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Natural variation for root traits, morphological and yield parameters in lentil (*Lens culinaris* M.)

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ABSTRACT
In the present study, 20 lentil genotypes were evaluated for root traits and yield parameters. Among root and shoot traits under laboratory conditions LSN-2016-186 had maximum value for root angle (56.50^0) whereas LSN-2016-183 had steepest root angle (31.25^0). LSN-2016-186 had maximum root depth of 11.30 cm, whereas LSN-2016-185 had minimum root depth (5.55 cm). LSN-2016-199 had maximum shoot length (16.25 cm). Number of lateral roots was found highest in LSN-2016-148 (13.5) and lowest in LSN-2016-139, LSN-2016-142 and LSN-2016-226 (4.5). LSN-2016-201 had maximum value for root biomass (0.094 g) whereas LSN-2016-226 had minimum value of root biomass (0.20 g). Plant height was highest for genotype LSN-2016-185 (44.733 cm) followed by LSN-2016-139 (44.533 cm). Minimum value was observed for LSN-2016-166 (28.667 cm). LSN-2016-227 had maximum number of secondary branches (2.530), followed by LSN-2016-186 (2.487). Lowest number of primary branches per plant was observed for LSN-2016-199 (1.150). Highest value for 100 seed weight was found for LSN-2016-227 (3.55 g) followed by LSN-2016-219 (3.5 g) and lowest 100 seed weight was found in LSN- 2016-221 (1.567 g). Maximum number of seeds per pod (1.860) was found for genotype LSN-2016-183 where as minimum was found for LSN-2016-199 (1.397). LSN-2016-142 had maximum number of pods per plant (65.487) whereas LSN-2016-166 had minimum number of pods per plant (27.273). Highest yield per plant was observed for LSN-2016-186 (3.526 g) followed by LSN-2016-227 (3.122 g). Lowest yielding genotype was LSN-2016-166 (1.10 g). Analysis of variance depicted significant variability for all the traits under study, viz. plant height, primary branches per plant, 100 seed weight, seeds per pod, pods per plant and yield per plant. Maximum variability can be expected from pods per plant followed by yield per plant and plant height. Similar results in lentil have been reported by various workers. Seed yield per plant was significantly correlated with pods per plant, primary branches per plant and seeds per pod. Among yield contributing traits, pods per plant was positively correlated seeds per pod, primary branches per plant and shoot biomass but was negatively correlated 100-seed weight.
Key words: *Lentil, root traits, yield parameters*

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INTRODUCTION

Pulses are a type of leguminous crop that are harvested solely for the dry seed. Dried beans, lentils and peas are the most commonly known and consumed types of pulses. pulses are not merely a source of food. They have nutritional importance. They are an alternate to meat,they are one of best green manure crops, they can be used for green fodder,animal cake, catch cropping, oils and can be cultivated on low fertility soils. The lentil or daal or Masoor dal (*Lens culinaris* Medik) is a bushy annual plant of the legume family, grown for its lens-shaped seeds. It is about 15 inches tall and the seeds grow in pods, usually with two seeds in each. The plant originated in the Near East and has been part of the human diet since the aceramic (non-pottery producing) Neolithic times, being one of the first crops domesticated in the Near East. It is one of the oldest and an important seed legume crop, cultivated worldwide as human food in the fertile crescent 7000-9000 years ago [13]. Production of this cool season annual crop spread from the Near East to the Mediterranean area, Asia, Europe and finally the Western Hemisphere [7]. It is an annual, diploid (2n=14) and autogamous species [10]. It grow well in limited rainfall areas of the world [7]. With 26% protein, lentils have the third highest level of protein from any plant-based food after soybeans and hemp and it is an important part of the diet in many parts of the world, especially in Indian subcontinent which have large vegetarian populations. Lentil seeds are valued as a food of both high quality plant proteins and fiber. It plays an important role in rain-fed cropping systems, providing an alternative to

cereal grains [5]. It is cultivated mainly for its seed and only cotyledon is used as food in India. It has ability to fix symbiotically with certain bacteria atmospheric nitrogen and thus contributes greatly to soil fertility [3].

MATERIALS AND METHODS

Location of the experiment: The present study was conducted during 2015-2016 at Division of Genetics and Plant Breeding, the field experiment was laid at Dryland (karewa) Agriculture Research Station (DARS) Budgam. Laboratory experiments were done at Division of Genetics and Plant Breeding, Faculty of Agriculture Wadura, SKUAST-K Sopore.

Plant Materials: Twenty diverse genotypes of Lentil obtained from ICARDA BIGM Nursery were evaluated for various root and shoot traits in laboratory and yield parameters in the field.

Field experiment

The field experiment was laid at DARS, Budgam. The meteorological data of the location will be recorded for the period of experiment for drawing inferences.

