academicJournals

Vol. 6(1), pp. 115-120, January 2014
DOI: 10.5897/IJBC2013.0618
ISSN 2141-243X © 2014 Academic Journals
http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Correlation and path coefficient analysis of yield and yield components in lentil (*Lens culinaris* Medik.) germplasm in the highlands of Bale, Ethiopia

Tadele Tadesse*, Teshome Leggesse, Behailu Mulugeta and Gashaw Sefera

Sinana Agricultural Research Center, P. O. Box 208 Bale-Robe, Ethiopia.

Accepted 22 August, 2013

Genetic diversity is essential for genetic improvement of given crops. If the information on genetic diversity is not enough to utilize, the available variability genetic diversity study should be crucial. Accordingly, twelve lentil germplasms were evaluated at two locations, Sinana and Agarfa, South eastern Ethiopia in the 2012/13 cropping season to obtain information on genetic diversity and variability in the Ethiopian lentil germplasm. At Sinana, the genotypic correlation revealed that number of pod per plant had positive and highly significant association with seed yield, whereas hundred seed weight, days to maturity, number of seeds/plant and plant height had positive but non-significant association with seed yield per plot. However, negative association was observed for stand percentage. At Agarfa, positive and highly significant association was observed between number of pods/plant and seed yield, whereas plant height and number of seeds/pod had negative and highly significant association with seed yield at the genotypic level. The genotypic path analysis at Sinana showed that number of pods/plant and seeds/pod had very high and positive direct effect on seed yield, whereas days to maturity and plant height had negative direct effect on seed yield. At Agarfa, positive direct effect on seed yield was observed in days to maturity and stand percentage; whereas negative direct effect on seed yield was observed in plant height and hundred seed weight at genotypic level.

Key words: Genetic diversity, correlation, direct and indirect effect.

INTRODUCTION

Lentil (*Lens culinaris* Medik.) was one of the first domesticated plant species; its remains are as old as those of einkorn, emmer, barley and pea (Harlan, 1992). It has been cultivated for 10,000 years in the most difficult agricultural environments; is is perhaps second only to barley in this sense. It is an old world legume grown mainly in Central and South west Asia, Southern Europe, North Africa and Ethiopia. Ethiopia ranks first in its production and acreage in Africa followed by Eritrea, morocco, Egypt and Tunisia.

In world's lentil production, Ethiopia is 10th, India is leading followed by Canada, Turkey and Bangladesh (FAO, 2001). In Ethiopia, 1 616809.37 hectares of land are allocated for pulse crops; out of which 109895.27 is cultivated with lentil, which accounts for 6.79% of the total land allotted for pulse crops. In the study sites, Bale Zone, Ethiopia ester lentil accounts for 4.99% of the total pulse crops (CSA, 2011). The average lentil seed yield obtained in the study area ranged from 15-22qt./ha.

The lentil (*L. culinaris* Medikus subsp. *culinaris*) is a lens-shaped grain legume well known as a nutritious food. It grows as an annual bushy leguminous plant;

*Corresponding author. E-mail: tadyeko20@gmail.com or tadeleta20@yahoo.com. Tel: +251 911 96 72 86.

Table 1. Lists of lentil genotypes tested in the study.

SRRL-27-6
FLIP-86-16L
SRRL-36-5
FLIP-86-38L
SRRL-20-5
ILL-590
SRRL-17-5
Acc. No. 36152
Acc. No. 36103
ILL-1861
Asano
Local cultivar

typically 20-45 cm tall; it produces many small purse shaped pods containing one to two seeds each. Lentil seed is a rich source of protein, minerals (K, P, Fe and Zn) and vitamins for human nutrition (Bhatty, 1988). Furthermore, because of its high lysine and tryptophane content, its consumption with wheat or rice provides a balance in essential amino acids for human nutrition. Lentil straw is also a valued animal feed (Erskine et al., 1990).

Lentil seeds are consumed as whole grains and as dehulled *dhal*. There are two types of lentil: the large seeded (*macrosperma*) and the small to medium sized seeded (*microsperma*) lentil. The color of seeds also varies with lines being brown, red, green or white. Lentil seeds are relatively higher in protein content (25 percen-tage), carbohydrates and calories than other legumes (Muehlbauer et al. 1985).

