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Evaluation of Morpho-Physiological Selection Indices to Improve of Drought Tolerant Lentil Genotypes (*Lens culinaris* Medik) under Rainfed Condition Full Names of All Authors (In Order to Appear on Manuscript)

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Abstract: To determine the genetic parameters and the inter-relationship among yield, yield components and morpho-physiological characteristics, 16 diverse lines of lentil (including one local check) were compared based on randomized complete block design with six replicates at Gachsaran Dryland Agricultural Research Station (GDARS), Iran, during two growing seasons 2008/2009 and 2009/ 2010 under rainfed condition. TN-1768 genotype had the best yield (1651 kg ha^{-1}) compared with the local check (Gachsaran) that gave 1209 kg ha^{-1} seed yield. Sufficient variability was present in the germplasm for all characters, except harvest index. All characters except leaf area, days to 50% flowering and days to maturity showed significant positive correlation with seed yield. Higher estimates of heritability and genetic advance were observed for biological yield (97.34%, 39.59%) and seed yield (95.15%, 45.59%). Biological yield had maximum positive direct effect on seed yield followed by number of pod per plant, harvest index and days to maturity. Plant height, number of seeds per plant, leaf area, chlorophyll content, days to 50% flowering and 1000-seed weight had negative direct effect on yield. Biological yield and number of pod per plant were identified as important yield components; hence selection should be focused on these traits for yield improvement in lentil.

Key words: Genetic diversity · Lentil · Morpho-physiological indices

INTRODUCTION

Lentil (*Lens culinaris* Medik.) is the fourth most important pulse (legume) crop in the world. Major lentil producing countries in Asia are India, China, Syrian, Iran and Bangladesh. Lentil after beans and chickpea is at the third rank among the grain legumes in Iran in respect of sowing area and production, being 189.7 thousand ha and 839.9 thousand tonnes, respectively [1]. Lentil because of adaptable to low rainfall and drought stress is considered for dry areas [2, 3]. On the other hand, lentil as a winter crop compared with the cereal because of shorter growing period, lower faced with drought stress in the end of the season in arid and semi-arid regions and it can be considered as an ideal plant for these areas. Therefore, evaluation of new lentil genotypes to develop of drought tolerant genotypes with acceptable performance in rainfed condition is necessary. One of the primary objectives of lentil breeders in any breeding program is to increase the seed yield. Generally, yield represents the final character resulting from many developmental and biochemical processes which occur between germination and maturity. Before yield improvements can be realized, the breeder needs to identify the causes of variability in seed yield in any given environment. Since fluctuation in environment generally affects yield primarily through its components [4]. Many researchers have analyzed yield through its components [5-8]. Information on genetic variability and heritability is useful to formulate selection criteria for improvement of seed yield. Since lentil is primarily a rainfed crop, yield stability is a major objective in any breeding program. This could be achieved through a better understanding of the components contributing to final yield. The correlation coefficient gives a measure of the relationship between traits and provides the degree to which various characters of a crop are associated with productivity [9]. When more variables are correlated with yield, it is important to identify appropriate traits for

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selection. In such case, path analysis provides an effective means of finding out direct and indirect contribution of different component traits towards seed yield. A lot of research has been done to increase the present yield of grain legumes including lentil. But so far, no breakthrough has occurred in the yield ceiling of these crops and yield of this crop remain low. However, the information on the genotypic plasticity of morpho-physiological characters and its relationships with the major yield components in lentil are scarce. On the other hand, component characters for yield are interdependent to each other while one character may express at the expense of other [10-11]. However, these components vary from year to year and from location to location, even for the same lentil genotype [13]. Keeping all these facts in view, the present investigation was planned to study variability, heritability values and association between yield and its components and determination of direct and indirect relationships between yield and certain plant characters by using path analysis in advance breeding lines of lentil.

