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Performance of Different Lentil Genotypes in Southern Belt of Bangladesh

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Abstract: An experiment was conducted to study on the performance of 76 lentil genotypes that are suitable to cultivate under the southern belt of Bangladesh (AEZ–13). The experiment was laid out in RCBD with three replications. Correlation co–efficient was done to identifying the best relationship among the characters and path coefficient was also used to determine the direct and indirect relationships between yield and certain characters in 76 lentil genotypes. The data were analyzed statistically and means were adjudged by DMRT at 5% level of probability. Results revealed that genotypes had a significant control in all the studied characters at 1% level. Among the genotype, BD–3818 requiring more time for plant maturity (102.50 days) while it was also recorded the maximum pods and seeds (154.90 plant^{-1} and 2.0 pod^{-1}, respectively) as well as higher grain yield (173.70 g line^{-1} plot^{-1}). So the genotype BD-3818 would be most suitable productive genotype and may be useful in improving seed yield of lentil under the southern belt of Bangladesh (AEZ-13). Correlation co–efficient and path analysis also revealed that highly significant positive correlations were detected between first and 50% flowering (r= 0.925**) and also between grain yield and biological yield (r = 0.821**) while path analysis demonstrated that grain yield had the highest positive direct effects (0.8373) and the higher negative direct effect was -0.1904 in respect of days to 50% flowering with an average residual effect of 0.2839. Above result indicated that 50% flowering is the main yield contributing traits and it suggested that the delay flowering significantly increased the grain yield.

Key Words: Grain yield, Lentil Genotypes, Plant maturity

Introduction

Lentil (*Lens culinaris* Medik.) is an important grain legume belongs to the sub–family Papilionaceae and family Leguminousae. Lentils were probably one of the oldest grain legume crops domesticated in the World (Sandhu and Singh, 2007). Lentil is the fourth most important pulse crop in the world after bean (Phaseolus vulgaris L.), pea (Pisum sativum L.), and chickpea (Cicer arietinum L.) (Lizica Szilagyi *et al*., 2011). In Bangladesh, it is popularly known as *masur*. Total production of lentil in Bangladesh is 228 thousand tons from an area of 180 thousand hectare with an average yield of 1.2657 ton ha^{-1} during 2010–11 while it covers 33.33% of the total area of pulse in the country (BBS, 2012). In developing countries like Bangladesh, pulse constitutes the major concentrate source of dietary protein. It is considered as poor man's meat as well as cheapest source of protein for under privileged group of people who cannot afford to buy animal protein. Lentil seeds are most commonly used as main dishes, side dishes or as sprouted grain in salads with rice or rotis (Sandhu and Singh, 2007). It was also rich in important vitamins, minerals, soluble and insoluble dietary fiber (Hojjat and Galstayan, 2011). In Bangladesh yield of lentil are low because of using low yielding varieties by farmers. There are many factors for low productivity of lentil. Lentil has been also identified as a narrow adapted crop and the principal constraint of lentil production is its low yield potential because of undesirable plant type (Hanlan *et al*., 2006). Lentil is adapted to low rainfall and is predominantly grown in the winter in regions where the annual average rainfall is 300 to 400 mm reported by Sarker *et al., (*2003). Different lens genotypes showed some genetic variation for plant height, number of branch, number of pod plant^{-1}, number of seed plant^{-1} and yield. Among different released varieties of lentil BINA masur 2, BINA masur 3, BARI masur 4 are mentionable for their growth performance, yield and quality. So, the variety selection is an important factor for more production with good quality of lentil. BARI developed some new lentil varieties which was higher yielder than previous genotypes. All the high yielding varieties require high inputs, one of which variety selection regarding to regional adaptability. On the basis of the above aspect the present study was to identify the suitable lentil genotypes for maximizing the yield under southern belt of Bangladesh and to select the most valuable trait for maximizing the yield via correlation co–efficient and path analysis.

