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Effect of cold temperature on morphological development and quality characteristics of some population of *Festuca arundinaceae* Schreb

Efecto de la baja temperature en el desarrollo morfológico y las características de calidad de poblaciones de *Festuca arundinaceae* Schreb

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Abstract

In order to study the effect of cold temperature on morphological and quality characteristics of tall fescue (*Festuca arundinaceae*), seeds of five populations were provided from natural resource gene bank, Iran as: Bejnord, Esfahan, Brojen, Kamiran and Mashhad were sown on pots with condition of fluctuation temperatures at 20±5°C during day and (5-12)°C during night time in greenhouse. The base temperature (4°C) were applied on 15th days seedling age for 30 days for vernalization compare with control. The pots were return in normal conditions besides control pots in greenhouse and then outdoor. The pots were arranged using factorial experiments based on completely randomized design with three replications. The plants had grown up to their flowering and maturity stage. In flowering stage, morphological traits including: plant height, peduncle length, panicle length, flag leaf area and flag leaf length, fresh and dry weight and seed yield and quality traits as dry mater digestibility (DMD), crude protein (CP), water soluble carbohydrates (WSC), acid detergent fiber (ADF) and total ash (ASH) were recorded. Results showed that populations of Mashhad, and Brojen had higher values for fresh and dry weight than those of other populations. For plant height, peduncle length, flag leaf area the Brojen, Bojnord and Kamyaran had higher values, respectively. For quality traits, the higher values of both DMD (56.5%) and WSC (14.09%) were obtained for Esfahan and higher value of CP (18.1%) for Bojnord. Results also showed that the growth degree days (GDD) of those populations which were subjected to cold treatment was lower flowering stage than those for control. It was concluded that cold treatment had no effect on vegetative developments particularly in seedling stage, but it reduced flowering dates in generative stage and increased plant dry matter yield. It was proved that the Tall fescue is cool season grass and it needs a period of vernalization for promotion of flowering.

Keywords: Tall fescue, *Festuca arundinaceae*, morphological and quality traits, growth degree days.

Resumen

Con el objeto de evaluar el efecto de la temperatura baja sobre las características fenológicas de la festuca alta (*Festuca arundinaceae*) se recolectaron semillas de cultivares Bejnord, Esfahan, Brojen, Kamiran, Mashhad en bancos de germoplasma. Estas fueron sembradas en recipientes con temperaturas fluctuantes de 20 ± 5°C durante el día y de 5 - 12°C durante la noche. Posteriormente el semillero de 15 días de edad se cultivo a una temperatura base de 4 °C durante 30 días. Los materos fueron retornados a condiciones normales de invernadero y de campo hasta su etapa de floración. En la etapa de floración, las características morfológicas incluyeron: altura de planta, longitud de pedúnculo, longitud de panícula, número de panículas y longitud de la hoja bandera, peso fresco y seco y los pesos de la semilla, características de calidad como la digestibilidad de materia seca (DMD), proteína cruda (CP), carbohidratos solubles en agua (WSC), fibra detergente ácida (ADF) y cenizas totales, se registraron. Los resultados mostraron que las poblaciones de los cvs. Mashhad y Esfahan presentaron valores superiores para altura de la planta, longitud del pedúnculo, longitud de la panícula, peso de la semilla, peso fresco y seco con

respecto a otras poblaciones. Exceptuando la población Esfahan, las otras cuatro poblaciones fueron evaluadas por su buen valor nutritivo debido al alto contenido de carbohidrato soluble en agua. Los resultados también mostraron que los días grados crecimiento (GDC) de aquellas poblaciones que estaban sujetas a temperatura fría, presentaron menor estado de floración que el tratamiento control. Se concluyó que la temperatura fría no presentó efecto alguno sobre los desarrollos vegetativos, particularmente sobre la etapa de floración, pero redujo las fechas de floración en la etapa generativa.

Palabras clave: Festuca alta, *Festuca arundinaceae,* características morfológicas y de calidad, días grado crecimiento (GDC).

