



Characterization of morphological and yield variation of fenugreek (*Trigonella foenum-graecum* L.) genotypes

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ABSTRACT

Trigonella foenum-graecum L. has an important place among cultivated plants in our country as well as in the world. This study was carried out to determine the morphological and yield properties of 118 fenugreek genotypes which obtained from United States Department of Agriculture and local cultivars. Among the genotypes and controls, plant height (24.95-85.15 cm), first pod height (17.00-35.78 cm), pod weight (0.63-63.05 g per plant⁻¹), number of seed per pod (3.56-14.30), pod length (7.01-36.10 cm), 1000 seed weight (0.49-56.31 g) and seed yield per plant (0.21-27.44 g) were determined. As a result of study, the highest seed yield and 1000 seed weight were seen in PI 296394 genotype. Dendrogram analysis grouped the set of fenugreek genotypes into two main groups and many of fenugreek genotypes in same origin were found in different groups.

Key words: Dendrogram, Fenugreek, Morphological, Yield properties.

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is an annual crop and member of the family Fabaceae the order Leguminosae. *Trigonella* genus includes nearly 100 species and out of which 50 species grow naturally in Turkey. The important fenugreek producing countries are India, Morocco, Egypt, Ethiopia and Turkey in the world (Parthasarathy *et al.* 2008). In 2017 year, fenugreek was sown in 144990 ha, produced 1521 tonnes, and recorded 1050 kg ha⁻¹ seed yield in Turkey (Anonymous, 2018a).

Fenugreek leaves and seeds have been used extensively to prepare extracts and powders for medicinal uses (Basch *et al.*, 2003). This plant is primarily used as a spice in India and countries of the Mediterranean regions. Seeds of *Trigonella foenum-graecum* L contain tannic acid, fixed and vegetable oils, diosgenin, trigonelline, trigocoumarin, trigomethyl coumarin, steroidal saponin such as gitogenin and traces of trigogenin and vitamin A (Jayaweera, 1981). Some of the therapeutic uses of *Trigonella foenum-graecum* L include its use as anti ulcer, wound healing, immunomodulatory, antioxidant, antidiabetic, anticancer (Srinivasan, 2006).

This study was carried out with the aims of determining yield and some morphological characteristics of 118 diverse genotypes of fenugreek and 2 controls (Çiftçi and Güraslan cultivars) in field experiment.

MATERIALS AND METHODS

Site description: The study was conducted in the experimental field of the Department of Field Crops, Faculty

of Agriculture and Natural Sciences, Bolu Abant İzzet Baysal University, Bolu, Turkey, (40° 44' 44'' N, 31° 37' 45'' E) and an altitude of 881 meters in 2017. Average climatic data were recorded 16.08 °C temperature; 41.37 mm rainfall; 69.2% humidity during the vegetation period for 2017 (Anonymous, 2018b). Soil properties of experimental fields were as follows: rich in phosphorus (10.3 ppm), potassium (235 ppm) and organic matter (4.7%), clay-loam and slightly alkaline (pH=7.8) (Anonymous, 2015).

Plant material and experimental design: 118 fenugreek genotypes, which obtained from United States Department of Agriculture (USDA) with 2 controls (Çiftçi and Güraslan cultivars) were considered in this study. All the selected genotypes seeds were sown on April 19th 2017 and were planted on 30 cm at plant to plant and row to row distance of 10 cm according to augmented trial design with 2.20 m long and 0.3 m inter-plant spacing.

As the base fertilizer, DAP (diamonium phosphate) was added at the rate of 60 kg ha⁻¹, and total 40 kg ha⁻¹ AN (ammonium nitrate) fertilizer application was the applied to the plots as top fertilizer during soil preparation in two splits in April (with sowing) and of May (before flowering). Fenugreek genotypes were regularly irrigated to demonstrate good progress in its period vegetation at regular interval of 3 to 6 days. Before the harvest, the morphological and yield properties, seedling, 50% flowering, plant height were measured. These genotypes were harvested at physiological maturity from middle of July to early August. The first harvest was made in PI 250235 genotype, the last harvest was made

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in PI 613632 genotype. The seeds were separated by hand threshing.

Statistical analysis: Results were subjected to analysis of variance and Least Significant Difference Test (LSD) in order to find differences among the genotypes and controls. XLSTAT statistic software was used to determine statistical significance levels at 0.05 level.