Materials and Methods

A field experiment was conducted at Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Rahmatpur, Barisal during the period from November 2012 to April 2013 under the southern belt of Bangladesh (AEZ–13). Seventy six lentil genotypes namely BD–3804, BD–3806, BD–3807, BD–3808, BD–3809, BD–3810, BD–3811, BD–3812, BD–3815, BD–3817, BD–3818, BD–3819, BD–3820, BD–3821, BD–3822, BD–3823, BD–3824, BD–3825, BD–3826, BD–3827, BD–3828, BD–3829, BD–3830, BD–3831, BD–3832, BD–3833, BD–3834, BD–3835, BD–3836, BD–3837,

BD–3838, BD–3839, BD–3840, BD–3841, BD–3842, BD–3843, BD–3844, BD–3845, BD–3846, BD–3848, BD–3849, BD–3850, BD–3851, BD–3852, BD–3853, BD–3854, BD–3855, BD–3856, BD–3857, BD–3858, BD–3859, BD–3860, BD–3861, BD–3863, BD–3864, BD–3866, BD–3867, BD–3868, BD–3870, BD–3871, BD–3872, BD–3873, BD–3874, BD–3875, BD–3876, BD–3877, BD–3878, BD–3879, BD–3880, BD–3881, BD–3882, BD–3883, BARI masur–1, BARI masur–4, BARI masur–6, BARI masur–7 were used for the present study which was collected from Pulse Research Division (PRD), BARI, Joydebpur, Gazipur–1701. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of each unit plot was 4.0 m × 30 cm thus the 1.2 m^2 plot where line to line and seed to seed distances were 30 cm and 10 cm, respectively, in each plot. The different fertilizers such as cowdung (1.2 kg $plot^{-1}$ or 10 tons ha^{-1}), TSP (0.01 kg $plot^{-1}$ or 85 kg ha^{-1}), MP (0.004 kg $plot^{-1}$ or 35 kg ha^{-1}), Urea (0.054 kg $plot^{-1}$ or 45 kg ha^{-1}), Sulphur (0.0072 kg $plot^{-1}$ or 60 kg ha^{-1}), Boron (0.00018 kg $plot^{-1}$ or 1.5 kg ha^{-1}) and Zinc (0.00036 kg $plot^{-1}$ or 3 kg ha^{-1}) were applied during final plot preparation (BARC, 1997). The applied fertilizers were mixed properly with the soil in the plot using a spade. The seed were sown in the morning on 19 Nov., 2012. Various intercultural operations such as thinning out, gap filling and irrigation were also done during the study. Harvesting of the lentil was done after 110 days of sowing when 80% pod turned yellowish or the foliage turned pale yellow. The morphological, growth and yield attributes of lentil data were done at harvest. Data were recorded from the randomly selected 5 plants in each plot. Yield data were also collected at harvest. The harvested plants tagged as per plot and kept it on cleaned floor. The separated plants of each plot are threshing by hand and allowed them for drying well under bright sunlight. Finally, grain weights were taken on individual plot as per genotypes at moisture content of 12% and converted into g $plant^{-1}$ and t ha^{-1}. The obtained data were statistically analyzed in MSTAT–C computer program. The mean values were adjusted by Duncan's Multiple Range Test (DMRT) at 5% level. Pearson's correlation coefficients were calculated to determine the relationships between yield and yield components. Path coefficient was used as determined by Dewey and Lu (1959) to partition the correlation coefficients and to determine the direct and indirect effects.

Results and Discussions

Performance of morpho–physiological, yield and yield characters as influence by genotypes

Days to 50% flowering: A significant variation was found on days to 50% flowering among the genotypes where the genotype BD–3818 requiring minimum time for 50% flowering (47.50 days) and BARI masur–6 requiring the maximum time (59.00 days) followed by BD–3830 (58.50 days); BD–3825 (58.00 days) (Table 1). The variation in requiring days was recorded due to the variation in their characteristics of the genotypes and also the variation of the climatic factors of the area and physical and chemical properties of the soil. Similarly, Bicer and Sakar, (2008) reported that days to 50% flowering varied significantly due to the effect of 64 lentil genotypes where it was varied from 141 (2003–16L) to 149 days (2003–13L) which results was also supported by the findings of Hojjat and Galstayan, (2011).