MATERIALS AND METHODS

The study was carried out at the experimental fields of Gachsaran Dryland Agricultural Research Station (GDARS), [50°50'N, 30°17'W, altitude 710 m] in the Southwestern of Iran during 2008-2009 and 2009-2010 growth seasons under rainfed condition. The soil is classified as silt clay loam texture; pH is neutral (7.5), lightly alkali, lime, middle phosphate and less than 1% organic matter. Fifteen lentil genotypes, obtained from International Centre for Agricultural Research in the Dry Areas (ICARDA) and Iran, were used. The experiment site had a hot climate with moderate winter and dry and warm summer. Gachsaran cultivar, a local recommended variety, was included in the experiment as a check. Field experiments were conducted in a Randomized Complete Block Design (RCBD) with six replications. Each experimental plot was comprised of 6 rows of 7m length, with inter and intra-row spacing of 20 cm and 2.5 cm, respectively. The Rhizobium bacterium inoculation wasn't done. The sowing was conducted 22 Dec 2008 and 29 Dec 2009. The crop was raised following the recommended cultural practices without irrigation. No-disease was shown during growth season and weed control was made by hand. The Observations were recorded on ten randomly selected competitive plants from each plot per replication on metric traits viz., plant height (cm), number of branches per plant, number of pods per plant, number of seeds per plant and 1000-seed weight (g). The observations on days to 50 % flowering and days to maturity were recorded on plot basis. Biological yield and grain yield were recoded at harvest on 5.6 m^2 and calculated on hectare basis. Physiological parameters such as leaf area, chlorophyll content and canopy temperature in leaves were recorded during anthesis stage. Leaf area was measured by Portable Laser Leaf Area Meter (Model CI-202L). Leaf chlorophyll was estimated following the method of Yoshida *et al.* [14]. A hand held infra-red thermometer (Model: LT300, Sixth Sense, Total Temperature Instrumentation, Inc (DBA Instrument)) was used to measure canopy temperature which was focused to 5:1 meter and at late morning to early afternoon cloudless periods (11:00 to 15:00 hours). Canopy temperature depression is the difference between air temperature and canopy temperature [15]. Genotypic and phenotypic coefficient of correlation was computed according to [16]. The correlations were further partitioned into direct and indirect effects as suggested [17]. Statistical analysis and mean comparison for traits as Duncan multiple-range test were performed using statistical software SAS 9.1 [18] at 5% probability level.

RESULTS

The combined analysis of variance over two years is given in Table 1. Genotypes showed considerable differences ($P < 0.01$) for all studied traits. Year effect on all traits was significant and genotype x year interaction was significant for all characters, except Chlorophyll content. The highest values were taken from ILL-9893 genotype in plant height and number of branches per plant (34.33 cm and 6.4, respectively), ILL-8095 genotype in number of pods per plant, number of seeds per plant and harvest index (47.87, 74.65 and 34.92%, respectively), ILL-9919 genotype in leaf area and days to maturity (184.09 and 123.83, respectively), ILL-6031 genotype in chlorophyll content (2.28), ILL-8173 genotype in canopy temperature depression (7.03), ILL-6439 genotype in days to 50% flowering (82.83) and TN-1768 in 1000-seed weight, biological yield and grain yield (52.5, 500.45 and 1651.6, respectively).

The estimates of different parameters of genetic variability are presented in Table 2. The phenotypic coefficient of variation (PCV) was maximum for number of brunches/plant followed by canopy temperature depression, grain yield, leaf area, number of seeds per plant, biological yield, chlorophyll content, days to 50% flowering, 1000-seed weight, number of pods per plant

