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Original article

Evaluation of the possibility of autumn sowing of *Plantago major* ecotypes in Mashhad climate

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Extended abstract

Introduction

Autumn sowing leads to production improvement and yield stability of *Plantago major* due to the longer growing season, avoid late summer heat stress, and effective use of rainfall. However, in order to succeed in autumn sowing, cold tolerance is essential. It is crucial to carry out plant selection to evaluate and identify top traits for adaptation to environmental factors and ultimately higher production of valuable plants such as broadleaf plantain. Therefore, evaluation of the characteristics of important plants such as broadleaf plantain plays a fundamental role in the selection of top ecotypes for different purposes of selection and increase of yield in different climatic conditions of each region.

Materials and methods

This experiment was conducted as split-plot based on randomized complete block design with three replications at Research Farm of Agriculture Faculty of Ferdowsi University of Mashhad (36°15' N, 56°28' E, 985 m altitude) during the growing season 2013-14. The experimental factors included six ecotypes of *Plantago major* (Bojnord, Kalat, Mashhad, Ghaen, Torbat Heydarieh, and Birjand) and four sowing dates (late September, late October, late March, and late April). Irrigation was done immediately after planting and during the growing season according to the need of the farm by furrow method. Survival percentage, spike length, peduncle length, number of capsules, seed in capsule, 1000 grain weight, grain yield, biomass, and harvest index were evaluated. Data analysis was performed in SAS v9.4, and the means were compared by Duncan test at a 95% confidence interval.

Results and discussion

The results showed that delay in autumn sowing from September to October reduced the survival percentage in all ecotypes. While, the delay in spring sowing from March to April improved the survival percentage in Birjand, Ghaen, Mashhad and Kalat ecotypes by 12, 8.9, 7.3 and 5%, respectively. The highest percentage of survival in April sowing belonged to Mashhad, Birjand, Ghaen, and Kalat ecotypes and in March sowing belonged to Bojnord ecotype. The highest grain yield (796.9 g m^{-2}) was observed in Ghaen ecotype and the lowest was obtained in Torbat Heydariyeh, Mashhad, and Kalat ecotypes. So that grain yield in Ghaen ecotype was 48, 46, and 59% higher than the mentioned ecotypes, respectively. The highest biomass was observed in September sowing in Bojnord ecotype (2768 g m^{-2}) and the lowest was obtained in April sowing in Kalat ecotype (622 g m^{-2}). Ghaen ecotype had the highest harvest index in all sowing dates. Autumn planting of Plantago major L. leads to reduce in survival percentage compared with the survival percentage of spring planting. Lack of significant difference in grain yield of

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Plantago major ecotypes in autumn and spring sowing dates indicates the high flexibility of this plant to the date of sowing.

Conclusions

Despite the effectiveness of other factors in the improvement of a plant's growth, it could be predicted that the *Plantago major* L. ecotypes that have the ability for establishment in cold conditions are more likely to be in a better position than other ecotypes at other stages of development. Due to the occurrence of heat and drought stresses during the spring growing season and production of suitable biomass for most ecotypes in autumn sowing, the continuation of field and controlled experiments is necessary to evaluate the success of autumn sowing of this plant seems necessary.

***Keywords*:** Ecotype, Medicinal plant, Sowing date, Survival percentage, Yield

Table 1. Longitude, latitude and altitude of the collected areas of Plantago major ecotypes (earth.google.com)

Ecotype	Latitude	Longitude	Altitude (m)
Birjand	32° 52′	59°12′	1491
Gheyen	33°43′	59°10′	1432
Torbat heydariyeh	35°16′	59°13′	1451
Mashhad	35°16′	59°38′	999
Kalat	36°77′	60°21′	850
Bojnord	37°28′	57°16′	1120

