforesaid analysis was done using the R v. 4.1.1 software on the basis of pooled data.

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RESULTS AND DISCUSSION

Genetic variability of a crop plant is the principal element of plant breeding as presence of sufficient variability in economic traits is most crucial to improve the productivity and enhance the production of an individual crop. Therefore, the present investigation was carried out to study the extent of variability in genetically diverse genotypes of lentil.

The ANOVA revealed highly significant differences among the genotypes for all the studied characters and also when the genotypes were found to be interacting with different environments as presented in **Table 2.** Similar result was also reported by Chowdhury *et al*. (2018) in their study on the same crop. The same when assessed over the years revealed a similar significant differences except for the characters primary branches plant^{-1}, secondary branches plant^{-1}, number of seeds pod^{-1}, pod weight plant^{-1} and yield plant^{-1}.

The mean, range, GCV, PCV, heritability, genetic advance as percentage of mean have been presented in **Table 3**. The PCV values were higher than GCV values for all the eleven yield attributing characters ranging from 3.12 to 47.01 for GCV and 4.19 to 50.44 for PCV respectively and it was in conformity with the classification as proposed by Sivasubramanian and Madhavamenon (1973). The highest genotypic coefficient of variation was noticed for yield plant^{-1} (47.01%) followed by pod weight plant^{-1}(46.98), number of pod plant^{-1} (45.45%) and 100 seed weight (20.72%). The remaining characters showed low to moderate genotypic coefficient of variation. Highest phenotypic coefficient of variation was noted for pod weight plant^{-1} (50.44%) while lowest PCV was recorded for number of seed pod^{-1} (9.12%) and days to 90% maturity (4.19%). Higher values of PCV than GCV for seed yield have also been reported by Sadiq *et al*. (2000) and Idress *et al.* (2006) in mung bean and Tyagi and Khan (2011) in lentil.

The variable effect of environment on the expression of the studied characters was validated with the phenotypic coefficient of variation being higher than the corresponding genotypic coefficient of variation for the characters which was in consonance with the observation reported by Vanve *et al*. (2019), Debbarma *et al*. (2018), Chowdhury *et al.* (2019), Bicer and Sakar (2008) , Haddad *et al.* (1982), Solanki (2006) and Pandey *et al.* (2015) .

High broad sense heritability was observed for all the characters under present investigation ranging between 66.50 to 98.13 percent; similar observation in lentil have been reported by Crippa *et al,* (2009), Chowdhury *et al.* (2019), Singh and Srivastava (2013), Bicer and Sakar (2008), Tyagi and khan (2011). The range of genetic advance as percent of mean was classified as suggested by Johnson *et al.* (1955). As the heritability estimation alone is not sufficient, the impact of both additive and non-additive gene action also need to be estimated. Hence, the coupling effect of genetic advance as percent of mean and heritability estimate plays an important role in selection. High genetic advance as percent of mean was recorded for characters like plant height (26.32) while the character days to 90% maturity (4.78) and seeds pod^{-1} (4.69) recorded the lowest of the same. Hence the characters with high heritability coupled with high genetic advance as percent of mean could be favourably considered for selection, as these parameters are supposed to be governed by additive gene action. Ghimire and Shah (2019) similarly reported high heritability coupled with high genetic advance as percent mean (GAM) for pod plant^{-1} and 100 seed weight in lentil. Shaktivel *et al.* (2019) recorded coupling of high heritability with high genetic advance as percent mean for pod plant^{-1}, seed yield and 100 seed weight and high heritability with moderate high genetic advance as percent mean for days to 50% flowering while working with lentil. Days to 90% maturity in lentil, however, exhibited high heritability coupled with low high genetic advance as percent mean as reported by Durgassa *et al.* (2014) and Paliya *et al.* (2015). Predominance of non-additive gene action for the remaining characters may offer lesser scope for selection for the said characters and further scope for generating enough of variability remains there for them.

The genotypic correlation coefficient between yield and its' attributing characters indicated different degrees of association between the characters at the genotypic level as presented in **Table 4**. The yield plant^{-1} showed significant and positive correlation with the characters viz., primary branches plant^{-1}(0.905), secondary branches plant^{-1} (0.416), pods plant^{-1}(0.846) pod weight plant^{-1} (0.992) and harvest index (0.432). Positive association between seed yield and primary branches plant^{-1} and secondary branches plant^{-1} were also reported by Singh and Shrivastava (2013), Solanki *et al*. (2006), Kumar *et al*. (2002) and Chowdhury *et al.* (2019). Plant height revealed a significant positive correlation with secondary branches plant^{-1} (0.406) and number of seeds pod^{-1} while pods plant^{-1} was significantly and positively associated with primary branches plant^{-1} and secondary branches plant^{-1}.