Introduction

The tall fescue *Festuca arundinaceae* is perennial and cool season grasses. It has strong and deep main root. Its stem is stolen and this situation caused for its fast growing bunch. The leaves are greenish-dark. The length of its head is 10 up to 30 cm. Each panicle has 5 up to 7 seeds [Hidari and Dorri. 2002]. This plant is used for cultivation in rangeland (Hoveland, 2005). The tall fescue has good adaptability in different climate and soil type and this good adaptability in response of different environmental condition has direct correlation with establishment of tall fescue in the filed (Ervin, 1995). In study of the effect of temperature on of cocksfoot seeds, Gunn and Farer (1999) treated seeds with pre-chilling treatment at 4°C and then treated seeds were transferred at constant and variable temperature between (10-30) °C. Their result showed germination of some cocksfoot populations' were increased by pre-chilling treatment (Gunn and Farer, 1999). Barthomolew and Williams (2005) studied the effect accumulate temperature on development cool season grass under a range of temperature regimes. They concluded that the effect of variation temperature in mean daily temperature and of plant exposure to bellow freezing temperature phyllochron should be considered if accumulate temperature is used to predict development stage of cool season grasses in the field.

Thomass and Stoddart (2005), in studying on the temperature sensitivities of tall fescue and cooks foot (*Dactylis glomerata L.)* found that, ecotypes from the coldest habitats were the most sensitive to low temperature inhibition. Tall fescue often forms large, dense tiller clumps moderately in tall vegetation on wet or moist soils.

When the clumps get very large with 150 vegetative tillers, the outermost tillers become procumbent, growing along the soil surface but without rooting. When the species is abundant, such as on fairly rich soil, it is often patchily distributed, in an open-structured sward among the other perennial plants. It can be abundant and locally dominant, occurring as small clumps that are difficult to distinguish from each other (Giblson and Newman, 2001). Tall fescue is a stress-tolerant ruderal species. It is one of a group of species promoted by burning on embankments and dikes in the Netherlands. Morphological features are highly correlated, and the largest plants have many vegetative and flowering tillers, long and wide leaves, and tall flowering culms with long panicles, long and wide upper culm leaves, and many spikelets. The largest plants in a comparison across habitats in southern England were from an ungrazed waste ground (MG9) dominated by *Arrhenatherum elatius, Dactylis glomerata, Deschampsia cespitosa and Rubus fruticosus* AGG (Giblson and Newman, 2001). The objective of this study was to determine the effects of cold temperature on tall fescue for subsequent growth and development and forage quality.

Materials and Methods

In greenhouse, the seeds of five populations were provided from natural resource gene bank as: Bojnord, Esfahan, Brojen, Kamiran and Mashhad. Seeds were sown on pots with fluctuation temperatures 20±5°C during day and (5-12)°C during night by light illumination about 6000-10000 lux. The temperature of 4°C was used as base temperature of cold treatment for vernalization. The pots of each population were divided into two groups. The first group were placed into cold chamber with (4°C) on 15th days seedling age for 30 days. The control groups were not treated by cold. After cold treatments, all of the pots were placed in normal conditions of greenhouse in order to complete their vegetative growth. The pots were arranged using factorial experiments based on completely randomized design with four replications. When vegetative growth was completed, the pots were placed in outdoor in research institute of forests and rangelands, Tehran, Iran. The flowering date was measured as days from the 21st of March to panicles emergence date. In flowering stages, morphological characteristics including: plant height, peduncle length, panicle length, flag leaf length and flag leaf area of populations were measured. After recording of generative traits when the plants matured, all of them were cut and then their fresh weights were measured. The samples were put into an oven (80°C) for 48 hr, their dry weights were measured. Thereafter, the samples were grinded

by mill. The grinded samples were analyzed for five forage quality traits as: dry matter digestibility (DMD), crud protein (CP), water soluble carbohydrate (WSC), acid digestibility fiber (ADF) and total ash (ASH%) by NIR technology, using Inframatic 8620, 20 fixed-filter NIR instrument. (Perten Instruments AB, Sweden), Details of the methodology and calibrations of NIR are given by Jafari, Connolly, Frolich and Walsh (2003).