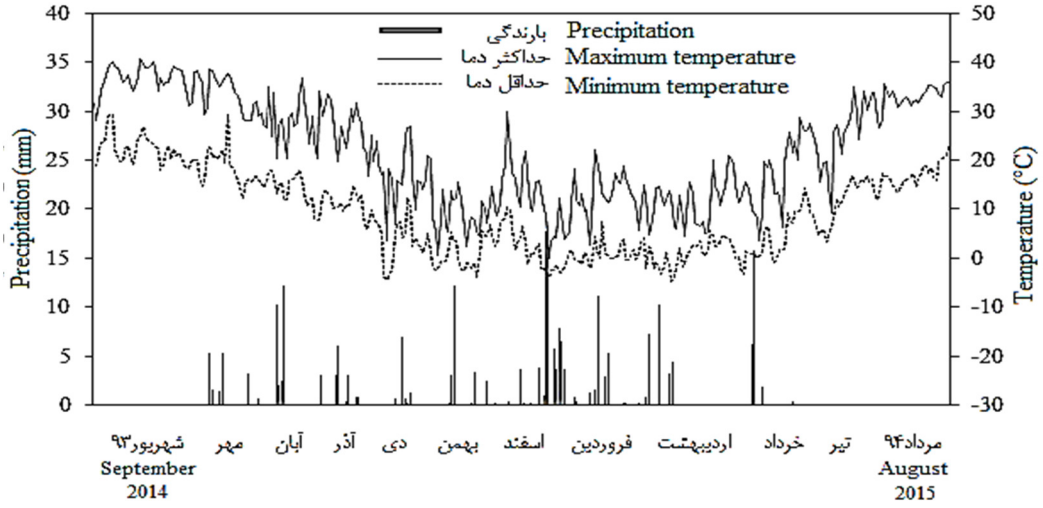

Fig. 1. Daily minimum and maximum temperature and precipitation of Mashhad during *Plantago major* L. growing season in 2014-2015.

Table 2. Weather conditions of Mashhad during the growing season of 2014-2015

Months	Freezing nights*	Absolute monthly minimum temperature	Monthly precipitation	Total temperatures below 0˚C
		˚C	*mm*	
Aug-Sep	-	11.9	-	-
Sep-Oct	-	3.2	16.7	-
Oct-Nov	4	-3.3	30.6	7.1
Nov-Dec	12	-4.9	21.8	27.9
Des-Jan	12	-2.3	20.9	10.2
Jan-Feb	10	-4	38.7	25.2
Feb-Mar	14	-4	41.6	23.3
Mar-Apr	4	-4.5	26.1	14.1
Apr-May	-	7.6	23.8	-
May-Jun	-	12.2	0.3	-
Jun-Jul	-	18	-	-
Total	56		220.5	

*The number of nights with temperature less than 0˚C

Table 3. Sources of variation, degree of freedom and mean squares of the planting date and ecotype on yield and yield components of Plantago major L. during growing season in 2014-2015.

S.O.V	df	Survival%	Spike length	Peduncle length	Number of capsules	Seed in capsule	1000 grain weight	Grain yield	Biomass	Harvest index
Block	2	18.3^{ns}	37.1^{**}	0.23^{ns}	299^{ns}	4.31^{**}	5443^{*}	9571^{**}	9692^{**}	31.0^{**}
Planting date(D)	3	408^{**}	1.38^{ns}	316^{**}	440^{ns}	0.01^{ns}	3864^{*}	400^{ns}	889453^{**}	395^{**}
Error a	6	17.6	1.38	0.31	142	0.07	606	225	424	1.35
Ecotype (E)	5	31.5^{**}	4363^{**}	88.1^{**}	20965^{**}	91.9^{**}	57286^{**}	473018^{**}	359190^{**}	1553^{**}
D × E	15	19.1^{**}	1.81^{ns}	15.7^{**}	512^{ns}	0.06^{ns}	1771^{ns}	1654^{ns}	440568^{**}	162^{**}
Error b	40	7.21	11.9	2.11	332	0.31	1887	1135	1286	5.35
CV%		*3.25*	*4.71*	*7.96*	*4.5*	*6.2*	*4.5*	*6.7*	*3.2*	*4.8*

**, * and ^{ns}: significant at one, five percent probability levels and non-significant, respectively

Table 4. Interaction of planting date and ecotypes of Plantago major L. in different traits during the growing season in 2014-2015