Further partitioning of the total correlation as performed through path analysis and presented in **Table 5** to study the direct and indirect effect of yield attributing characters on the yield revealed a residual effect of 0.0233 thereby establishing the effect of genotypes on the studied association. Characters like pod weight plant^{-1} showed highest direct effect on yield (0.699) indicating the scope for direct selection for the character and also through primary branches plant^{-1}(0.666). Number of pod plant^{-1} had shown high indirect effect with yield through pod weight plant^{-1}. Primary branches plant^{-1} revealed moderate positive direct effect with yield plant^{-1}(0.241). Characters such as harvest index (0.083), number of pod plant^{-1} (0.070), 100 seed weight (0.063) and days to 90% maturity (0.047) exhibited negligible positive direct effect with yield palnt^{-1}. Abo-Hegazy *et al.* (2012), Mekonnen *et al*. (2014) and Sharma *et al.* (2014) reported 100 seed weight and pod plant^{-1} having positive direct effect on yield plant^{-1}.

On the contrary number of seeds pod^{-1} (-0.066), secondary branches plant^{-1} (-0.056), plant height (-0.042) and days to 50% flowering (-0.020) showed negative direct effect at genotypic level with yield plant^{-1} similar to that observed by Pandey *et al.* (2017) . The above interpretation on the effects of attributing characters on yield has been presented after Lenka and Mishra (1973). Chowdhury *et al.* (2019) similarly reported that days to maturity, number of primary branches plant^{-1}, pod plant^{-1} and 100 seed weight had positive direct effect on seed yield plant^{-1}. Highest positive direct effect of pod weight plant^{-1} and significant positive association with yield plant^{-1} suggested that selection for the trait could be instrumental for improvement of economic yield in lentil.

CONCLUSION

The present study revealed significant variability among the genotypes for the characters taken under study and also when the genotypes were in interaction with the environment (year). The significant and positive correlation between yield plant^{-1} and the characters viz., primary branches plant^{-1} (0.905), secondary branches plant^{-1} (0.416), pods plant^{-1} (0.846) pod weight plant^{-1} (0.992) and harvest index (0.432) along with the character pod weight plant^{-1} showing highest direct effect on yield could favourably be considered for further selection of desirable genotypes. The presence of significant variability among the genotypes for the studied characters and the strong association between the characters thereby offers the scope for selection of desirable genotypes based on their performance and taking them further in future crop improvement programme

Table 2: Analysis of variance (ANOVA) for eleven yield attributing characters in Lentil genotypes.

Sources of variation	d.f	Mean Sum of Square (MSS)										
		Days to 50% flowering	Plant height (cm)	Days to 90% maturity	Primary branches $plant^{-1}$	Secondary branches $plant^{-1}$	No. of pods $plant^{-1}$	No. of seed pod^{-1}	Pod weight $plant^{-1}$ (g)	100 seed weight (g)	Yield $plant^{-1}$ (g)	Harvest index (%)
Year	1	697.00**	325.00**	152.00**	0.10	0.79	345.30**	0.02	0.16	0.31**	0.19	131.94**
Rep (Year)	4	15.60	4.00	13.27*	0.20**	4.24**	24.80	0.05**	0.12	0.02	0.03	55.33**
Block (year×rep)	18	5.00	3.80	6.22	0.03	0.40	31.10	0.02	0.13*	0.005	0.06	7.66
Genotype	39	101.70**	79.10**	43.50**	0.18**	3.32**	1394.80**	0.04**	2.35**	0.51**	1.58**	133.69**
Year×Genotype	39	16.00**	6.60**	23.62**	0.11**	1.78**	66.20**	0.04**	0.24**	0.03**	0.11**	19.55**
Error	138	7.10	3.00	4.39	0.06	0.27	28.10	0.01	0.07	0.01	0.05	7.64

'*' and '**' indicates significance at 5% and 1 % probability level.

Table 3:Mean, range, GCV, PCV, heritability (bs) and genetic advance for eleven yield attributing characters in Lentil.