During, vegetative and generative growth, the daily maximum and minimum temperature for measuring of growth degree days (GDD) was recorded. GDD were calculated according equation of Frank, Sedivec and Hofmann (1993):

$$GDD = \frac{Tmin + Tmax}{2} - Tb$$

where:

GDD= Growth degree days

Tmax = Maximum daily temperature

Tmin = Minimum daily temperature

Tbase = is the base temperature

The collected data were analyzed based on factorial experiment as factor A cold treatment with two levels and Factor B, populations with five levels. Mean comparisons between effects were made using Duncan method using SAS software.

Result and discussion

Morphological traits: Results of analysis variance showed significance differences between populations for traits including: plant height, peduncle length, flag leaf area, fresh weight and seed weight (P≤0.01) and plant dry weight (P≤0.05). Also there were significance differences between treatments for fresh and dry weight (P≤0.01) and flag leaf area (P≤0.05). There were also significant effects of population x treatment interaction effects for plant height, peduncle length, flag leaf area (P≤0.01) and for panicle length, flag leaf length, fresh weight and dry weight (P≤0.05), (Table 1).

Result of mean comparisons among five populations showed that populations of Mashhad, and Brojen with average values of (82.53 and 84.44 g/plant) for fresh weight and (41.15 and 44.02 g/plant) for dry weight had higher production than those of other populations, respectively (Table 2). For plant height, peduncle length, flag leaf area, the populations Brojen, Bojnord and Kamyaran with average values of 69.34 cm, 49.96 cm and 5.63 cm^2 had higher values than those of other populations, respectively (Table 2). Also population of Mashhad, Esfahan and Kamyaran had higher seed yield than other populations (Table 2).

Table 1. Summary of analysis of variance and the level of significant of mean squares for morphological traits.

Source of variation	df	MS							
		Plant Height (cm)	Panicle Length (cm)	Flag leaf Length (cm)	Peduncle Length (cm)	Fresh weight (g)	Dry Weight (g)	Flag leaf Area (cm^2)	Seed Weight (g)
Population (P)	4	597.66**	3.50	15.60	536.73**	2396.6**	676.5*	6.19**	1.19**
Treatment (T)	1	16.49	6.83	8.56	37.60	1445.8**	1063.7**	2.10*	0.11ns
P x T	4	214.16**	11.12*	48.64*	145.79**	250.3*	47.68*	4.21**	0.24ns
Error	20	32.73	3.58	16.85	25.73	68.20	19.47	0.35	0.42
CV%		10.49	15.65	16.52	13.53	13.13	14.09	13.46	69.69

ns ,*, **= non significant, significant at 5% and 1% respectively

Table 2. Comparing means of morphological traits of five population of tall fescue (*Festuca arundinaceae*).

Name of population	Plant Height (cm)	Panicle Length (cm)	Flag leaf Length (cm)	Peduncle Length (cm)	Fresh Weight (g/p)	Dry Weight (g/p)	Flag leaf area (cm^2)	Seed Weight (g)
Esfahan	46.20 c	12.33 a	25.11 a	31.96 cd	56.87 b	22.96 b	4.15 b	1.35 a
Brojen	69.34 a	12.58 a	26.56 a	38.38 bc	82.53 a	41.15 a	4.76 b	0.60bc
Mashhad	58.21 b	12.71 a	25.58 a	41.95 b	84.44 a	44.02 a	4.58 b	1.30 a
Bojnord	54.32 bc	10.81 a	22.23 a	49.96 a	38.49 c	20.86 b	2.85 c	0.30cd
Kamyaran	44.72 c	12.03 a	24.76 a	25.20 d	52.11 bc	27.61 b	5.63 a	1.10 a

Dissimilar letters in each column mean significant difference at the 5% level using Duncan's multiple range test

The mean values of fresh weight, dry weight, flag leaf area and seed weight were significantly increased in cold treatment by 30%, 48%, 12% and 150% higher than that for control, respectively (Table 3). This result was in agreement with result of Alizadeh and Jafari, (2010) in *Dactylis glomerata* that showed that some populations produced higher tiller in cold treatment compare with control. There was relationship between flag leaf area and forage production, Sambo (2011) in comparison among three grass species including: *Dactylis. glomerata*, *F.arundinacea* and *Phalaris tuberose* found that increasing of leaf area of these species leaded to higher forage production.