Days to maturity: There were significant differences among the genotypes in respect of days to maturity where both BD–3843 and BD–3855 genotypes requiring least time (97.50 days) followed by BD–3842, BD–3844, BD–3849, BD–3856 (98.00 days) (Table 1) while BD–3818, BARI masur–1 and BARI masur–4 requiring more time for maturity (102.50 days). The present productivity of lentil invariably encounters terminal moisture stress, thus, leading to forced maturity and lower yield which findings were similar to Mondal *et al.* (2013). The variation in days to maturity had also occur by the variation of the studied genotypes which are agreed to the findings of Hojjat and Galstayan, (2011).

Plant height: Plant height is the most important character among the morpho–physiology which also acts as a key of shoot yield as well as total biomass production. Plant height data was recorded at harvest where the genotype BD–3861 found to be the tallest plant (46.80 cm) closely followed by BD–3807 and BD–3866 (45.70 and 45.00 cm, respectively). On the other hand, the shortest plant (29.00 cm) was obtained from the genotype BD–3850 which was statistically identical to BD–3832 (29.70 cm). These results revealed that different genotypes obtained the variation result in respect of plant height which might be due to the genetic variation of the studied genotypes which findings are similar to Hojjat and Galstayan, (2011); Mondal *et al*., (2013).

Branches $plant^{-1}$: Effect of genotypes was significantly influence on branches $plant^{-1}$ at harvest while the genotype BD–3807 produced maximum branches $plant^{-1}$ (4.10) followed by BD–3836 (4.00). Similarly, minimum branches $plant^{-1}$ (2.30) was found from the variety BD–3867 (Table 1). These results revealed that the genotype BD–3807 showed better performance than that of other genotypes which might be due to their genetic make up of the genotypes. The findings of Hojjat and Galstayan, (2011); Mondal *et al*., (2013) and many other scientist were also found similar results.

Table 1. Performance of lentil genotypes on days to final stand, first flowering, 50% flowering and maturity; plant height and number of branches during 2012-13