Planting date	Ecotype	Survival percentage	Peduncle	Biomass	Harvest index
		%	cm	g.m^{-2}	(%)
September	Birjand	82.8^{d-h}	24,0^{b}	2056^{c}	29.2^{i}
	Gheyen	77.8^{j-l}	34.3^{a}	1175^{fg}	66.8^{a}
	Torbat heydariyeh	76.1^{kl}	20.7^{c}	651^{j}	50,0 ^{de}
	Mashhad	81.7^{e-j}	18^{def}	759 ^{i}	44.5^{gh}
	Kalat	82.2^{-i}	20.3^{cd}	661^{j}	50.7^{de}
	Bojnord	82.2^{d-i}	23.3^{b}	2768^{a}	^{j} 24.9
October	Birjand	81.7^{e-j}	19.5^{c-e}	1996^{d}	29.1 ^{i}
	Gheyen	75,0^{l}	23.5^{b}	1193 ^{f}	66.4 ^{a}
	Torbat heydariyeh	75.8^{kl}	16.5 $^{f-i}$	661 ^{j}	52.8 ^{cd}
	Mashhad	79.2^{g-l}	18,0^{ef}	738 ^{i}	44.7 ^{fgh}
	Kalat	77.5^{i-l}	17,0^{f-h}	637 ^{j}	48.5^{ef}
	Bojnord	78.3^{h-l}	21,0^{c}	2672^{b}	24.9^{j}
March	Birjand	79.4^{h-l}	13.7^{jk}	1261 ^{e}	42.9^{h}
	Gheyen	80.6^{f-k}	17.7^{ef}	1194 ^{f}	66.1^{a}
	Torbat heydariyeh	83.9^{d-g}	14.3$^{i.k}$	657 ^{j}	49.6^{c}
	Mashhad	84.4^{c-f}	12.7 ^{k}	820 ^{h}	47.9^{efg}
	Kalat	84.4^{c-f}	15^{h-k}	645^{j}	51.2^{cde}
	Bojnord	88.3^{a-c}	14.3^{i-k}	1184^{fg}	54.6 ^{bc}
فروردین April	Birjand	91.1^{a}	14,0^{jk}	1200^{f}	43.6 ^{h}
	Gheyen	89.5^{ab}	17.3 $^{e-g}$	1219^{ef}	67.1 ^{a}
	Torbat heydariyeh	86.7^{b-d}	13.3^{jk}	650 ^{j}	51.5 ^{cde}
	Mashhad	91.7 ^{a}	14.3^{i-k}	778^{hi}	44.7 ^{gh}
	Kalat	89.4^{ab}	15.3 $^{g-j}$	622^{j}	52.8 ^{cd}
	Bojnord	85.6^{b-e}	14.7 ^{ijk}	1129 ^{g}	57.6^{b}

Means in each column followed by the same letters are not significantly different at 0.05 probability level using of Duncan test

Table 5. Comparison of mean the spike length, number of capsules, seed in capsule, 1000 grain weight and grain yield ecotypes of Plantago major L.

Ecotype	Spike length	Capsules in Spike	Seeds in capsules	1000 grain weight	Grain yield
	cm			mg	g.m^{-2}
Birjand	92.9 ^{b}	446^{a}	8.5 ^{c}	923 ^{b}	561^{c}
Gheyen	92.9 ^{a}	428^{b}	11.6 ^{a}	1041^{a}	796^{a}
Torbat heydariyeh	51.5 ^{d}	363^{d}	5.8 ^{d}	1012^{a}	334^{d}
Mashhad	54.1 ^{d}	392^{c}	5.6 ^{d}	1029^{a}	353^{d}
Kalat	83.9 ^{a}	363^{d}	5.6 ^{d}	1016^{a}	326
Bojnord	63.3 ^{c}	459^{a}	10.9 ^{b}	883^{c}	662^{b}

Means in each column followed by the same letters are not significantly different at 0.05 probability level using of Duncan test

Table 6. Correlation coefficients between survival percentages, morphological traits, yield and yield components of Plantago major L. during growing season in 2014-2015.

	Traits	1	2	3	4	5	6	7	8
1	**Survival percentage**	1							
2	**Spike length**	0.00^{ns}	1						
3	**peduncle length**	-0.17^{**}	0.30^{*}	1					
4	**Number of capsules**	0.04^{ns}	0.14^{ns}	0.15^{ns}	1				
5	**Seed in capsule**	-0.01^{ns}	0.33^{**}	0.41^{**}	0.76^{**}	1			
6	**1000 grain weight**	0.04^{ns}	0.11^{ns}	0.14^{ns}	-0.62^{**}	-0.51^{**}	1		
7	**Grain yield**	-0.01^{ns}	0.39^{**}	0.46^{**}	0.78^{**}	0.97^{**}	-0.34^{**}	1	
8	**Biomass**	-0.11^{ns}	0.08^{ns}	0.46^{**}	0.71^{**}	0.62^{*}	-0.46^{**}	0.62^{**}	1
9	**Harvest index**	-0.10^{ns}	-0.27^{*}	0.01^{ns}	0.17^{ns}	0.20^{ns}	-0.27^{*}	0.22^{ns}	0.61^{**}

❋ ,❋❋and ns: significant at one, 1 and 5% probability levels and non-significant, respectively.