Characters studied and observational procedure

Observations were recorded on 10 randomly selected and tagged competitive plants from each experimental plot in each replication for plant height, primary branches per plant, secondary branches per plant, pods per plant, seeds per pod, pods per plant, test weight and seed yield per plant. Days to 50 percent flowering and days to maturity were recorded on the whole plot basis. Mean values for all the characters and median values for days to 50 percent flowering were worked out for analysis of variance

RESULTS AND DISCUSSION

From the study of means table for root and shoot traits under laboratory conditions (Table 1) LSN-2016-186 had maximum value for root angle (56.50^0) whereas LSN-2016-183 had steepest root angle (31.25^0). LSN-2016-192 had a root angle of 45^0 which is considered perfect for selection for drought stress screening. LSN-2016-186 had maximum root depth of 11.30 cm, whereas LSN-2016-185 had minimum root depth (5.55 cm). LSN-2016-199 had maximum shoot length (16.25 cm). Minimum shoot length was observed for LSN-2016-227 (7.40 cm). Number of lateral roots was found highest in LSN-2016-148 (13.5) and lowest in LSN-2016-139, LSN-2016-142 and LSN-2016-226 (4.5). LSN-2016-201 had maximum value for root biomass (0.094 g) whereas LSN-2016-226 had minimum value of root biomass (0.20 g). For shoot biomass LSN-2016-185 possessed highest value (0.288 g) whereas LSN-2016-227 had minimum shoot biomass of 0.052g. Gahoonia *et al* [4] reported significant variation in root traits in lentil.

Table 1: Mean performance of laboratory scored root and shoot parameters in lentil

Genotype	Root angle	Root depth	Shoot length	Number of laterals	Root biomass	Shoot biomass
LSN- 2016-221	47.500	10.600	10.050	7.500	0.039	0.095
LSN-2016-185	52.500	5.550	11.750	8.000	0.058	0.288
LSN-2016-191	43.500	9.750	11.750	11.000	0.034	0.081
LSN-2016-174	53.000	25.167	12.750	11.000	0.072	0.113
LSN-2016-227	43.417	6.750	7.400	5.000	0.033	0.052
LSN-2016-229	51.250	9.050	9.250	7.000	0.043	0.050
LSN-2016-139	43.750	5.850	10.250	4.500	0.081	0.079
LSN-2016-199	52.500	7.100	16.250	5.500	0.034	0.089
LSN-2016-148	46.123	9.600	14.250	13.500	0.085	0.113
LSN-2016-219	48.123	4.050	15.400	8.500	0.050	0.105
LSN-2016-192	45.000	8.250	10.150	9.000	0.076	0.098
LSN-2016-142	50.000	7.850	13.850	4.500	0.037	0.068
LSN-2016-226	52.500	6.850	10.900	4.500	0.020	0.055
LSN-2016-181	44.000	9.050	9.900	9.500	0.088	0.095
LSN-2016-137	55.750	9.000	8.950	7.000	0.059	0.075
LSN-2016-183	31.250	8.450	10.300	9.000	0.065	0.092
LSN-2016-166	50.000	6.850	10.450	9.000	0.044	0.076
LSN-2016-201	46.250	5.350	14.000	9.000	0.094	0.149
LSN-2016-194	37.250	6.500	13.150	9.500	0.056	0.097
LSN-2016-186	56.500	11.300	14.100	10.000	0.075	0.145
Mean	47.508	8.645	11.742	8.125	0.057	0.100

From the study of means of morphological and yield parameters (Table 2) maximum plant height was observed for genotype LSN-2016-185 (44.733 cm) followed by LSN-2016-139 (44.533 cm). Minimum

value was observed for LSN-2016-166 (28.667 cm). LSN-2016-227 had maximum number of secondary branches (2.530), followed by LSN-2016-186 (2.487). Lowest number of primary branches per plant was observed for LSN-2016-199 (1.150). Highest value for 100 seed weight was found for LSN-2016-227 (3.55 g) followed by LSN-2016-219 (3.5 g) and lowest 100 seed weight was found in LSN- 2016-221 (1.567 g). Maximum number of seeds per pod (1.860) was found for genotype LSN-2016-183 followed by LSN-2016-142 (1.853). Minimum number of seeds per pod was found for LSN-2016-199 (1.397). From the study of pods per plant LSN-2016-142 had maximum number of pods per plant (65.487) followed by LSN-2016-186 (63.483) whereas LSN-2016-166 had minimum number of pods per plant (27.273). Highest yield per plant was observed for LSN-2016-186 (3.526 g) followed by LSN-2016-227 (3.122 g). Lowest yielding genotype was LSN-2016-166 (1.10 g). A large number of workers have reported substantial variation in lentil for morphological, maturity and yield traits that can be utilised in breeding early maturing and high yielding varieties that could fit in diverse cropping systems [9, 11, 8].