Table 1: Difference among genotypes in terms of characters

Genotypes	Plant height (cm)	No. branches per plant	No. pods per plant	No. seeds per plant	Leaf area (cm^2)	Chlorophyll content ($mg\ g^{-1}fw$)	Canopy temperature depression (°C)	Days to 50% flowering	Days to maturity	1000-seed weight(g)	Biological yield ($kg\ ha^{-1}$)	Seed Yield ($kg\ ha^{-1}$)	Harvest Index (%)
ILL-9832	28.64	5.17	39.31	58.09	119.43	1.67	6.56	65.16	91.16	42.27	3300.7	1118.3	33.84
ILL-323	22.47	4.17	29.41	44.03	96.71	1.62	3.37	81.16	122.11	33.37	2772.3	730.47	26.29
ILL-1878	32.2	6.17	41.17	57.16	103.83	1.98	4.7	63.17	93.1	40.67	3721	1018.3	27.34
ILL-7677	24.71	3.17	33.97	49.53	114.41	1.72	5.37	78.17	117.16	44.37	2414.8	837.8	34.63
ILL-9919	26.22	3.93	36.83	50.52	184.09	1.48	4.81	81.83	123.83	40.09	2836.3	929	32.75
ILL-8173	28.16	4.83	42.24	60.06	136.25	2.16	7.03	65.83	97	32.86	3516.7	1056	30.02
ILL-6439	29.17	4.83	31.08	30.46	183.04	1.58	3.51	82.83	112	36.05	2829.3	891.4	31.50
ILL-6031	29.5	3.82	40.87	60.86	167.83	2.28	5.58	75.83	114.9	42.83	3942.6	1155.8	29.31
ILL-8095	28.4	4.82	47.87	74.65	96.08	2.19	4.87	64.83	97.9	48.53	3972.5	1387.5	34.92
ILL-9893	34.33	6.4	33.71	45.51	110.54	2.18	6.01	60.24	110.33	50	4656.6	1445.2	31.03
ILL-8146	32.23	5.2	38.4	51.46	136.61	1.81	5.75	61.8	116.33	46	3672.5	1111.6	30.25
TN-1772	31.02	5.83	37.83	50.75	129.83	1.75	5.83	63.83	92.33	42.85	3518	1073.7	30.52
TN-1768	32.6	4.82	45.17	66.36	121.07	2.08	6.24	63.83	98.9	52.5	5004.5	1651.6	32.99
TN-1751	28.63	4.2	41	59.45	148.33	1.49	4.71	69.33	120.33	41	3440.9	932.33	27.08
Flip-97-8	34	5.82	43.47	58.63	172.3	1.56	6.75	68.83	111.9	51.07	4420.4	1509.8	34.15
Gachsaran	33.48	6.20	37.62	51.16	143.54	1.98	6.57	65.1	113.33	42.1	3742.6	1209.3	32.29
Year	**	*	**	**	*	**	**	*	**	*	**	**	**
Genotype	**	**	**	**	**	**	**	**	**	**	**	**	**
Year x Genotype	**	*	*	**	**	ns	*	*	**	*	**	**	**
CV (%)	3.89	17.7	5.3	7.47	5.3	13.06	15.18	10.80	8.02	4.69	3.22	5.12	2.2
Range	20.7-35.1	2-7.5	26.7-49.6	26.2-78.5	87.5-192	1.22-2.45	2.21-7.9	37.7-84.5	65.5-127	30.7-54.3	2264-5099	647-1700	24.7-36.2
Mean±SE	29.73±0.35	4.94±0.12	38.75±0.53	54.29±1.06	135.3±2.9	1.85±0.03	5.48±0.13	69.58±1.1	108±1.4	42.91±0.61	3610±70.8	1129±26	31.2±0.28
LSD (Genotype)	1.3298	1.006	2.3635	4.6622	8.2543	0.2776	0.9569	8.6451	9.9742	2.3124	133.84	66.515	0.7898

ns,* and **: Not significant and significant at the 5% and 1% levels of probability, respectively

Table2: Genetic parameters for different traits in Lentil

Genetic parameters	Plant height	No. branches per plant	No. pods per plant	No. seeds per plant	Leaf area	Chlorophyll content	Canopy temperature depression	Days to 50% flowering	Days to maturity	1000-seed weight	Biological yield	Seed Yield	Harvest Index
Phen.Var	16.65	1.52	28.5	115.17	977.92	0.12	1.76	128.12	195.16	37.31	508114.33	68919.08	7.78
Gen.Var	14.32	0.75	24.28	98.74	806.41	0.07	1.07	118.25	175.35	33.27	494573.29	65574.50	7.31
PCV (%)	13.72	24.93	13.78	19.77	22.27	18.98	24.23	16.27	12.91	14.24	19.75	23.26	8.94
GCV (%)	12.73	17.55	12.72	18.30	21.63	13.81	18.89	15.63	12.24	13.44	17.48	22.69	8.67
h^2 (%)	85.97	49.58	85.18	85.73	82.46	52.91	60.76	92.30	89.85	89.17	97.34	95.15	93.95
G.A (%)	24.31	25.46	24.18	34.91	39.26	20.69	30.33	30.93	23.90	26.15	39.59	45.59	17.31

