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# Effect of Cold Temperature and Growth Degree Days (GDD) on Morphological and Phenological Development and Quality Characteristics of Some Ecotypes of Cocksfoot (*Dactylis glomerata*)

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**Abstract:** In order to study the effect of cold temperature on phenological characteristics cocksfoot (*Dactylis glomerata*), the seeds of four domestic ecotypes (Bijar, Ardebil, Karaj, Hamedan) and a foreign one were sown on pots with fluctuation temperatures 20±5°C during day and (5-12)°C during night time. Then, base temperature, 4°C was used on 15th and 30th seedling age compare with control. The pots were return in normal conditions of greenhouse and outdoor up to their flowering stage. In flowering stage, morphological traits including: plant height, peduncle length, panicle length, panicle number and flag leaf area, fresh and dry weight 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 ecotypes of Hamadan, Bijar and foreign had higher values for plant height, peduncle length, panicle length and fresh and dry weight than those of other ecotypes. The ecotypes Karaj, Hamadan and Ardebil for DMD and CP and the foreign ecotype for WSC had higher quality. Results also showed that the growth degree days (GDD) of those ecotypes which were subjected to 15 day cold treatment was higher in vegetative stage and lower in flowering stage than those for control, respectively. It was then concluded that cold treatment had no effect on vegetative developments particularly in seedling stage, but it reduced flowering dates in generative stage.

**Key words:** Cold treatment · Phenology · Forage quality · Orchard grass

## INTRODUCTION

The cocksfoot plant is perennial and cool season grasses. It is an upright, fast growing bunch grass. The stem is straight and rigid. The stem and the seed head of cocksfoot can stand over 1 meter tall. The leaves are long and broad and rolled around the stem. The seeds of cocksfoot are light and small. The number of seeds were 726,000 to 1.236,000 seed $kg^{-1}$. They have a very short awn and are slightly curved. The seeds loosed in the hulls and are dispersed by the wind when mature and released [1].

The beneficial economic importance of cocksfoot is in its ability to be high yielding forage for livestock as pasture, hay and silage. It is a commercially available grass because it has high level of palatability when harvested or grazed in the vegetative stage. Cocksfoot is often used where growing conditions aren't ideal and a grass crop is needed. Its establishment and fast growth are things that make it a difficult weed to control, but also are the qualities that make it a high yielding forage crop. These qualities allow it to withstand greater grazing pressure than other grass species. The other use of cocksfoot is for erosion control. Quality analysis for this species showed that DMD and CP content of cocksfoot was 61.3 and 8.2 at flowering stage, respectively [2].

Cocksfoot is growing between 12-22°C. The optimum temperature for its growth is 21°C. The habitat growth of cocksfoot will be reduced at over 22°C but it has favorable growth on early spring and late autumn, therefore this species is nominated as cool season-grass [3]. The effect of over 4°C temperature studied on leaf area, dry mater, root and shoot length and carbohydrate contents studied by Gunn and Farurr. Their result showed that all of traits were increased in temperature over than 4°C [4].

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The study of Pannangpetch and Bean showed that the germination of some cocksfoot populations' was increased by pr-chilling treatment [5]. Cocksfoot is growing in rangeland of Zagros and Alborz area of Iran. Distribution of cocksfoot related to region with altitude of 500 to 3000 meter from the sea and precipitation of more than 300mm [6-7].

Keeping in view the feed production importance of this grass, the present study was mainly aimed to design an experiment on the effect of pre-cool temperature on phonological, morphological traits, fresh and dry matter yield, growth degree days (GDD) and forage quality on five ecotypes.