Results showed that there were significant effects of population x treatment interaction for all of morphological traits except seed yield (Table 1). The higher values of plant height and peduncle length with average values of 78.33 cm and 61.11 cm were obtained in Brojen and Bojnord under control condition indicating that cold treatments had no significant effects on these traits. In contrast, the population of Brojen with average values of 29.67 cm, 91.57 g/plant, 46.67 g/plant, respectively, had higher means values of flag leaf length, fresh weight and dry weight under per chilling treatments. Similarly, Mashhad population with average values of 14.66 cm, 95.86 g/plant, 52.53 g/plant, 6.09 cm^2 and 1.30 g/plant, respectively, had higher values of peduncle length, fresh weight, dry weight flag, leaf area and seed yield than those for other populations in cold treatment (Table 4). Also, the higher seed production with average values of 1.35, 1.10 and 1.30 g/plant, were obtained by population Esfahan, Kamyaran and Mashhad in cold treatment (Table 4), indicating that vernalization had increase yield and yield components in tall fescue.

The results of this research work was in agreement with result of Durand, Schaufele, and Gastal (1999), for elongation of successive leave under constant temperatures of 24°C and 14°C, and after temperature changes from 24 to 14°C and vice versa. A morphological analysis of the growing leaf was made from the time it was 1 mm long until it was fully elongated. They concluded that temperature change had an immediate effect on LER (leaf elongation rate) but the response

Table 3. Effect of cold treatment on15th of seedling ages on morphological traits of tall fescue (*Festuca arundinaceae*)

Treatments	Plant Height (cm)	Panicle Length (cm)	Flag leaf Length (cm)	Peduncle Length (cm)	Fresh Weight (g/p)	Dry Weight (g/p)	Flag leaf area (cm^2)	Seed Weight (g)
Cold	54.14 a	12.60 a	25.79 a	36.83 a	69.76 a	37.66 a	4.68 a	1.00 a
Control	55.27 a	11.62 a	24.20 a	38.84 a	53.80 b	25.38 b	4.17 b	0.40 b

Dissimilar letters in each column mean significant difference at the 5% level using Duncan's multiple range test

Table 4. Means of morphological traits of five populations of tall fescue grown from seeds that germinated in cold and normal condition

Treatments	Name of population	Plant Height (cm)	Panicle Length (cm)	Flag leaf Length (cm)	Peduncle Length (cm)	Fresh Weight (g/p)	Dry Weight (g/p)	Flag leaf area (cm^2)	Seed Weight (g/p)
Cold	Bojnord	53.67 bcd	11.17 ab	22.94 ab	41.82 bc	51.23 c	27.97 c	2.94 d	0.30 d
	Brojen	60.33 b	13.83 ab	29.67 a	39.22 bcd	91.57 a	46.67 a	5.29 ab	0.60 c
	Esfahan	53.86 bcd	12.58 ab	25.78 ab	33.61 de	57.89 bc	25.75 cd	3.28 cd	1.35 a
	Kamyaran	43.28 cd	10.78 b	21.94 b	26.33 ef	52.26 c	35.38 b	5.80 a	1.10 a
	Mashhad	59.56 bc	14.66 a	28.62 ab	43.17 b	95.86 a	52.53 a	6.09 a	1.30 a
Control	Bojnord	56.67 bc	10.89 ab	22.56 ab	61.11 a	24.00 d	13.77 e	2.61 d	0.10 d
	Brojen	78.33 a	11.33 ab	23.44 ab	37.33 cd	64.48 bc	36.54 b	4.22 bc	0.10 d
	Esfahan	38.67 d	11.78 ab	24.44 ab	30.11 def	56.00 bc	20.10 de	5.17 ab	0.90 b
	Kamyaran	46.00 bcd	13.33 ab	28.00 ab	24.00 f	52.00 bc	19.67 de	5.50 ab	0.70bc
	Mashhad	56.67 bc	10.78 ab	22.56 ab	41.67 bcd	72.50 b	36.83 b	3.33 cd	0.14 d

Dissimilar letters in each column mean significant difference at the 5% level using Duncan's multiple range test

varied depending on the direction of the temperature change.