Phen. Var. = Phenotypic Variance, Gen. Var. = Genotypic Variance, PCV = Phenotypic Coefficient of Variance, GCV= Genotypic Coefficient of Variance, h^2= Heritability and G.A. = Genetic Advance (as per cent of mean)

Table 3: Genotypic (G) and Phenotypic (P) correlation coefficients among 13 characters in 16 genotypes of Lentil

Variables		Plant height	No. branches per plant	No. pods per plant	No. seeds per plant	Leaf area	Chlorophyll content	Canopy temperature depression	Days to 50% flowering	Days to maturity	1000-seed weight	Biological yield	Seed yield
No. branches per plant	G	0.829**											
	P	0.743**											
No. pods per plant	G	0.370**	0.099										
	P	0.424**	0.334**										
No. seeds per plant	G	0.129	-0.094	0.923**									
	P	0.212	0.202*	0.934**									
Leaf Area	G	0.114	-0.217*	-0.083	-0.318**								
	P	0.168	0.018	0.017	-0.196								
Chlorophyll content	G	0.332**	0.101	0.379**	0.428**	-0.439**							
	P	0.409**	0.538**	0.519**	0.547**	-0.147							
Canopy temperature depression	G	0.548**	0.303**	0.469**	0.408**	-0.007	0.286**						
	P	0.574**	0.607**	0.576**	0.528**	0.142	0.589**						
Days to 50% flowering	G	-0.790**	-0.908**	-0.527**	-0.462**	0.453**	-0.457**	-0.677**					
	P	-0.426**	-0.541**	-0.398**	-0.361**	0.262**	-0.347**	-0.451**					
Days to maturity	G	-0.371**	-0.550**	-0.525**	-0.437**	0.436**	-0.416**	-0.443**	0.643**				
	P	-0.312**	-0.403**	-0.433**	-0.355**	0.294**	-0.335**	-0.326**	0.335**				
Thousand kernel weight	G	0.606**	0.239*	0.469**	0.425**	-0.142	0.225*	0.401**	-0.456**	-0.155			
	P	0.628**	0.389**	0.535**	0.495**	-0.052	0.380**	0.500**	-0.350**	-0.157			
Biological yield	G	0.794**	0.568**	0.600**	0.504**	-0.126	0.592**	0.536**	-0.656**	-0.376**	0.722**		
	P	0.782**	0.509**	0.609**	0.521**	-0.082	0.537**	0.513**	-0.476**	-0.312**	0.726**		
Seed yield	G	0.739**	0.485**	0.633**	0.527**	-0.084	0.508**	0.609**	-0.572**	-0.350**	0.828**	0.934**	
	P	0.740**	0.487**	0.655**	0.559**	-0.027	0.511**	0.600**	-0.419**	-0.292**	0.835**	0.934**	
Harvest Index	G	0.134	-0.058	0.278**	0.214*	0.096	0	0.417**	-0.018	-0.203*	0.540**	0.124	0.466**
	P	0.194	0.122	0.338**	0.279**	0.145	0.157	0.461**	-0.017	-0.178	0.570**	0.155	0.492**

* and **: Significant at the 5% and 1% levels of probability, respectively

Table 4: Direct (Bold) and indirect effects of 12 characters (Independent variables) on seed yield (Dependent variable) in 16 genotypes of Lentil