## MATERIALS AND METHODS

In greenhouse, the seeds of four domestic and one foreign ecotypes were provided from gene bank: viz. Bijar, Ardebil, Karaj, Hamedan and foreign ecotypes were sown on pots ( Size: 22cm) 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. The pots of each ecotype were divided in to three groups. The first and second groups were placed into cold chamber (with 4°C) at 15$^{th}$ and 30$^{th}$ seedling age for two weeks. 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. When vegetative growth was completed, the pots were placed into farm nursery in research institute of forests and rangelands, Tehran, Iran. In the flowering stage morphological characteristics including: plant height, peduncle length and panicle length, number of panicle, flag leaf area, of each ecotype were recorded. Then plants were cut and their fresh weights were measured. The samples were placed into an oven (80°C) for 48 hr. their dry weights were also measured. Thereafter, the samples were grinded by mill and were then analyzed for 5 forage quality traits i.e. dry mater digestibility (DMD%), crude protein (CP%), water soluble carbohydrates (WSC%), acid detergent fiber (ADF%) and total ash (ASH%) were analyzed by NIR, An Inframatic 8620*, 20* fixed-filter NIR instrument. (Perten Instruments AB, Sweden), Details of the methodology and calibrations of NIR are given by Jafari *et al*. [8].

During, vegetative and generative growth, the daily maximum and minimum temperature for estimation of growth degree days (GDD) was recorded. The GDD were calculated by using the equation postulated by Frank *et al.* as given below:

$$GDD = \frac{T\max + T\min}{2} - Tbase$$

GDD = Growth degree days
Tmax = Maximum daily temperature
Tmin = Minimum daily temperature
Tbase = Is the basal temperature set at 3°C

## RESULTS

**Morphological Traits:** Table 1 showed significant differences ($P \leq 0.05$) among treatments for all mentioned traits except panicle length. Similarly, there were significant differences among ecotypes for all of traits and ecotype x treatment interaction effects for all of traits except plant height and panicle length (Tables 1 to 3).

For plant height, the lower value of 52 cm was obtained for 30$^{th}$ seedling cold treatment. The ecotype of Hamadan with average values of 66.33 cm had higher plant height. Data presented in Table 3 proved that there was no significant differences ($P \leq 0.05$) between five ecotypes for plant height with respect to cold treatment in 15$^{th}$ and 30$^{th}$ seedling age compare with control.

For panicle length and panicle number, the effect of cold treatment (especially in 15$^{th}$ days of seedling age), the length of panicle was higher than control (Table 1). In comparison among ecotypes for panicle length, The Bijar ecotype with average values of 9.89 cm had higher values than other ecotypes. This ecotype also with average values of 11.72 cm had higher panicle length than other ecotypes when the 15$^{th}$ seedling age subjected to cold treatment. The Ardebil and Hamadan ranked as medium panicle length in order of 9.33 and 9.05 cm compare with control. For number of panicles there was no significant difference among cold treatments and control. The Bijar ecotype with average values of 3.52 panicle number had higher panicle number than other ecotypes. There was no significant difference between other ecotypes for panicle number. The results also indicated that the panicle number in Bijar ecotype was increased by the effect of cold treatment of 15$^{th}$ seedling age about 18% more than control.

There were found no significant difference for peduncle length of five ecotypes by the effect of cold treatment on 15$^{th}$ days of seedling growth age.

Table 1: Effect of cold treatment in15th and 30th of seedling ages on phenological traits of cocksfoot (*Dactylis glomerat*) compare with control

| Treatment | Plant height (cm) | Panicle Length(cm) | Panicle N0 | Peduncle length (cm) | Fresh weight (g) | Dry weight (g) | Flag leaf area ($cm^2$) |
|---|---|---|---|---|---|---|---|
| 15 days age | 58.33 a | 9.11 a | 3.70 a | 24.62 a | 42.18 ab | 27.10 ab | 4.61 a |
| 30 days age | 52.96 b | 7.56 ab | 2.71 a | 22.60 ab | 48.55 a | 29.79 a | 4.58 ab |
| Control | 59.11 a | 29.41 a | 2.78 a | 22.18 b | 37.44 b | 25.71 c | 4.36 b |

Means of each columns followed by the same letters had no significant differences (P≤0.05) based on DMRT method.