Genotypes	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	Hundred –seed weight (g)	Grain yield (g line^{-1})
BD–3804	55.00 F–I	100.5 A–E	37.60 R–Y	3.700 DE	76.10 \]	2.000 A	1.300 LM	127.7 IJK
BD–3806	54.50 G–J	100.5 A–E	36.90 U–Z[\	2.902 JK	73.40 _`a	1.800 A–C	1.700 DE	110.5 N
BD–3807	52.50 K	101.0 A–D	45.70 AB	4.100 A	91.80 OP	2.000 A	0.801 S	83.60 W
BD–3808	54.50 G–J	101.5 A–C	38.50 O–V	3.300 FG	74.80]^_	2.000 A	1.901 A	70.10 YZ
BD–3809	53.50 I–K	101.5 A–C	40.80 G–M	3.002 IJ	73.90 ^_`	1.700 BC	1.301 LM	91.70 S–U
BD–3810	54.50 G–J	101.0 A–D	36.90 U–Z[\	2.702 LM	60.90 f	2.000 A	0.900 R	120.3 L
BD–3811	54.50 G–J	99.50 C–G	42.80 D–G	3.102 HI	95.00 LM	2.000 A	1.250 MN	164.9 B
BD–3812	55.50 E–H	99.50 C–G	35.80 YZ[\]^_	3.000 IJ	73.00 `a	1.900 AB	1.651 EF	74.80 X
BD–3815	53.00 JK	99.50 C–G	36.50 V–Z[\	3.400 F	70.60 bc	2.000 A	1.851 AB	94.90 RS
BD–3817	53.50 I–K	101.0 A–D	42.70 D–H	3.602 E	78.50 XYZ	1.900 AB	1.400 JK	162.1 B
BD–3818	47.50 L	102.5 A	42.40 D–I	2.900 JK	154.9 A	2.000 A	1.902 A	173.7 A
BD–3819	55.50 E–H	101.5 A–C	34.45]^_`	2.802 KL	84.60 U	2.000 A	1.100 P	109.1 N
BD–3820	56.50 C–F	99.00 D–G	36.00 [\]^	3.000 IJ	99.40 J	2.000 A	1.650 EF	108.2 NO
BD–3821	56.50 C–F	100.5 A–E	36.80 U–Z[\	2.700 LM	78.30 X–Z	2.000 A	1.701 DE	55.60 `a
BD–3822	54.50 G–J	100.5 A–E	33.30 `ab	2.800 KL	73.50 _`	2.000 A	1.152 OP	52.60 a
BD–3823	57.00 B–E	100.0 B–F	37.40 S–Z	2.400 OP	133.6 C	2.000 A	1.551 GH	97.85 QR
BD–3824	55.00 F–I	98.50 E–G	37.20 T–Z[	3.100 HI	70.00 c	1.900 AB	1.300 LM	140.4 E
BD–3825	58.00 A–C	100.5 A–E	38.10 P–W	3.100 HI	76.30 [\]	1.900 AB	1.451 IJ	68.10 YZ[\
BD–3826	56.00 D–G	99.50 C–G	41.00 G–M	2.602 MN	70.40 bc	1.800 A–C	1.153 OP	84.00 W
BD–3827	55.50 E–H	98.50 E–G	37.10 T–Z[	2.500 NO	51.60 h	1.800 A–C	1.301 LM	92.60 S–U
BD–3828	57.50 A–D	99.50 C–G	38.00 P–X	3.400 F	92.80 NO	2.000 A	1.301 LM	59.35 ^_`
BD–3829	56.00 D–G	100.0 B–F	33.90 _`a	2.600 MN	92.20 N–P	2.000 A	1.400 JK	43.85 c
BD–3830	58.50 AB	100.0 B–F	39.50 L–R	2.602 MN	154.2 A	2.000 A	1.351 KL	60.35 ^_
BD–3831	56.00 D–G	99.00 D–G	35.80 YZ[\]^_	3.102 HI	79.70 V–X	2.000 A	1.152 OP	48.35 b
BD–3832	56.00 D–G	101.5 A–C	29.70 c	3.602 E	77.20 Z[\	1.800 A–C	1.401 JK	92.35 STU
BD–3833	57.50 A–D	101.0 A–D	39.80 J–P	3.902 BC	80.90 V	1.900 AB	1.500 HI	46.90 bc
BD–3834	58.50 AB	100.0 B–F	39.30 M–S	2.802 KL	67.40 d	1.900 AB	1.551 GH	77.00 X
BD–3835	57.50 A–D	99.50 C–G	39.00 M–T	3.202 GH	67.40 d	1.900 AB	1.501 HI	90.00 TU
BD–3836	54.00 H–K	99.50 C–G	35.00 \]^_`	4.002 AB	66.30 de	2.000 A	1.301 LM	62.25]^
BD–3837	55.00 F–I	99.50 C–G	37.20 T–Z[	3.402 F	79.20 W–Y	2.000 A	1.400 JK	131.3 HI
BD–3838	55.00 F–I	99.00 D–G	40.40 I–O	3.302 FG	96.10 L	2.000 A	1.351 KL	69.90 YZ[
BD–3839	56.00 D–G	98.50 E–G	40.00 J–P	3.100 HI	52.10 h	2.000 A	1.001 Q	89.60 UV
BD–3840	54.50 G–J	98.50 E–G	33.80 _`a	3.202 GH	75.20]^	2.000 A	1.201 NO	65.35 \]
BD–3841	57.00 B–E	101.0 A–D	36.6 V–Z[\	3.802 CD	111.4 F	1.800 A–C	1.500 HI	123.6 KL
BD–3842	55.00 F–I	98.00 FG	38.70 N–U	3.600 E	59.30 g	2.000 A	1.103 P	89.20 UV
BD–3843	53.00 JK	97.50 G	39.50 L–R	2.700 LM	84.90 TU	2.000 A	1.250 MN	112.5 MN
BD–3844	55.00 F–I	98.00 FG	43.20 C–F	3.102 HI	96.10 L	1.900 AB	1.150 OP	110.9 N
BD–3845	56.50 C–F	98.50 E–G	31.70 b	2.802 KL	59.20 g	1.900 AB	1.152 OP	44.05 c
BD–3846	56.00 D–G	98.50 E–G	38.00 P–X	3.102 HI	117.7 E	2.000 A	1.351 KL	91.35 STU
BD–3848	55.00 F–I	98.50 E–G	35.40 Z[\]^_	2.553 M–O	65.35 e	1.600 C	1.301 LM	57.80 _`
BD–3849	54.50 G–J	98.00 FG	35.50 Z[\]^_	3.102 HI	92.20 NOP	2.000 A	1.301 LM	84.00 W
BD–3850	55.00 F–I	98.50 E–G	29.00 c	2.602 MN	66.50 de	2.000 A	1.350 KL	45.40 bc
BD–3851	55.50 E–H	98.50 E–G	36.30 W–Z[\]	2.602 MN	91.50 OP	1.900 AB	1.301 LM	91.90 S–U
BD–3852	56.00 D–G	99.50 C–G	35.20 [\]^_`	2.702 LM	86.30 ST	1.900 AB	1.301 LM	66.85 Z[\
BD–3853	55.00 F–I	100.0 B–F	35.45 Z[\]^_	2.500 NO	80.40 VW	2.000 A	1.351 KL	85.80 VW
BD–3854	54.00 H–K	99.50 C–G	37.70 Q–Y	2.900 JK	89.50 Q	2.000 A	1.500 HI	127.0 JK
BD–3855	53.50 I–K	97.50 G	41.50 F–L	2.400 OP	91.70 OP	2.000 A	1.501 HI	94.20 R–T
BD–3856	53.50 I–K	98.00 FG	32.20 ab	2.900 JK	88.20 QR	1.900 AB	1.351 KL	92.60 S–U
BD–3857	54.50 G–J	99.00 D–G	40.80 G–M	2.700 LM	67.60 d	1.900 AB	1.103 P	104.7 OP
BD–3858	55.00 F–I	99.00 D–G	39.50 L–R	2.900 JK	73.10 `a	2.000 A	1.351 KL	89.15 UV
BD–3859	55.00 F–I	99.50 C–G	36.60 V–Z[\	3.000 IJ	93.00 NO	1.900 AB	1.421 J	70.90 Y
BD–3860	55.50 E–H	99.00 D–G	40.90 G–M	2.600 MN	75.30]^	2.000 A	1.250 MN	111.6 N
BD–3861	55.00 F–I	100.0 B–F	46.80 A	3.300 FG	112.2 F	2.000 A	1.550 GH	156.4 C
BD–3863	55.00 F–I	100.5 A–E	44.40 B–D	3.400 F	105.0 G	2.000 A	1.300 LM	136.4 FG
BD–3864	56.00 D–G	101.5 A–C	43.20 C–F	3.000 IJ	77.90 YZ	1.900 AB	1.500 HI	145.2 D
BD–3866	54.50 G–J	101.5 A–C	45.00 A–C	2.700 LM	72.40 `a	1.900 AB	1.600 FG	146.9 D
BD–3867	54.50 G–J	101.0 A–D	39.10 M–T	2.300 P	66.00 de	2.000 A	1.200 NO	101.3 PQ
BD–3868	56.00 D–G	101.5 A–C	43.50 C–F	2.702 LM	101.6 I	2.000 A	1.550 GH	109.3 N
BD–3870	55.50 E–H	99.00 D–G	39.60 K–R	2.502 NO	103.5 H	1.900 AB	1.150 OP	132.8 GH
BD–3871	56.50 C–F	99.00 D–G	44.10 B–D	2.452 N–P	71.80 ab	1.900 AB	1.550 GH	102.9 P
BD–3872	55.50 E–H	99.50 C–G	41.80 E–J	2.600 MN	66.80 de	1.900 AB	1.250 MN	157.6 C
BD–3873	54.50 G–J	99.00 D–G	41.60 F–K	2.602 MN	91.60 OP	1.900 AB	1.600 FG	126.4 JK
BD–3874	54.50 G–J	100.0 B–F	39.70 K–Q	3.002 IJ	143.3 B	2.000 A	1.800 BC	126.6 JK
BD–3875	55.00 F–I	99.50 C–G	34.20 ^_`	2.900 JK	80.70 VW	1.750 BC	1.601 FG	90.60 TU
BD–3876	55.50 E–H	100.0 B–F	42.70 D–H	2.900 JK	91.00 P	1.900 AB	1.600 FG	115.5 M