Variables	Plant height	No. branches per plant	No. pods per plant	No. seeds per plant	Leaf area	Chlorophyll content	Canopy temperature depression	Days to 50% flowering	Days to maturity	1000-seed weight	Biological yield	Harvest Index	Correlation with Seed yield
Plant height	-0.335	-0.278	-0.124	-0.044	-0.039	-0.112	-0.184	0.264	0.124	-0.203	-0.266	-0.045	0.739**
No. branches per plant	0.075	0.091	0.009	-0.009	-0.020	0.009	0.027	-0.083	-0.051	0.021	0.051	-0.006	0.485**
No. pods per plant	0.225	0.060	0.608	0.561	-0.051	0.230	0.285	-0.321	-0.320	0.285	0.365	0.169	0.633**
No. seeds per plant	-0.074	0.053	-0.529	-0.573	0.181	-0.245	-0.234	0.264	0.249	-0.244	-0.289	-0.123	0.527**
Leaf Area	-0.017	0.032	0.012	0.046	-0.148	0.064	0.001	-0.067	-0.065	0.020	0.018	-0.015	-0.084
Chlorophyll content	-0.002	-0.001	-0.002	-0.002	0.001	-0.005	-0.002	0.002	0.001	-0.002	-0.003	0	0.508**
Canopy temperature depression	0.019	0.010	0.016	0.014	-0.001	0.010	0.035	-0.025	-0.016	0.014	0.019	0.014	0.609**
Days to 50% flowering	0.088	0.101	0.058	0.051	-0.051	0.051	0.075	-0.112	-0.072	0.051	0.073	0.002	-0.572**
Days to maturity	-0.103	-0.152	-0.145	-0.121	0.120	-0.115	-0.122	0.177	0.275	-0.043	-0.104	-0.056	-0.350**
Thousand kernel weight	-0.054	-0.022	-0.042	-0.038	0.012	-0.020	-0.036	0.040	0.013	-0.089	-0.065	-0.048	0.828**
Biological yield	0.854	0.611	0.645	0.542	-0.136	0.637	0.576	-0.706	-0.405	0.776	1.076	0.133	0.934**
Harvest Index	0.058	-0.026	0.121	0.093	0.041	0	0.182	-0.008	-0.089	0.235	0.054	0.436	0.466**

Residual Effects= 0.123, * and **: Significant at the 5% and 1% levels of probability, respectively

and plant height, whereas harvest index had low estimates of PCV. Similar trend was observed for genotypic coefficient of variation (GCV) for almost all the traits, though they were slightly low compared to PCV. The heritability estimate was the highest for biological yield (97.34%), followed by grain yield, harvest index, days to 50% flowering, days to maturity, 1000-seed weight, plant height, number of seeds per plant, number of pods per plant and leaf area. Canopy temperature depression, chlorophyll content and number of branch per plant had showed moderate heritability.

The highest genetic advance was observed for grain yield (45.59%), biological yield, leaf area, number of seeds per plant, days to 50% flowering, canopy temperature depression, 1000-seed weight, number of branches per plant, plant height, number of pods per plant, days to maturity, chlorophyll content and harvest index.

Genotypic and phenotypic correlation coefficients among different traits are presented in Table 3. Plant height had significant positive genotypic correlation with all traits expect number of seeds per plant, leaf area and harvest index, whereas days to 50% flowering and days to maturity showed significant negative genotypic correlation with plant height. Number of branches per plant showed significant positive correlation with canopy temperature depression, 1000-seed weight, biological yield and grain yield, whereas leaf area, days to 50% flowering and days to maturity exhibited significant negative genotypic correlation with number of branches per plant. Number of pods per plant and number of seeds per plant had significant positive correlation with chlorophyll content, canopy temperature depression, 1000-seed weight, biological yield and grain yield, whereas days to 50% flowering and days to maturity had significant negative genotypic correlation with number of pod and seed per plant. Leaf area had significant positive genotypic correlation ($P < 0.01$) with days to 50% flowering and days to maturity, whereas chlorophyll content exhibited significant negative genotypic correlation with leaf area. Chlorophyll content and canopy temperature depression exhibited significant positive correlation with biological yield, 1000-seed weight and grain yield. On the other hand, 1000-seed weight, biological yield and grain yield showed significant negative genotypic correlation with days to 50% flowering. Days to maturity also had significant negative genotypic correlation with biological yield, grain yield and harvest index. 1000-seed weight showed significant positive genotypic correlation with biological yield, grain yield and harvest index. Overall, all characters except leaf area had significant positive genotypic correlation ($P < 0.01$) with grain yield, whereas days to 50% flowering and days to maturity exhibited significant negative genotypic correlation with grain yield.