RESULTS AND DISCUSSION

Growth: Under Bolu conditions, these genotypes attained 50% seedling between 7.09 and 29.09 days after sowing, while plants from controls (Güraslan and Çiftçi) began seedling in 12.82-13.36 days, respectively. PI 661005 (8.09 days) and PI 296394 (8.59) were the fastest seedling genotypes. The slowest ones were PI 237564 and PI 613632. These genotypes attained 50% flowering ranged from 40.41-57.91 days, while plants from controls began flowering in 53.57-55.55 days. The earliest flowering time was recorded in PI 572538 genotype whereas, the latest flowering time was recorded in PI 250235 genotype. First flowering time

was positively correlated with first pod setting time (70.82 day) in PI 250235 which was followed by PI 141728 with 63.32 days.

Based on the data obtained from the field trial, there were significant differences in average plant height of genotypes and controls. PI 170834 genotype had the highest plant height and it was respectively followed by PI 661005 and PI 661011. The examined fenugreek genotypes and controls had significant mean plant height (24.95-85.15 cm). The different fenugreek genotypes have been studied by many researchers to determine the plant height under different ecological conditions 68.57-91.33 cm (Gürbüz *et al.*, 2000), 19.22-64.66 cm (Panwar *et al.*, 2018), 32.42-46.58 cm (Senkal *et al.*, 2018). The results of the present study with respect to the plant height were in agreement with the above-mentioned findings of researchers.

Yield and yield attributes: Number of seeds per pod are usually more controlled by natural factor which is due to the number of ovules being constant, it could be concluded that

Table 1: Observed range of different morphometric parameters of fenugreek genotypes and controls.

Country	Accessions	50% SD (days)	DFT (days)	FPS (days)	FPH (cm)	PH (cm)	PL (cm)	NSP (no pod ⁻¹)	PW (g plant ⁻¹)	1000 SW	SY (g plant ⁻¹)
Iran	PI 141728	9.09	55.41	63.32	29.03	55.45	11.31	9.43	19.67	7.49	4.03
Iran	PI 143505	13.09	49.91	58.82	29.31	64.82	11.23	11.59	35.72	11.65	7.55
India	PI 164507	10.09	44.41	61.32	12.48	43.7	8.24	3.08	8.95	6.89	0.94
Turkey	PI 167246	18.59	49.41	57.82	37.75	76.00	30.5	8.36	7.63	10.87	5.55
Turkey	PI 170834	14.59	50.41	56.82	26.88	85.15	12.65	10.92	4.22	5.38	2.86
Turkey	PI 173136	13.09	46.41	60.32	14.08	77.45	10.85	9.94	7.25	1.53	0.99
Turkey	PI 173820	13.09	47.41	56.82	27.68	58.15	21.48	8.27	10.83	4.83	2.39
Turkey	PI 175933	17.09	48.41	62.32	28.18	56.05	16.66	10.49	5.64	8.89	4.03
Turkey	PI 179057	15.09	48.41	56.32	28.28	77.45	13.28	11.98	24.9	7.87	5.43
Turkey	PI 182308	13.09	56.41	51.32	19.99	71.55	16.27	8.89	7.05	21.05	10.86
Ethiopia	PI 194020	17.09	46.41	56.32	22.18	57.15	12.54	8.42	32.61	19.60	8.14
Ethiopia	PI 197471	14.09	51.91	57.82	18.12	40.84	14.66	13.75	13.35	10.79	9.84
Greece	PI 199264	12.09	49.91	59.82	21.2	55.39	13.7	9.40	52.61	12.60	8.55
Turkey	PI 204527	9.09	48.91	59.82	23.8	58.39	15.74	9.70	25.29	24.40	15.51
Nepal	PI 208465	16.09	49.41	62.32	22.83	47.45	10.6	8.08	27.72	34.88	17.00
Afghanistan	PI 212124	16.09	50.91	58.82	20.20	43.49	11.93	11.6	16.25	8.42	7.13
India	PI 214351	18.59	51.41	58.82	26.65	48.8	8.80	9.81	10.44	11.13	6.41
India	PI 215615	17.09	50.91	57.32	26.24	38.04	12.7	10.16	9.58	0.49	0.79
Ethiopia	PI 226572	15.09	47.41	58.82	22.08	50.95	13.5	9.32	13.20	14.98	8.00
Australia	PI 229793	15.09	52.41	52.32	23.59	45.55	13.59	8.68	2.06	6.44	3.58
Italy	PI 237564	29.09	42.91	58.32	29.78	42.5	8.06	4.79	1.11	1.10	0.90
Spain	PI 244291	11.09	53.41	56.32	22.59	40.9	13.56	7.58	24.61	5.86	3.20
Pakistan	PI 250235	12.09	57.91	70.82	23.65	41.28	10.33	8.79	15.17	5.52	3.10
Egypt	PI 250627	15.09	45.41	56.32	20.33	57.35	12.75	10.17	18.74	9.27	4.99
Ethiopia	PI 251640	12.59	52.41	59.82	19.28	55.15	11.17	4.47	13.43	46.01	12.25
Afghanistan	PI 253996	14.09	54.91	59.82	22.71	62.22	11.61	10.73	2.80	3.55	1.92
Ethiopia	PI 257604	16.09	49.91	54.82	21.98	54.09	14.6	12.89	60.17	35.10	24.44
Afghanistan	PI 268434	11.09	51.91	60.82	17.00	43.79	8.48	11.75	14.38	14.62	11.75
Pakistan	PI 269992	14.59	54.41	57.82	26.88	64.15	9.92	7.99	28.61	6.90	2.82
Pakistan	PI 269994	15.59	57.41	57.82	21.82	61.00	9.67	10.94	29.5	14.03	8.68
Pakistan	PI 269995	21.09	54.41	60.82	19.98	42.35	7.96	13.87	19.33	6.37	5.14
Pakistan	PI 269996	14.09	50.91	57.32	22.58	24.95	11.68	8.86	31.05	2.47	1.58
Nepal	PI 286436	18.09	45.41	55.32	18.99	40.09	8.22	6.22	13.94	1.60	0.92