Plant breeders are seldom interested in one character, and therefore, there is the need to examine the relationship among various characters, especially between yield and other characters. Selection is an integral part of a breeding program by which genotypes with high productivity in a given environment could be developed. However, selection for high yield is made difficult because of its complex nature. This selection criterion takes into account the information on interrelationship among agronomic characters, their relationship with grain yield as well as their direct influence on grain yield. Nevertheless, selection for yield *via* highly correlated characters becomes easy if the contribution of different characters to yield is quantified using path coefficient analysis (Dewey and Lu, 1959). According to Hawatin (1978), when there is little or no work done on determining associations of characters, selection may be based on little more than an intelligent guess and it may lead to the practice of unilateral selection of characters.

Generally, information and knowledge of the extent and pattern of variability, particularly of genetic variability present in a population of a given crop is absolutely essential for further improvement of the crop. In Ethiopia, since the information on genetic diversity and correlation among different growth parameters on lentil is limited, this study was mainly emphasized to generate informa-tion on the genetic variability and association among yield components in lentil. Based on this, the aim of this present work is study the associations among yields and yield related traits in lentil.

MATERIALS AND METHODS

The experiment was carried out at two locations. One of the experimental sites was at the research farm of Sinana Agricultural Research Center, Oromia Agriculture Research Institute, and the other was at Agarfa sub-site in Southeastern Ethiopia. The experiment was conducted at each location on vertisol clay loam soil under rain fed conditions during the Meher season (August-January) of 2012/13 cropping season. Meher season is characterized by annual rain fall of 850 mm, and with minimum and maximum temperature of 9 and 22°C, respectively.

Twelve lentil genotypes were used for this study (Table 1). The genotypes were arranged in randomized complete block design with four replications. Each experimental plot consisted of 4m long rows with inter-row spacing of 20-cm. Seeding rate was applied at the rate of 65 kg/ha .Weeds were controlled by hand. Data were collected on both plot and plant basis.

Phenotypic (r_p) and genotypic (r_g) correlation coefficient

Correlation coefficient (r)

Phenotypic correlation, the observable correlation between two variables, which includes both genotypic and environmental effects, and genotypic correlation, the inherent association between two variables were estimated using the standard procedure suggested by Miller et al. (1958). Covariance analysis between all pairs of the variables followed the same form as the variance. Thus, estimates of genetic covariance component between two traits (σg_{xy}) and the phenotypic covariance component (σp_{xy}) were derived in the same fashion as for the corresponding variance components:

$$r_{gxy} = \left[\frac{\sigma g_{xy}}{\sqrt{\sigma^2 g_x \mathrm{X} \sigma^2 g_y}}\right]$$

$$r_{pxy} = \left[\frac{\sigma p_{xy}}{\sqrt{\sigma^2 p_x \mathrm{X} \sigma^2 p_y}}\right]$$

where, σg_{xy} = genotypic covariance of two variables x and y; σp_{xy} = phenotypic covariance of two variables x and y.

Path coefficient analysis

Path coefficient analysis was carried out using the phenotypic correlation coefficients as well as genotypic correlation coefficients to determine the direct and indirect effects of the yield components and other morphological characters on seed yield. Path coefficient analysis was also conducted to determine the direct and indirect effect of various traits on seed yield using the general formula of Dewey and Lu (1959).

Table 2. Genotypic correlation coefficient (above diagonal) and phenotypic correlation coefficient (below diagonal) for 7 traits of lentil genotypes tested at Sinana in 2012.

	Days to mature	Plant ht. (cm)	Stand percentage	Number of pod/plant	Number of seed/pod	100 seed wt. (g)	Seed yield (kg/ha)
Days to mature		0.47	-0.07	0.71**	0.39	0.21	0.44
Plant height (cm)	0.17		-0.20	-0.33	0.92**	0.20	0.09
Stand percentage	-0.06	0.03		-0.94**	0.73**	0.24	-0.04
No. pod/plant	0.04	0.17	0.12		-0.18	-0.06	0.97**
No. seed/pod	0.05	0.04	0.01	-0.05		0.35	0.23
100 seed wt	0.20	0.11	0.10	0.01	0.10		0.52
Seed yield	0.30	0.16	0.08	0.04	-0.03	0.36	

** Significant at n-2 degree freedom, where n is the number of genotypes.

Table 3. Genotypic correlation coefficient (above diagonal) and phenotypic correlation coefficient (below diagonal) for 7 traits of lentil genotypes tested at Agarfa in 2012.