The results obtained from path analysis on genotypic levels taking grain yield as dependent and other characters as independent variables are presented in Table 4. Biological yield showed the highest positive direct effect (1.076) towards seed yield followed by number of pods per plant, harvest index, days to maturity, number of branches per plant and canopy temperature depression. The direct effects of plant height, number of seeds per plant, leaf area, chlorophyll content, day to 50% flowering and 1000-seed weight were negative.

Plant height, number of branches per plant, number of pods per plant, number of seeds per plant, chlorophyll content, canopy temperature depression 1000-seeed weight and harvest index showed high positive indirect effect on seed yield via biological yield while, leaf area, days to 50% flowering and days to maturity exhibited high negative indirect effect on seed yield via biological yield. Plant height, number of pod per plant, chlorophyll content, canopy temperature depression, 1000-seed weight, biological yield and harvest index showed high negative indirect effect on seed yield via number of seed per plant. On the other hand, all character, except leaf area and days to 50% flowering had negative indirect effect on seed yield via days to maturity. Low value of residual effect (0.123) indicated high contribution of component traits studied towards seed yield.

DISCUSSION

The estimates of different genetic variability parameters revealed that sufficient variability was present in the collected germplasm almost for all characters expect harvest index (Table 2). This variability can be utilized effectively to develop high yielding early maturing cultivars through hybridization followed by selection. Genotype TN-1768 had the best yielding ability (1651.6 kg ha^{-1}) along with early maturity (98.9 days) as compared to check. Besides this, ILL-1878 (63.17 and 93.1 days), ILL-8095(64.83 and 97.9 days), ILL-9893 (60.24 and 110.33 days) and TN-1772 (63.83 and 92.33 days) were also early in flowering and maturity as compared to check cultivar. ILL-8095 (1387.5 kg); ILL-9893 (1445.2 kg) and Flip-97-8 (1509.8 kg) have good yield potential. These genotypes were also promising in other yield attributing traits such as number of branch per plant, number of pod per plant, days to maturity, days to flowering, 1000-seed weight, biological yield etc. (Table 1). Utilization of these promising genotypes in breeding programme can be helpful in development of short duration and drought tolerant varieties in rainfed condition. These results were in conformity with the findings of Salehi *et al.* [19] and Azizi Cha Khar Chaman *et al.* [20].

The PCV estimates were higher than their corresponding GCV for all the traits; however, the difference between the two was narrow for almost all the traits, except number of branches per plant, chlorophyll content and canopy temperature depression indicating that most of the characters were comparatively stable to environmental variation (Table 2).

Although GCV is an indicative of the presence of high degree of genetic variation, the amount of heritable portion of variation can be determined with the help of heritability estimates coupled with genetic advance [21]. In the present study, biological yield, grain yield, harvest index, days to 50% flowering, days to maturity, 1000-seed weight, plant height, number of seeds per plant, number of pods per plant and leaf area showed very high heritability. These results are in line with the findings of Younis *et al.* [2], Rasheed *et al.* [9], Tyagi and Khan [4]. This suggests that selection for these traits may respond high to breed ideal genotypes in lentil. The highest value of broad sense heritability may be due to additive gene effects, reports are also there in lentil to support the similar findings of Vir and Gupta [22] and Singh *et al.* [23]. On the other hand, canopy temperature depression, chlorophyll content and number of branches per plant had medium heritability. Punia *et al.*, [21] also reported medium heritability for number of branches per plant, whereas, Tyagi and Khan [4] and Rasheed *et al.*, [9], reported that high and low heritability for this trait, respectively. Though high heritability indicates the effectiveness of selection on the basis of phenotypic performance, it does not show any indication of the amount of genetic progress for selecting the best individuals. Therefore, heritability in conjunction with genetic gain is more useful than heritability alone in predicting the resultant effect for selecting the best genotype for a given trait. In the present study, high heritability estimates coupled with high genetic advance (Table 2) were observed for grain yield and biological yield indicating that these traits were under the additive genetic control and simple selection can be used for further improvement of these traits. Younis *et al.*, [8], grain yield, harvest index and days to maturity, Punia *et al.*, [21], days to flowering and plant height, Rasheed *et al.*, [9], harvest index, biological yield and 1000-seed yield reported as traits with high heritability coupled with high genetic advance.