Table 1 Continue.....

Table 1 Countinue.....

India	PI 286533	16.09	53.91	58.82	17.31	49.02	9.70	9.79	2.46	4.40	2.24
Iran	PI 296394	8.59	50.41	59.82	32.48	63.15	11.45	8.12	3.83	56.31	27.44
India	PI 302448	17.09	51.41	54.32	18.68	53.65	9.19	5.24	40.72	53.26	14.86
India	PI 302449	17.09	54.41	59.82	22.11	45.42	9.12	11.17	0.63	0.82	0.64
Morocco	PI 338679	18.09	54.91	59.82	17.71	44.42	11.15	9.74	63.05	9.96	5.52
Egypt	PI 343170	15.09	45.41	57.32	20.58	60.05	11.29	11.69	22.53	15.19	10.27
Iran	PI 381061	15.09	51.91	60.32	34.98	50.8	12.71	14.01	24.99	3.16	6.05
Iran	PI 381062	16.09	46.41	54.32	27.93	47.55	12.81	7.62	29.8	10.31	3.65
Turkey	PI 383791	12.09	53.41	60.82	20.48	43.15	9.50	5.75	16.88	12.60	4.50
Bulgaria	PI 426970	15.09	44.41	49.32	19.89	55.05	12.91	13.63	10.61	9.97	6.95
Pakistan	PI 426971	13.09	46.41	49.32	14.59	48.35	12.68	11.08	21.05	14.77	8.89
Pakistan	PI 426972	17.09	51.91	51.32	26.18	49.5	13.24	10.26	56.28	2.15	2.45
Pakistan	PI 426973	15.09	42.91	59.32	33.58	75.5	13.52	5.23	40.17	22.67	5.33
Egypt	PI 479776	10.09	44.41	53.82	17.2	60.59	12.49	9.60	21.94	48.97	25.13
Pakistan	PI 532860	18.59	43.91	50.82	21.15	65.8	9.88	5.89	3.28	6.05	2.76
Pakistan	PI 532861	16.09	46.41	53.82	25.66	37.08	7.40	6.72	6.65	1.31	0.21
Pakistan	PI 532862	15.09	45.41	54.32	18.93	50.15	12.62	13.43	17.86	10.25	7.09
Pakistan	PI 532863	12.09	45.41	49.32	22.58	32.45	11.24	8.16	16.83	0.69	0.48
Pakistan	PI 532865	15.09	51.91	59.32	17.09	38.4	11.08	8.13	10.78	5.86	3.17
Pakistan	PI 532866	11.09	45.41	50.32	20.88	50.35	10.37	8.69	8.74	16.10	6.44
India	PI 532867	16.59	46.41	54.32	22.68	60.55	10.29	8.22	23.28	13.79	6.03
Pakistan	PI 543072	21.09	41.41	55.82	20.78	48.95	9.87	9.77	8.37	8.43	4.71
Turkey	PI 557489	18.59	44.41	57.82	26.98	69.25	15.34	12.17	8.58	10.16	6.45
Turkey	PI 568214	12.59	44.41	55.82	26.48	68.35	11.57	10.17	14.17	4.89	2.28
Turkey	PI 568215	15.09	49.91	52.32	35.78	60.3	14.33	9.36	3.00	0.90	0.80
Egypt	PI 572538	19.09	40.91	58.32	28.58	62.1	12.07	7.51	14.83	3.77	1.33
Egypt	PI 572539	14.59	44.41	54.82	22.65	39.14	10.16	3.56	8.36	12.04	3.60
Syria	PI 572540	13.09	44.91	53.82	22.81	57.32	13.37	10.79	23.05	11.88	6.62
Morocco	PI 577711	12.09	48.41	54.32	21.24	43.95	13.51	10.74	40.08	16.20	7.95