	Days to Mature	Plant ht. (cm)	Stand percentage	Number of pod/plant	Number of seed/pod	100 seed wt. (g)	Seed yield (kg/ha)
Days to Mature		0.26	0.08	0.76**	-0.04	0.21	0.03
Plant ht. (cm)	0.006		0.01	-0.12	0.02	-0.40	-0.73**
Stand percentage	0.21	-0.02		0.09	-0.47	0.20	0.12
No. pod/plant	0.15	0.05	-0.02		0.82**	-0.93**	0.92**
No. seed/pod	0.05	0.09	-0.11	-0.03		-0.08	-0.89**
100 seed wt	0.14	-0.10	0.11	-0.15	0.03		0.23
Seed yield	0.04	0.03	0.28	0.02	0.03	0.17	

Path coefficient

$$r_{ij} = p_{ij} + \sum r_{ik} p_{kj}$$

where, r_{ij} = mutual association between the independent character (i) and dependent character (j) as measured by the correlation coefficients; p_{ij} = components of direct effects of the independent character (i) on the dependent variable (j) as measured by the path coefficients and $\sum r_{ik}p_{kj}$ = summation of components of indirect effects of a given independent character (i) on a given dependent character (j) *via* all other independent characters (k).

RESULTS AND DISCUSSION

Correlation studies

Estimates of correlation coefficient at genotypic and phenotypic level for individual locations are given in Tables 2 and 3.

At Sinana (Table 2), number of pods/plant (0.92) had positive and highly significant association with seed yield. Similar positive association between number of pods/ plant and seed yield was reported by different investigators (Seifu, 1988; Ramigry et al., 1989; Zaman et al., 1989; Bakhsh et al., 1991; Esmail et al., 1994; Khattab, 1995; Kumar et al., 1995; Singh et al., 1995; Abo-Shetaia et al., 1997; Chakraborty and Haque, 2000).

Though the association was non-significant, hundred seed weight (0.52), days to maturity (0.44), number of seeds/pod (0.23) also showed positive association with seed yield. However, stand percentage had very low and negative association with seed yield at genotypic level. Though the correlation value of seed yield with other parameters at phenotypic level was low, it showed the same trend with the corresponding genotypic correlation. The association among other parameters indicates plant height and stand percentage had positive and highly significant association with number of seeds/pod; whereas, stand percentage had negative and highly significant association with number of pods/plant. In the same manner, days to maturity also had positive and highly significant association with number of pods/plant. Positive and non-significant association was also observed among days to maturity, plant height, stand percentage and number of seeds/pod with hundred seed weight. Days to maturity also had positive association with plant height; whereas the other parameters had negative association with one another at genotypic level.

At Agarfa (Table 3) similar to Sinana, the correlation between numbers of pods/plant with seed yield was positive and highly significant. This indicates that plants with more number of pods per plant provide more seed yield than those of less number of pods. Thus selection for pods per plant will bring about a significant seed yield

Table 4. Estimate of direct (bold) and indirect effect at genotypic levels for 6 traits on seed yield at Sinana.

Variables	Days to mature	Plant ht. (cm)	Stand percentage	Number of pod/plant	Number of seed/pod	100 seed wt. (g)
Days to mature	-0.82	-0.38	0.03	0.88	0.64	0.09
Plant ht. (cm)	-0.39	-0.80	0.08	-0.41	1.52	0.09
Stand percentage	0.06	0.16	-0.40	-1.15	1.20	0.10
No. pod/plant	-0.59	0.27	0.37	1.23	-0.29	-0.02
No. seed/pod	-0.32	-0.74	-0.29	-0.22	1.64	0.15
100 seed wt	-0.17	-0.16	-0.09	-0.07	0.58	0.44

Table 5. Estimate of direct (bold) and indirect effect at phenotypic levels for 6 traits on seed yield at Sinana.

Traits	Days to Mature	Plant ht. (cm)	Stand percentage	Number of pod/plant	Number of seed/pod	100 seed wt. (g)
Days to Mature	0.23	0.016	-0.003	-0.00002	-0.004	0.059
Plant ht. (cm)	0.04	0.094	0.002	-0.0001	-0.003	0.033
Stand percentage	-0.01	0.003	0.06	-0.00005	-0.001	0.031
No. pod/plant	0.01	0.016	0.01	-0.0004	0.004	0.002
No. seed/pod	0.01	0.004	0.0004	0.00002	-0.1	0.031
100 seed wt	0.05	0.010	0.01	-0.000003	-0.01	0.304

improvement. This finding was in agreement with the result reported by Khattab (1995), Kumar et al. (1995), Singh et al. (1995), Abo-Shetaia et al. (1997) and Chakraborty and Haque (2000). Plant height (-0.73) and number of seeds/pod (-0.89) had negative and highly significant association with seed yield. The association among other parameters indicated as number of pod per plant showed positive and highly significant association with number of seeds/pod (0.82); and negative but highly significant association with hundred seed weight (-0.93). Days to maturity (0.76) had also positive and highly significant association with number of pods/plant.