BD–3877	55.50 E–H	100.0 B–F	38.40 O–V	2.500 NO	80.20 VW	1.800 A–C	1.450 IJ	140.0 EF
BD–3878	54.50 G–J	98.50 E–G	40.70 H–N	2.700 LM	87.20 RS	2.000 A	1.200 NO	116.2 M
BD–3879	54.50 G–J	99.50 C–G	43.80 B–E	3.202 GH	95.50 L	2.000 A	1.250 MN	127.3 JK
BD–3880	55.50 E–H	100.0 B–F	40.30 J–O	3.102 HI	77.70 YZ[	2.000 A	1.300 LM	110.8 N
BD–3881	56.00 D–G	100.0 B–F	46.50	3.002 IJ	97.60 K	1.700 BC	1.450 IJ	129.4 HIJ
BD–3882	57.50 A–D	102.0 AB	39.5 K-R	3.000 IJ	59.60 fg	2.000 A	1.200 NO	110.9 N
BD–3883	56.00 D–G	101.5 A–C	41.20 B–D	2.902 JK	130.1 D	2.000 A	1.150 OP	110.6 N
BARI masur–1	55.00 F–I	102.5 A	38.70 O-V	2.602 MN	81.00 V	1.600 C	1.200 NO	131.9 H
BARI masur–4	57.00 B–E	102.5 A	43.0 C-G	2.800 KL	93.70 MN	1.900 AB	1.650 EF	102.1 P
BARI masur–6	59.00 A	101.5 A–C	36.9 U–Z[\	2.500 NO	72.40 `a	2.000 A	1.801 BC	66.00 [\]
BARI masur–7	55.00 F–I	100.5 A–E	42.80 D-H	3.100 HI	65.60 e	1.900 AB	1.750 CD	124.3 K
$LSD_{(0.05)}$	**1.396**	**1.713**	**0.647**	**0.143**	**1.458**	**0.032**	**0.058**	**3.630**
CV (%)	**1.56**	**1.06**	**1.03**	**2.99**	**1.06**	**1.03**	**2.60**	**2.24**