Spain	PI 577713	12.09	50.41	61.32	20.78	47.45	12.99	7.94	27.77	2.47	1.17
Morocco	PI 613629	19.09	46.41	57.82	20.98	47.95	12.8	8.72	8.02	11.72	5.83
Australia	PI 613632	20.59	42.41	52.82	20.15	45.3	36.10	6.91	28.46	5.87	2.83
Australia	PI 613633	11.09	44.41	49.32	17.68	45.4	16.29	10.08	15.05	10.81	6.11
Morocco	PI 617075	18.59	47.41	54.82	32.15	49.8	11.77	3.21	43.72	13.15	3.63
Iran	PI 617076	17.09	43.41	49.32	23.59	55.55	13.14	13.38	20.61	20.15	14.21
Pakistan	PI 617078	15.09	51.41	50.32	16.99	52.15	13.19	12.58	25.94	19.04	12.93
Bulgaria	PI 617079	13.09	45.41	57.82	26.08	59.95	7.01	7.47	12.18	22.08	9.33
Nepal	PI 628787	14.09	46.91	51.82	19.81	52.77	10.66	11.89	24.19	13.15	7.79
India	PI 628788	12.09	45.41	55.32	19.13	52.55	12.63	10.57	20.39	24.22	13.81
Jordan	PI 628790	15.59	40.41	52.82	22.08	58.95	13.61	10.12	48.74	16.27	8.40
Armenia	PI 639185	13.09	47.91	54.82	32.20	62.19	14.05	14.30	41.70	13.55	11.86
Bulgaria	PI 660994	10.09	44.41	57.32	20.23	44.85	12.99	7.08	24.11	12.70	4.60
Armenia	PI 660995	10.09	46.91	57.82	34.80	64.29	12.75	13.00	24.05	8.67	7.84
Palestinian Territory	PI 661005	8.09	46.91	57.82	32.00	82.19	14.42	8.05	10.61	15.20	8.61
Palestinian Territory	PI 661006	12.09	47.91	55.82	23.51	60.42	13.48	10.49	8.90	10.43	5.81
Palestinian Territory	PI 661007	16.09	42.41	57.32	22.18	57.55	10.45	8.78	12.22	1.42	0.24
Pakistan	PI 661008	14.09	44.91	50.82	21.03	57.56	13.91	10.49	20.56	16.43	8.54
Palestinian Territory	PI 661009	15.09	45.41	56.32	32.08	77.05	13.75	8.29	12.75	12.88	5.94
Palestinian Territory	PI 661010	13.09	43.41	51.32	18.58	47.79	13.66	9.19	11.29	21.98	9.25
Palestinian Territory	PI 661011	11.09	46.41	56.32	24.68	77.85	12.15	6.34	30.24	11.84	4.06
Palestinian Territory	PI 661012	7.09	41.41	54.32	19.83	50.45	13.32	4.72	16.91	19.45	4.34
Palestinian Territory	PI 661013	9.09	41.41	57.32	17.06	44.62	14.35	6.53	13.33	5.93	1.66
Pakistan	PI 661014	12.09	45.91	50.82	20.91	52.22	13.32	11.69	40.11	11.26	6.40
Turkey	Çiftçi	13.36	53.27	60.73	29.36	67.34	10.12	9.88	17.06	13.19	9.44
Turkey	Güraslan	12.82	55.55	63.91	24.00	50.97	14.86	7.98	17.94	7.47	4.10
	Average	14.48	48.20	56.52	23.39	54.29	12.63	10.38	19.86	12.62	6.51
	LSD (5%)	31.87	6.18	6.51	11.81	13.98	1.63	4.71	27.17	12.64	7.25