Quality traits: Analysis variance showed that there were significance differences P≤0.01 between populations for all of quality traits (Table 5). Also there were significance differences P≤0.01 between treatments for WSC and ADF. There were significance differences for treatment by population interaction effects for all of quality traits (Table 5). Result showed that maximum values of DMD% was 59.39% and it was related to population of Mashhad. Lower value of DMD was 51.52% and it was related to population of Bojnord (Table 6). The population of Bojnord had values of CP% (18.1%). The lower and higher values of CP with 16.50% 18.1% were related in to Kamyaran and Bojnord population, respectively (Table 6). Esfahan population had higher values of total ASH (7.81%) than the other population. Lower value of ASH (6.91%) was related to population of Brojen (Table 6).

With effect of cold treatment, the mean values of CP and WSC were significantly reduced in cold treatment by 5% and 20% lower than that for control, respectively (Table 7). The results also indicate that cold treatment caused to early flowering of all of populations *Festuca arundinaceae* (Figure 1). Three are evidence that forage qualities are reduced by plant growth (Jafari, Anvari, Nakhjavan and Rahmani, 2010). The result indicated

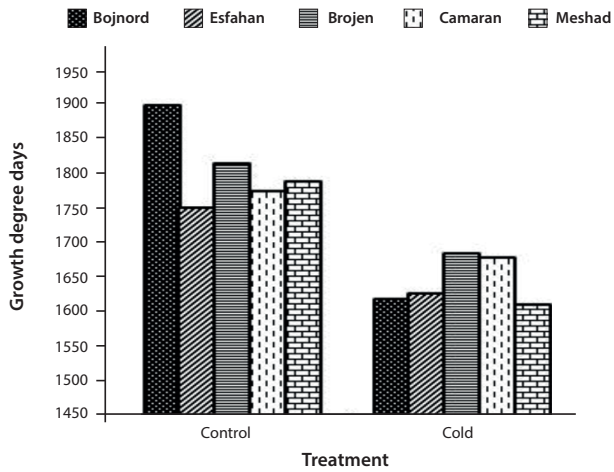

Figure 1. Growth degree days of five population of Festuca arundinaceae

Table 5. Summary of analysis of variance and the level of significant of mean squares for quality traits.

Source of variation	df	MS						
		DMD%	CP%	WSC%	ADF%	ASH%	NDF%	CF%
Population (P)	4	49.90**	2.80*	12.48**	33.22**	0.71**	39.86*	27.12*
Treatment (T)	1	0.97	1.29	28.46**	4.23	0.01	44.35*	2.23
P x T	4	23.60*	4.22**	28.06**	35.08**	1.02**	55.21*	28.53**
Error	20	7.72	0.76	0.43	2.25	0.13	10.96	5.26
CV%		4.95	5.04	5.65	5.02	4.89	5.01	5.01

ns ,*, **= non significant, significant at 5% and 1% respectively

Table 6. Comparing means of quality traits of five population of tall fescue (*Festuca arundinaceae*).

Name of population	DMD%	CP%	WSC%	ADF%	ASH%	NDF%	CF%
Esfahan	56.52 a	16.75 ab	14.09 a	29.03 b	7.81 a	67.25 ab	42.36 b
Brojen	55.94 ab	17.83 ab	10.94 b	31.70 a	6.91 b	62.90 c	47.39 a
Mashhad	59.39 a	17.36 ab	11.63 b	27.52 b	7.20 ab	65.86 c	45.93 ab
Bojnord	51.52 b	18.10 a	10.83 b	32.96 a	7.35 ab	68.00 a	47.69 a
Kamyaran	57.20 a	16.50 b	10.55 b	28.13 b	7.57 a	66.33 b	45.39 ab

Dissimilar letters in each column mean significant difference at the 5% level using Duncan's multiple range test

Table 7. Effect of cold treatment on15th of seedling ages on quality traits of tall fescue (*Festuca arundinaceae*)

Treatments	DMD%	CP%	WSC%	ADF%	ASH%	NDF%	CF%
Cold	55.86 a	17.50 b	10.61 b	29.49 a	7.35 a	66.50 a	45.98 a
Control	56.43 a	18.29 a	12.67 a	30.24 a	7.45 a	65.63 b	45.48 a

Dissimilar letters in each column mean significant difference at the 5% level using Duncan's multiple range test

that reduction of CP and WSC was related to early flowering of cold treatment compare to control. Therefore In populations that harvesting in the same time, the early heading had always lower quality (Jafari *et al*, 2010).