However, making indirect selection for grain yield based on the correlated response, appropriate design and statistical tools should be used to reduce confounding effect of environmental factors and their interaction with genotypes in lentil. Seed yield was associated positively with all yield attributing traits studied ($P < 0.01$) except leaf area, days to 50% flowering and days to maturity (Table 3). Biological yield had the highest correlation with seed yield ($r = 0.934$, $P < 0.01$), which is agree with findings of Salehi *et al.*, [24], Bicer and Sakar [25], Karadavut [26]. This character could be a good index for selection high yield genotype in rainfed condition. Plant height, number of branches per plant and number of pods had positive correlation with biological yield and seed yield. Positive correlation of plant height with seed yield has also been reported by Kumar *et al.* [6], Younis *et al.* [8], Bicer and Sakar [25], Hamid *et al.* [27]. Yadav *et al.* [7] and Singh *et al.* [23] also reported positive association of seed yield with number of pod per plant. Positive and significant correlation number of pods per plant with seed yield, biological yield and seed yield has been reported by Ayub *et al.*, [28], Younis *et al.* [8], Rasheed *et al.* [9]. Plant height also had positive correlation with number of branches per plant and pods/plant. Similar results were also obtained by Rasheed *et al*. [9], Karadavut [26]. Days to 50% flowering showed positive correlation with days to maturity, which is agreement with the findings of Rasheed *et al*. [9], Younis *et al*. [8]. Days to 50% flowering and days to maturity had negative correlation with all the traits except leaf area. Younis *et al*. [8], also showed days to 50% flowering had negative correlation with all the traits except number of pod per plant. Whereas, Arshad *et al*. [29] and Younis *et al*. [8], reported that days to maturity had positive and significant correlation with all traits including seed yield. The results of these researchers revealed that long duration genotypes have all the desirable traits. However, the effect of days to 50% flowering and days to maturity on seed yield, in contrast to the findings of above researchers, was considerably high and negative. The reason of such effect may be attributed to the sudden increase in temperature in March and April when instance flowering and pod elongation occurred. This may force the plant to maturity and prevent flower setting, pod formation and pod lodging. The highest precipitation during growth period promoted the high quantity of fresh material [26]. This situation indicated that the selection of earlier flowering and maturing genotypes must always be considering by researchers under rainfed condition.

The path analysis results indicated that biological yield showed the highest positive direct effect (1.076) towards seed yield followed by number of pods per plant, harvest index, days to maturity, number of branches per plant and canopy temperature depression were important yield contributing characters (Table 4). Similar results were obtained by Tyagi and Khan [4]. Karadavut, [26], biological yield and harvest index, Rasheed *et al*. [9], Younis *et al*. [8], 1000-seed weight, harvest index and biological yield, Bicer and Sakar [25], biological yield and number of pods per plant were recognize as important yield contributing characters based on the path analysis results.

CONCLUSION

On the basis of correlation and path analysis studies, it can be concluded that biological yield and number of pod per plant exerted high direct influence on seed yield per plant resulting in strong positive correlation and this should be taken into consideration while selecting desirable genotypes for higher seed yield in lentil. Since lentil is mostly grown under the receding moisture conditions during *rabi* season, earliness along with high biomass through rapid dry matter accumulation in pods should also be taken into account in selection process.

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