*50% Seedling Day:SD, Days to Flowering Time:DFT, First Pod Setting:FPS, First Pod Height: FPH, Plant Height:PH, Pod Length:PL, Number of seed per pod: NSP, Pod Weight:PW, Seed Yield:SY, 1000 Seed Weight: SW.

pod length was influenced by genetic factors and was less affected by environmental conditions (Zandi *et al.*, 2011). There were significant differences in average number of seeds per pod of genotypes and controls (Table 1). The maximum seed number per pod (14.01 number) was recorded for the genotype PI 381061 and the minimum (3.08 number) for the genotype PI 164507. 32 genotypes were found higher and 21 genotypes were found lower than two control genotypes.

These results of the present study were in agreement with those of the study by Senkal *et al.* (2018), who reported that the number of seeds per pod ranged between 5.27-9.75. Similarly, Gurjar *et al.* (2016) found that number of seeds per pod ranged between 11.23-16.20 in 30 fenugreek genotypes in India conditions.

There was a significant difference among genotypes for pod length. PI 613632 recorded the highest pod length of 36.1 cm which was followed by PI 167246 (30.5 cm). Whereas, PI 617079 recorded the minimum pod length of 7.01 cm, which was on par with PI 532861 (7.4 cm), PI 269995 (7.96). It could be seen that 6 fenugreek genotypes were found higher and 16 genotypes were seen lower than control genotypes.

Gudjar *et al.*, (2016) reported that pod length ranged between 9.82-12.19 cm in 30 genotypes and 10.1-11.3 cm in 3 genotypes in Indian ecological conditions (Meena *et al.*, 2016). The observed differences in the pod length across countries may be a result of different environmental and genetic factors, different chemotypes.

The data relevant to the pod weight are presented in Table 1. Significant difference and wide variation were found among the genotypes with respect to pod weight. The highest pod weight was noticed in PI 338679 genotype (63.05 g plant⁻¹) followed by PI 257604 (60.17 g plant⁻¹), whereas, the least pod weight was recorded in PI

237564 genotype (1.11 g plant⁻¹). While the 39 genotypes were found higher, 44 genotypes were seen lower than control genotypes.

The 1000 seed weight in fenugreek genotypes were found between 0.49-56.31 g (Table 1). Among genotypes, PI 296394 and PI 302448 genotypes were the most highest with 56.31 and 53.26 g, respectively. 27 genotypes were found higher and 24 genotypes were seen lower compared to with control.

The different fenugreek genotypes have been studied by many researchers to determine the 1000 seed weight under different ecological conditions 11.10-19.10 g (Gurjar *et al.*, 2016), 1.3-1.7 g (Raje *et al.*, 2003), 12.07-13.76 g (Sing *et al.*, 2007). Our results had shown differences reported by reserchers. These differences could be due to different genotype, ecological and growing conditions.

Seed yield showed wide variation among the fenugreek genotypes in Table 1. Seed yield values changed between 0.21-27.44 g per plant. The maximum seed yield was found in PI 296394 genotype with 27.44 g plant⁻¹ and followed by PI 479766 (25.13 g plant⁻¹). Compared with the controls, 15 genotypes were seen higher and 33 genotypes were found lower.

It was reported that seed yield of fenugreek changed between 9.77-17.03 g (Gurjar *et al.*, 2016), 8.0-17.55 g (Panvar *et al.*, 2018), 6.80-9.90 g (Raje *et al.*, 2003).

Obtained results showed that there were some differences reported by researchers. These differences could be explained because of the genotype difference, environmental and growing conditions.