Results showed that there were significant effects of population × treatment interaction for all of quality traits (Table 8). The higher values of DMD, CP and WSC, with average values of 59.57%, 21.32% and 17.28%, respectively, were obtained in Esfahan under control condition indicating that cold treatments by promoting of flowering stage cause to reduce quality traits. Similarly, the population of Esfahan and Bojnord with average values of 70.73 and 50.73 had higher values of NDF and CF (Table 8). These traits had negative effect on forage quality and by plant growth there values are increased (Jafari *et al.*, 2010).

Growth degree days (GDD): GDD of populations were estimated for flowering stage (Fig 1). By effect of cold treatment, GDD of five populations were lower than control (Fig 1). Therefore these populations would be earlier when treated with cold treatment compare control. This result confirmed by Alizadeh and Jafari (2011). They studied the effect of temperature on phenological and quality of some ecotype of *Dactylis glomerata* with regard of growth degree days and their result showed that all five ecotypes trend to early flowering and heading than control.

Conclusion

From point of phenological characteristics, population of Masshad and Brojen population would prefer than three other ones. Regarding of to quality traits, the higher values of both DMD (56.5%) and WSC (14.09%) were obtained for Esfahan and higher value of CP (18.1%) for Bojnord. The Esfahan and Bojnord populations would select for both yield and quality traits. For seed production the higher values were obtained in population Esfahan, Kamyaran and Mashhad in cold treatment. This population cloud be use to release cultivars for range beneficiaries.

Results also showed that the growth degree days (GDD) of those populations which were subjected to cold treatment had lower flowering stage than those for control. It was concluded that cold treatment had no effect on vegetative developments particularly in seedling stage, but it reduced flowering dates in generative stage and increased fresh and dry matter and seed yield. It was proved that the Tall fescue is cool season grass and it needs a period of vernalization for promotion of flowering. Calculating of GDD during phenology is important factor for predicting of optimum time sowing, flowering, harvesting and grazing**.** Therefore it is recommended for cool season grass before planting.

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Table 8. Means of quality traits of five populations of tall fescue grown from seeds that germinated in cold and normal condition

Treatments	Name of population	DMD%	CP%	WSC%	ADF%	ASH%	NDF%	CF%
Cold	Bojnord	50.05 d	18.18 b	7.27 d	32.35 ab	6.79 d	69.09 b	50.73 a
	Brojen	57.13 b	17.98 bc	10.41 c	30.13 bc	6.95 cd	64.88 de	46.62 bc
	Esfahan	54.17 c	18.27 b	11.30 c	32.20 ab	7.99 a	70.73 a	43.05 de
	Kamyaran	59.37 a	16.55 c	10.60 c	24.82 e	7.33 bcd	61.64 f	46.36 bc
	Mashhad	58.61 ab	16.53 c	13.48 b	27.97 cd	7.72 ab	66.17 cd	43.15 de
Control	Bojnord	52.98 c	18.02 bc	14.46 ab	33.57 a	7.91 ab	66.91 c	44.65 cd
	Brojen	54.74 c	17.67 bc	11.46 bc	33.26 ab	6.88 cd	60.92 f	48.17 ab
	Esfahan	59.57 a	21.32 a	17.28 a	25.86 de	7.63 abc	63.77 e	41.44 e
	Kamyaran	54.70 c	16.25 c	10.37 c	31.45 ab	8.14 a	71.02 a	44.42 cde
	Mashhad	60.18 a	18.17 bc	9.78 cd	27.07 cde	6.68 d	65.54 cde	48.72 ab

Dissimilar letters in each column mean significant difference at the 5% level using Duncan's multiple range test

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