Pods plant^{-1}: Pods plant^{-1} was significantly affected due to genotypes where BD–3818 and BD–3830 recorded the maximum pods (154.90 and 154.20 plant^{-1}, respectively) while the genotypes BD–3839 produced minimum pods (52.10 plant^{-1}) (Table 1). These results revealed that pods production varied significantly due to the genetic variation of the studied genotypes and climatic factors of the studied area. Similar variation was also found by Mondal *et al*., (2013) who reported that the LM–507 and LM–1018 produce more pods plant^{-1} which might be due to the variation in their genetic make up and also the variation agro–ecological zones of Bangladesh.

Seeds pod^{-1}: Seeds pod^{-1} showed significant variation due to genotypes where the maximum genotypes (BD–3804, BD–3807, BD–3808, BD–3810, BD–3811, BD–3815, BD–3818, BD–3819, BD–3820, BD–3821, BD–3822, BD–3823, BD–3828, BD–3829, BD–3830, BD–3831, BD–3836, BD–3837, BD–3838, BD–3839, BD–3840, BD–3842, BD–3843, BD–3846, BD–3849, BD–3850, BD–3853, BD–3854, BD–3855, BD–3858, BD–3860, BD–3861, BD–3863, BD–3867, BD–3868, BD–3874, BD–3878, BD–3879, BD–3880, BD–3882, BD–3883 and BARI masur–6) were produced similar maximum seeds pod^{-1} (2.0) while BD–3848 and BARI masur–1 showed minimum seeds pod^{-1} (1.60). Similar result was also obtained by Hojjat and Galstayan, (2011) who found that the seeds production had significantly influenced due to genotypic variation. Mondal *et al*., (2013) also found similar results.

Hundred seed weight: Hundred–seed weight was significantly affected by lentil genotypes where BD–3808 and BD–3818 produced the highest weight of 100–seed (both similar 1.90 g) followed by BD–3815 (1.85 pod^{-1}) while the lowest weight of 100–seed (0.80 pod^{-1}) was found from the genotype BD–3807 (Table 1). The above variation regarding 100–seed weight was found due to their genetic variation. The observation of Habibur Rahman *et al*., (2013) was statistically similar to the present study in case of they also found significant variation in 100–grain weight which was occurred due to various genetic potential of the varieties for this character.