The dendrogram conducted to determine the genetic differences and show relationships among the 86 fenugreek genotypes and 2 controls depending on species diversity including morphological and yield properties (Fig 1). The

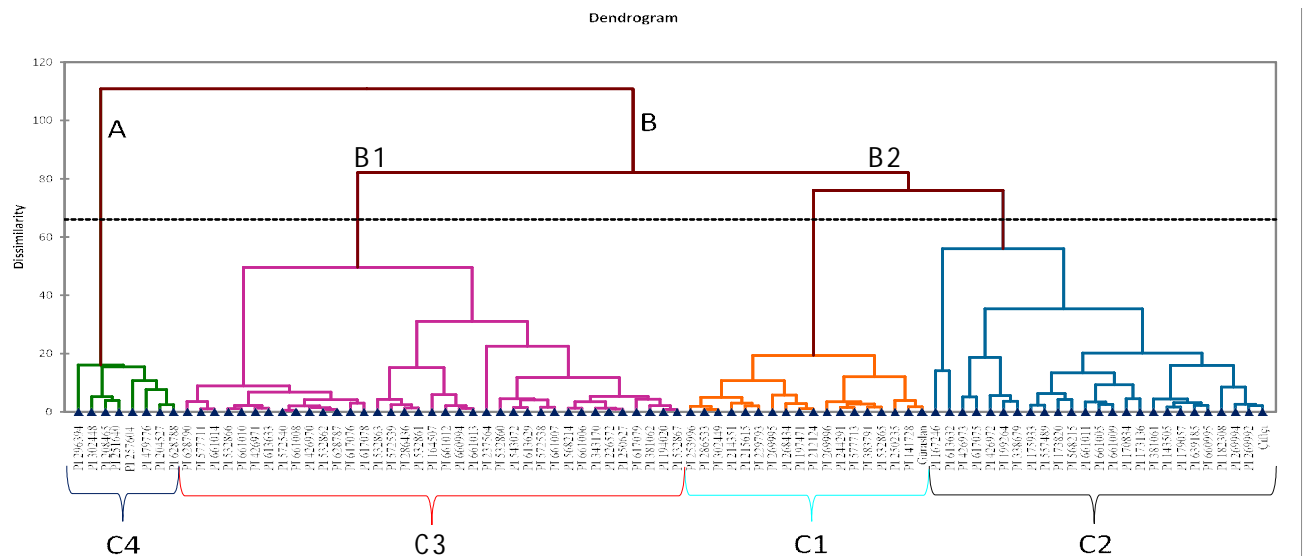


Fig 1: Dendrogram of 86 fenugreek genotypes and 2 controls reflecting 2 main groups.

genotypes and controls were divided into two major groups (A and B) and B group contained 2 subgroups (B1 and B2). Group A had only 1 cluster and it consisted of 8 genotypes. Group B included 78 fenugreek genotypes and 2 controls and it at dissimilarity 80 was further divided into two group (B1 and B2) with 3 cluster (C1, C2 and C3). The first sub-group contained 37 genotypes and the second sub-group contained 41 fenugreek genotypes and 2 controls. Güraslan genotype was close to PI 141728 genotype in terms of DFT, FPS, 1000 SW and SY values. Çiftçi genotype was close to PI 269992 and PI 269994 genotypes in group B2 in C2.

Generally, same origin of fenugreek genotypes did not take place in the same group according to their place of origin. Geographically close genotype can be genetically highly distant whereas geographically distant genotype can, in cases, more genetically similar. Reasons for the mixing of different genotypes from different countries background under same clusters might be due to better adaptation to local agro-climatic conditions.

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CONCLUSION

We have observed considerable variability among fenugreek genotypes. From this investigation, the fenugreek genotypes were highly variable for several traits, including phenology and yield components indicating the possibilities for genetic improvement of the crop through selection breeding. This study demonstrated that 86 of these fenugreek genotypes can be successfully grown as a culinary spice under Bolu conditions, but only 36 genotypes produced good ground phenology and yield properties compared to rest of genotypes. Among the imported genotypes, especially PI 338679 and PI 639185 genotypes were best adapted to Bolu conditions. The varying characters of the superior genotypes have implications for further work. As a breeding strategy, recurrent or family selection will be employed for the improvement of the traits that had low heritability and genetic advance.

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