Sl. No.	Parameters/ Characters	Mean	Range	GCV (%)	PCV (%)	Heritability Broad sense (%)	Genetic advance	Genetic advance as percent of mean
1	**Days to 50 % flowering**	52.64	45.00-79.00	10.37	12.33	93.01	9.45	17.95
2	**Plant height (cm)**	35.14	23.36-47.67	14.11	15.58	96.20	9.25	26.32
3	**Days to 90% maturity**	108.29	95.00-120.00	3.12	4.19	89.90	5.18	4.78
4	**Primary branches plant^{-1}**	1.98	1.20-3.00	9.65	16.57	67.08	0.23	11.59
5	**Secondary branches plant^{-1}**	5.24	3.00-9.00	18.06	23.49	91.79	1.50	28.59
6	**No. of Pods plant^{-1}**	46.80	20.00-91.40	45.45	47.29	97.98	42.10	89.97
7	**No. of Seed Pod^{-1}**	1.77	1.40-2.00	4.56	9.12	66.50	0.08	4.69
8	**Pod weight plant^{-1}**	1.84	0.51-4.10	46.98	50.44	96.82	1.66	90.15
9	**100 seed weight(g)**	1.96	1.50-2.86	20.72	21.61	98.13	0.80	40.92
10	**Yield plant^{-1} (g)**	1.51	1.51-2.86	47.01	49.92	96.68	1.38	91.20
11	**Harvest Index (%)**	35.38	0.41-2.76	18.07	20.36	94.28	11.69	33.06

Table 4: Genotypic correlation between yield and its attributing characters in Lentil.

Character	Plant height (cm)	Days to 90%maturity	100 seed weight (g)	No. Pods Plant^{-1}	Primary branches Plant^{-1}	Secondary branches Plant^{-1}	No. of Seed Pod^{-1}	Pod weight Plant^{-1} (g)	Harvest Index %	Yield Plant^{-1} (g)
Days to 50% flowering	-0.004	0.319 *	-0.302	-0.002	0.194	-0.022	0.184	0.220	-0.029	0.093
Plant height (cm)		0.177	0.08	0.207	0.250	0.406 **	-0.394 *	0.196	0.260	0.209
Days of 90%maturity			0.083	0.320 *	0.073	0.271	-0.037	0.209	0.019	0.214
100 seed weight(g)				-0.099	-0.327 *	0.095	-0.160	-0.137	0.021	-0.104
No. of Pods plant^{-1}					0.793 **	0.384 *	0.030	0.850 **	0.171	0.846 **
Primary branches plant^{-1}						0.532 **	0.292	0.952 **	0.285	0.905 **
Secondary branches plant^{-1}							-0.087	0.409 **	0.270	0.416 **
No. of Seeds pod^{-1}								-0.019	0.031	0.002
Pod weight plant^{-1} (g)									0.419 **	0.992 **
Harvest Index (%)										0.432 **

'*' and '**' indicates significance at 5% and 1 % probability level.

Table 5: Genotypic path coefficient showing the direct (diagonal) and indirect (off-diagonal) effects of eleven yield attributing characters in Lentil.

Characters	Days to 50% flowering	Plant height (cm)	Days to 90%maturity	100 seed weight (g)	No. of Pods Plant^{-1}	Primary branches Plant^{-1}	Secondary branches plant^{-1}	No. of Seed Pod^{-1}	Pod weight Plant^{-1} (g)	Harvest Index (%)	Correlation with yield plant^{-1}(g)
Days to 50% flowering	**-0.020**	0.0002	0.015	-0.019	-0.0002	0.047	0.001	-0.012	0.084	-0.002	0.093
Plant height (cm)	0.00009	**-0.042**	0.008	0.005	0.014	0.060	-0.023	0.026	0.137	0.022	0.209
Days to 90%maturity	-0.006	-0.007	**0.047**	0.005	0.022	0.018	-0.015	0.002	0.146	0.002	0.214
100 seed weight (g)	0.006	-0.004	0.004	**0.063**	-0.007	-0.079	-0.005	0.011	-0.096	0.002	-0.104
No. of Pods plant^{-1}	0.00004	-0.009	0.015	-0.006	**0.070**	0.191	-0.021	-0.002	0.594	0.014	0.846 **
Primary branches plant^{-1}	-0.004	-0.011	0.003	-0.021	0.055	**0.241**	-0.030	-0.019	0.666	0.024	0.905 **
Secondary branches plant^{-1}	0.0004	-0.017	0.013	0.006	0.027	0.128	**-0.056**	0.006	0.286	0.023	0.416 **
No. of seed Pod^{-1}	-0.004	0.017	-0.002	-0.010	0.002	0.071	0.005	**-0.066**	-0.013	0.003	0.002
Pod weight plant^{-1} (g)	-0.002	-0.008	0.010	-0.009	0.059	0.229	-0.023	0.001	**0.699**	0.035	0.992 **
Harvest Index (%)	0.0006	-0.011	0.0008	0.001	0.012	0.069	-0.015	-0.002	0.293	**0.083**	0.432 **

Residual value =0.0233

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