Grain yield: Effect of genotype on grain yield had significant at 1% level where BD–3818 obtained the higher grain yield (173.70 g line^{-1} plot^{-1}) while BD–3829 noticed the lowest grain yield (43.85 g line^{-1} plot^{-1}) and it was statistically similar to BD–3845 (44.05 g line^{-1} plot^{-1}). The genotype BD–3818 produced highest grain yield which might be due to the maximu of pods plant^{-1} and seeds pod^{-1} were found under this variety (Table 1). Besides, the variation in grain yield was also found due to the genetic make up of the studied genotypes. Habibur Rahman *et al*., (2013) agreed the present findings incase of the yield was higher in those two mutants (LM–507 and LM–1018) due to production of higher pods plant^{-1} and bolder seeds. The difference was due to genetic variations among the cultivars for this parameter was also reported by Mondal *et al*., (2013) and many researchers.

Co–relation studies among the studied characters

Correlation coefficients between the studied traits are presented in Table 2. Among the correlation studied, it was found that the days to 50% flowering were found to be the negative correlation co–efficient among the whole studied characters except days to maturity and 100-seed weight which indicated that the 50% flowering positively correlated with plant maturity (0.048) and 100-seed weight (0.0). Similarly, days to maturity negatively correlated with days to 50% flowering (–0.120) and number of seeds pod^{-1} (–0.121) while rest traits were positively correlated with plant maturity while days to maturity showed highest and significant correlation with 100–seed weight (0.255*) followed by grain yield (0.229*). Plant height showed the positive correlation among the whole traits except days to 50% flowering whereas plant height showed highest and positive correlation with grain yield (0.580**). Correlation observation also showed that branches plant^{-1} negatively correlated with days to 50% flowering, number of pods plant^{-1} and 100-seed weight while rest of the traits were positively correlated whereas branches plant^{-1} had higher positive correlation (0.133) with seeds pod^{-1}. Among the other correlation studied, pods plant^{-1} negatively correlated with days to 50% flowering and branches plant^{-1}, and positively correlated with days to maturity (0.152), plant height (0.248*), number of seeds pod^{-1} (0.209), 100-seed weight (0.246*) and grain yield (r= 0.236*). Seeds pod^{-1} also showed positive correlation co–efficient with plant height, branches plant^{-1} and pods plant^{-1} while days to 50% flowering, plant maturity, 100-seed weight and grain showed negative correlation co–efficient. Likewise, 100–seed weight were positive with days to maturity, plant height, pods plant^{-1}and grain yield while 100–seed weight had negative correlation co–efficient with branches plant^{-1}. Among them, 100–seed weight had significant and positive correlation with days to maturity (0.255*) and number of pods plant^{-1} (0.246*). Most of the studied characters were positively correlated with grain yield except days to mortality, 50% flowering and seeds pod^{-1} whereas grain yield showed the highest positive significant correlation co–efficient with in sequence plant height (0.580**), pods plant^{-1} (0.236*), plant maturity (0.229*), 100-seed weight (0.102) and branches plant (0.003) while it was significantly the higher negative relation with days to 50% flowering (–0.383**) and total mortality (r= –0.249*). From the above correlation study it could be found that the grain yield showed highest positive and significant correlation co–efficient with plant height (0.580**) followed by seeds pod^{-1} (0.236*) and days to maturity (0.229*) and negative and significant correlation with days to 50% flowering (–0.383**). These results revealed that significant increase of plant height, seeds pod^{-1} and days to maturity or significant decrease of 50% flowering significantly increase the grain yield. The findings of Abo–Hegazy *et al*., (2012) was similar with the present study who reported that the highly significant positive correlations were detected between seed yield plant^{-1} and each of seeds plant^{-1} (0.971**). However, highly significant negative correlations were observed between grain yield and days to 50% flowering (–0.383**) which was also similar to the findings of Hamdi *et al* (2003) showed that seed yield was negatively correlated with flowering duration.