Path analysis

Genotypic and phenotypic direct and indirect effect of six traits on seed yield at Sinana is presented in Tables 4 and 5, respectively. Accordingly, high level of direct effect was observed by number of seed/pod (1.64) followed by number of pods/plant (1.23) and hundred seed weight (0.44). On the contrary, days to maturity, plant height and stand percentage had negative direct effect on seed yield. Days to maturity and plant height though had positive association with seed yield, their direct effect was negative. This was due to the counter balancing of the negative indirect effect of other parameters. Days to maturity had positive indirect effect on seed yield *via* number of pods/plant (0.88) and seeds/pod (0.64), hundred seed weight (0.09) and stand percentage (0.03). And it also had negative indirect effect on seed yield *via* plant height. Number of pods/plant not only had positive and high direct effect on seed yield, it also had negative indirect effect on seed yield *via* days to maturity, number of seeds/pod and hundred seed weight. Therefore, one has to take this into consideration if seed yield improvement is to be achieved *via* number of pods/plant. Similar trend was observed among the parameters on seed yield at the phenotypic level, though the values are too low.

In Agarfa, at genotypic level (Table 6), positive direct effect on seed yield was observed in days to maturity (0.92) and stand percentage (0.05). Negative direct effect on seed yield was observed in plant height (-1.41), hundred seed weight (-0.98), number of seeds/pod (-0.53) and number of pods/plant (-0.44). At this location, though number of pods/plant and hundred seed weight had negative direct effect on seed yield, they had positive association with seed yield. This is due to the counter balancing of the positive indirect effect of other parameters. Number of pods per plant had positive indirect effect on seed yield *via* all parameters except number of seeds/plant. On the other hand, number of seeds per pod had negative indirect effect on seed yield *via* all parameters except hundred seed weight. Hundred seed weight had positive indirect effect on seed yield *via* all parameters. Similar trend again was observed in the variables for the phenotypic path too. At phenotypic level (Table 7), only stand % showed positive direct effect on seed yield but the other parameters showed negative direct effect on seed.

Conclusion

Understanding of the magnitude of variability present in crop plants and the degree of association between the

Table 6. Estimate of direct (bold) and indirect effect at genotypic levels for 6 traits on seed yield at Agarfa.

Trait	Days to Mature	Plant ht. (cm)	Stand percentage	Number of pod/plant	Number of seed/pod	100 seed wt. (g)
Days to mature	0.92	-0.37	0.001	-0.33	0.02	-0.21
Plant ht. (cm)	0.24	-1.41	0.00	0.05	-0.01	0.39
Stand percentage	0.07	-0.01	0.05	-0.04	0.25	-0.20
No. pod/plant	0.70	0.17	0.001	-0.44	-0.43	0.91
No. seed/pod	-0.04	-0.02	-0.02	-0.36	-0.53	0.08
100 seed wt	0.20	0.56	0.01	0.40	0.04	-0.98

Table 7. Estimate of direct (bold) and indirect effect at phenotypic levels for 6 traits on seed yield at Agarfa.

Traits	Days to Mature	Plant ht. (cm)	Stand percentage	Number of pod/plant	Number of seed/pod	100 seed wt. (g)
Days to Mature	-0.05	0.0003	0.06	0.008	0.003	0.02
Plant ht. (cm)	0.00	0.05	-0.01	0.003	0.01	-0.02
Stand percentage	-0.01	-0.0010	0.28	-0.001	-0.01	0.02
No. pod/plant	-0.01	0.0022	-0.01	0.054	-0.002	-0.02
No. seed/pod	0.00	0.004	-0.03	-0.002	0.06	0.01
100 seed wt	-0.01	-0.005	0.03	-0.008	0.002	0.16

different agronomic characters is of utmost importance as it provides the base for effective selection. The study of correlation indicates that for most of the parameters the genotypic and phenotypic correlation showed the same trend, though genotypic correlation was higher than the corresponding phenotypic correlation coefficient. From the result, it was observed that number of pods/plant had positive and significant association with seed yield at both locations. Significant negative association was also observed at Agarfa in number of seeds/pod and plant height with seed yield.

Path coefficient analysis showed number of pods/plant, seeds/pod and hundred seed weight had positive direct effect on seed yield at Sinana, whereas the same parameters had negative direct effect on seed yield at Agarfa. Therefore, for these two locations our selection criteria should be considered very seriously or different selection criteria should be developed.