Table 2: Mean performance of morphological and yield parameters in lentil

Genotype	PLANT HEIGHT	PRIMARY BRANCHES	100 SEED WEIGHT	SEEDS PER POD	PODS PER PLANT	YIELD PER PLANT
LSN- 2016-221	38.733	1.800	1.567	1.643	45.570	2.151
LSN-2016-185	44.733	2.253	2.493	1.783	56.693	2.590
LSN-2016-191	38.700	1.300	2.800	1.680	41.713	1.619
LSN-2016-174	35.633	1.997	2.133	1.767	47.970	2.382
LSN-2016-227	34.733	2.530	3.550	1.727	47.930	3.122
LSN-2016-229	40.233	1.367	2.377	1.467	36.900	1.140
LSN-2016-139	44.533	1.987	2.145	1.917	53.750	2.369
LSN-2016-199	37.267	1.150	2.533	1.397	41.000	1.557
LSN-2016-148	42.467	1.200	2.100	1.602	37.327	1.253
LSN-2016-219	43.433	1.720	3.500	1.457	37.617	2.020
LSN-2016-192	32.000	1.633	2.657	1.653	41.660	1.839
LSN-2016-142	34.533	2.207	1.590	1.853	65.487	3.021
LSN-2016-226	37.300	1.207	2.850	1.610	36.580	1.435
LSN-2016-181	43.400	2.477	1.920	1.660	43.663	1.841
LSN-2016-137	31.933	1.167	2.387	1.441	36.940	1.158
LSN-2016-183	39.167	1.837	2.127	1.860	55.037	2.529
LSN-2016-166	28.667	1.500	3.020	1.687	27.273	1.100
LSN-2016-201	37.300	1.857	2.200	1.637	54.543	2.363
LSN-2016-194	41.467	2.300	2.033	1.660	44.157	2.292
LSN-2016-186	34.233	2.487	1.881	1.853	63.483	3.526
Mean	38.023	1.798	2.393	1.667	45.764	2.065

Table 3: ANOVA for root and shoot parameters in lentil

Source of variation	df	Root angle	Root depth	Shoot length	Number of laterals	Root biomass	Shoot biomass
Treatment	19	113.539	55.837	16.804	18.148	0.002	0.001
Error	40	90.828	43.765	5.141	2.963	0.001	0.000

Table 4: ANOVA for morphological and yield parameters in lentil

Source of variation	df	PLANT HEIGHT	PRIMARY BRANCHES	100 SEED WEIGHT	SEEDS PER POD	PODS PER PLANT	YIELD PER PLANT
Replication	2	7.879	0.086	0.042	0.004	1.619	0.003
Treatment	19	61.572	0.672	0.045	0.065	290.848	290.848
Error	38	11.024	0.046	0.900	0.002	4.967	4.967

Table 5: Correlation matrix for root traits and morphological traits in lentil

Variables	Root angle	Root depth	Shoot length	Number of laterals	Root biomass	Shoot biomass	Plant height	Primary branches	100 seed weight	Seeds per pod	Pods per plant	Yield per plant
Root angle	1	0.236	0.193	-0.168	-0.172	0.176	-0.318*	-0.215	0.028	-0.300	-0.078	-0.130
Root depth		1	0.002	0.394*	0.164	-0.037	-0.217	0.051	-0.320*	0.173	0.069	0.077
Shoot length			1	0.265	0.119	0.301	0.185	-0.092	-0.151	-0.147	0.192	0.122
No. of laterals				1	0.521**	0.308	0.094	-0.044	-0.147	0.000	-0.157	-0.144
Root biomass					1	0.370*	0.226	0.285	-0.392*	0.264	0.268	0.150
Shoot biomass						1	0.339*	0.312	-0.140	0.230	0.401*	0.317
Plant height							1	0.170	-0.145	0.035	0.144	0.048
Pry. branches								1	-0.225	0.639**	0.669**	0.836**
100 seed weight									1	-0.345*	-0.506*	-0.224
Seeds per pod										1	0.710**	0.698**
Pods per plant											1	0.883**
Yield per plant												1

Analysis of variance (Table 3 & 4) depicted significant variability for all the traits under study, viz. plant height, primary branches per plant, 100 seed weight, seeds per pod, pods per plant and yield per plant. Maximum variability can be expected from pods per plant followed by yield per plant and plant height. Similar results in lentil have been reported by various workers [12, 5]. Root and shoot traits studied under laboratory conditions viz, root angle, root length, shoot length, root biomass shoot biomass and number of lateral roots also had significant variability. Root angle had maximum variability followed by root length, number of lateral roots and shoot length.

The correlation matrix depicting trait associations is presented in table 5. Seed yield per plant was significantly correlated with pods per plant (0.883**) followed by primary branches per plant (0.836**) and seeds per pod (0.698**). Among yield contributing traits, pods per plant was positively correlated seeds per pod (0.710**), primary branches per plant (0.669**) and shoot biomass (0.401*) but was negatively correlated 100-seed weight (-0.506**). Among root traits, number of laterals was positively correlated with rooting depth (0.394**) and root biomass (0.521**). Similar results were also reported by Tyagi and Khan [12]. Latif *et al*. [6], Aghili *et al*. [1], Singh *et al* [11], Alom *et al*. [2]. 100 seed weight showed negative and significant correlation with seed yield at both genotypic and phenotypic levels.

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