Path analysis among the studied characters

Path coefficient analysis was used to partition the correlations between studied parameters into direct and indirect effects as shown in Table 3. The results indicated that, pods plant^{-1} (0.658), seeds pod^{-1} (0.0481), 100–seed weight (0.0081) and plant height (0.0076) had direct positive effect on grain yield, indicating these are the main contributors to yield. Gupta *et al*., (2012) reported that path analysis revealed that pods plant^{-1} and 100–seed weight had positive direct effects on yield plant^{-1}. However, days to 50% flowering, days to maturity and branches plant^{-1} had direct negative effect on grain yield. Similarly, the highest positive indirect effects on grain yield was obtained by pods plant^{-1} (0.0251) followed by plant height (0.0229) while lowest direct effects was found by 100-seed weight (0.0000008) followed by days to 50% flowering (0.00002).

Table 2. Correlation studied among the different morpho–physiological and yield contributing characters as influenced by 76 genotypes

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100–seed weight (g)	Grain yield (g line^{-1} plot^{-1})
Days to 50% flowering	1	0.048	–0.120	**–0.105**	**–0.132**	**–0.074**	0.000	**–0.383****
Days to maturity		1	0.219	0.123	0.152	**–0.121**	0.255*	0.229*
Plant height (cm)			1	0.060	0.248*	0.016	0.063	0.580**
Number of branches plant^{-1}				1	–0.004	0.133	**–0.055**	0.003
Number of pods plant^{-1}					1	0.209	0.246*	0.236*
Number of seeds pod^{-1}						1	–0.045	**–0.071**
100–seed weight (g)							1	0.102
Grain yield (g line^{-1} plot^{-1})								1

* = Significant at 1% level of probability (range 0.228-0.296); ** = Significant at 5% level of probability (range 0.297-up)

Table 3. Partitioning of correlations into direct and indirect effects of the studied morpho–physiological and yield contributing characters as influenced by 76 genotypes by path analysis

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	100–seed weight (g)	Grain yield (g line^{-1} plot^{-1})
Days to 50% flowering	**<u>–0.1904</u>**	–0.0091	0.0229	0.0199	0.0251	0.0141	–0.00002	0.0729
Days to maturity	0.0030	**<u>–0.0633–</u>**	–0.0139	–0.0078	–0.0096	0.0076	–0.0162	–0.0145
Plant height (cm)	–0.0009	0.0017	**<u>0.0076</u>**	0.0005	0.0019	0.0001	0.0005	0.0044
Number of branches plant^{-1}	0.0013	–0.0016	–0.0008	**<u>–0.0127</u>**	0.00005	–0.0017	0.0007	–0.00004
Number of pods plant^{-1}	–0.0087	0.0100	0.0163	–0.0003	**<u>0.0658</u>**	0.0138	0.0162	0.0155
Number of seeds pod^{-1}	–0.0036	–0.0058	0.0008	0.0064	0.0101	**<u>0.0481</u>**	–0.0022	–0.0034
100–seed weight (g)	0.0000008	0.0021	0.0005	–0.0004	0.0020	–0.0004	**<u>0.0081</u>**	0.0008

Bold and underline figures indicate the direct effect; Residual effect = 0.2839

Again, the highest negative indirect effect on grain yield was recorded by 100–seed weight (–0.0162) followed by plant height (–0.0139). The direct effect of 100–seed weight on yield was highest negative (–0.0162) but it showed third highest indirect positive effect. Residual effect of the studied traits under path analysis was 0.2839. The above information revealed that highly positive correlation with highest positive direct effect was observed in pods plant^{-1}. So, the pods plant^{-1} could be considered as critical criteria for improvement of grain yield of the selected genotypes of the present study. Similar results had also been reported by Gupta *et al*., (2012).

In view of the above summary, it could be summarized that the different genotypes evaluate the morphological, physiological and yield characters changes in lentil under southern belt of Bangladesh whereas the genotype BD–3818 showed understanding superiority on the maximum characters of the present study the genotype BD–3818 hd higher capacity to obtain the greater performance on the production of pods plant^{-1}, seeds pod^{-1}, 100–grain weight which might be make sure the greater yield of lentil. So, the genotype BD–3818 would be suitable lentil genotype for maximizing the yield under southern belt of Bangladesh.

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