In conclusion, the present investigation indicated that there is wide range of genetic variability for the character studied. From the study, number of pods/plant and hundred seed weight were found to be positively correlated with seed yield and among other parameters. However, it would be advantageous to study more number of genotypes over locations and years to confirm the importance of these traits as direct contributor for seed yield. Furthermore, analysis on both correlation and path coefficient analysis was made on individual location, though the soil type for the two locations is the same. This is due to the variation in the result for the correlation and path. Therefore, to have separate selection strategies for the two sites, the combined analysis was not that important in order to conclude which selection criteria can fit the two sites.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Tamiru Meleta, Ermias Teshome, Dagne Kora, Kemal Muktar, Gebeyehu Wondimu, Muhidin A/Qadir, Hailu Reta, Negash Mohamed, Bekele Zenebe, Birhanu Bareke, Zara Kadir and Sundusa Abda of Sinana Agricultural Research Center pulse and oil crops research case team members for managing the trial, data collecting and compiling from each site. The authors also would like to thank Sinana Agricultural Research Center Administration staff for facilitating all the necessary resources. Finally, we also would like to thank Oromia Agriculture Research Institute, Ethiopia for financing this study.

REFERENCES

Abo-Shetaia AM, El-gawad AAA, Khttab AM, Mokhtar SA (1997). Physiological parameters and yield attributes as selection criteria in lentil crop. Ann. Agric. Sci. 42(2): 323-336.

Bakhsh A, Zubair M, Ghafoor A (1991). Character correlation and path analysis in linetil. Pak. J. Agric. Res. 12(4): 246-251

Bhatty RS (1988). Composition and quality of lentil (*Lens culinaris* Medik.): a review. Can. Inst. Food Sci. Technol. 21:144–160.

Chakraborty M, Haque MF (2000). Genetic variability and component analysis in lentil (*Lens culinaris* Medik.). J. Res. Birsa Agric. Univ. 12(2): 199-204.

CSA (Central Statistics Authority). 2011. Central Statistics Authority Report on Area and Production of Crops. Stat. Bull. Agric. Sample Survey, Volume I, Addis Ababa, Ethiopia.

Dewey DR, Lu KH (1959). A correlation and path coefficient analysis of components of crescent Wheat grass seed production. Agron. J. 51: 515-518.

Erskine W, Rihawe S, Capper BS (1990). Variation in lentil straw quality. Anim. Feed Sci. Technol. 28:61–69.

Esmail AM, Mohamed AA, Hamid A, Rabie EM (1994). Analysis of yield variation in lentil (*ens culinaris* Medik.). Ann. Agric. Sci. 32(3): 1073-1087.

Food and Agricultural Organization (FAO) (2001). Statistical bulletin 1(2): 17-38

Harlan J (1992). Crops and Man. Am. Soc. Agron., Madison, Wisconsin, USA.

Hawatin GC (1978). Selection criteria in chickpeas, broad beans and lentils. Introduction to breeding food legumes. ICARDA, Aleppo. Syria. pp. 1-7.

Khattab SAM (1995). Association and path analysis in lentil under different irrigation regimes. Egypt. J. Agric. Res. 29(1/2): 13-25.

Kumar ADP, Singh, Singh BB (1995). Association analysis in lentil. Indian J. Pulses Res. 8(1): 20-24.

Miller PA, Williams JC, Robinsin HF, Comstock RF (1958). Estimation of genotypic and environmental variances and covariance's in upland cotton and their implication in selection. Agron. J. 50: 126-131.

Muehlbauer FJ, Cubero JI, Summerfield RJ (1985). Lentil (*Lens culinaris Medik*.). In: R J Summerfield and E I I Roberts (eds) Grain Legume Crops. Collins, 8 Grafton Street, London, UK. pp. 266–311.

Ramigry SR, Paliwal KK, Tomar SK (1989). Variability and correlation of seed yield and other quantitative characters in lentil. Lens Newsletter 16 (1):19-23.

Seifu Tsegaye (1988). Correlation and path coefficient analysis in lentil (*Lens culinaris* Medik.) and their implication for selection. M.Sc. thesis, Heremaya University of Agriculture, Haremaya, Ethiopia.

Singh SP, Lal KB, Krishna.1995. Physiological parameters for selection in lentil (*Lens esculenta* L.). Legumes Res. 18(2): 129-132.

Zaman MW, Mian MAK, Rahman MM (1989). Variability and correlation studies in local germplasm of lentil in Bangladesh. Lens Newsletter 16 (1): 17-20.