Table 2: Comparing phenological traits of five ecotype of cocksfoot (Dactylis *glomerat*)

| Name of ecotype | Plant Height (cm) | Panicle Length (cm) | Panicle N0 | Peduncle Length (cm) | Fresh weight (g) | Dry weight (g) | Flag leaf area ($cm^2$) |
|---|---|---|---|---|---|---|---|
| Bijar | 56.20 ab | 9.89 a | 3.11 a | 31.48 a | 46.24 a | 29.97ab | 4.57 a |
| Ardebil | 55.61 ab | 9.00 a | 3.07ab | 20.30 b | 40.05 b | 32.01 a | 4.62 a |
| Karaj | 53.74 b | 7.04 b | 2.59 b | 15.04 c | 44.54 a | 29.71 ab | 3.20 b |
| Hamedan | 63.30 a | 9.15 a | 2.81ab | 28.56 ab | 38.89 ab | 24.99 b | 4.41 a |
| Foreign | 56.20 ab | 7.30 b | 2.67ab | 28.63 ab | 48.16 a | 21.00 c | 4.95 a |

Means of each columns followed by the same letters had no significant differences (P≤0.05) based on DMRT method.

Table 3: Interaction of cold treatment in15th and 30th of seedling ages on phenological traits of five ecotypes of cocksfoot ( *Dactylis glomerat*) compare with control

| Treatment | Name of ecotype | Plant Height (cm) | Panicle Length (cm) | Panicle N0 | Peduncle length(cm) | Fresh weight (g) | Dry weight (g) | Flag leaf area($cm^2$) |
|---|---|---|---|---|---|---|---|---|
| 15 days age | Bijar | 62.55a | 11.72 a | 3.55 a | 31.77 ab | 39.26 ab | 23.55 ab | 4.60 bc |
| | Ardebil | 51.00a | 9.33 ab | 3.11ab | 20.78 bde | 36.45 ab | 21. 87 abc | 4.60 bc |
| | Karaj | 50.70a | 7.60 b | 2.66 ab | 16.66 dec | 41.26 ab | 24.75 ab | 3.89 bcd |
| | Hamedan | 66.77a | 9.05 ab | 3.00 ab | 26.89 abc | 49.06 a | 29.43a | 2.88 cd |
| | foreign | 55.11a | 7.33 b | 3.00 ab | 27.00 abc | 44.90 ab | 26.93ab | 7.30 a |
| 30 days age | Bijar | 52.66a | 7.89 ab | 2.89 ab | 26.33 abc | 42.73 ab | 16.3 fge | 4.79 b |
| | Ardebil | 52.16a | 8.05 ab | 3.44 a | 18.89 cde | 39.00 ab | 13.3 hg | 5.05 b |
| | Karaj | 54.22a | 6. 44 b | 2.55 ab | 13.00 e | 51.30 a | 32.70 a | 3.37 bcd |
| | Hamedan | 53.22a | 8.89 ab | 2.14 b | 27.77 abc | 42.46 ab | 22.00 b | 3.77bcd |
| | foreign | 52/50a | 6.03 b | 2.55 ab | 26.89 abc | 45.90 ab | 26.6 ab | 3.58 bcd |
| Control | Bijar | 55.84a | 9.29 ab | 2.93 ab | 34.86 a | 41.29 ab | 33.3 cde | 4.54 bc |
| | Ardebil | 58.22e | 9.33 ab | 2.65 ab | 21.22 bdc | 44.70 ab | 40.0 ab | 4.20bc |
| | Karaj | 56.22a | 7.00 b | 2.55 ab | 15.33 de | 41.07 ab | 26.6 abc | 2.32d |
| | Hamedan | 66.89a | 9.22 ab | 3.33 ab | 31.00 ab | 25.15 b | 21.7 dcb | 6.55 a |
| | foreign | 61.00a | 8.22 ab | 2.44 ab | 32.30 ab | 53.59 a | 25.0 dfe | 4.22 bc |

Means of each columns followed by the same letters had no significant differences (P≤0.05) based on DMRT method.

Table 4: Growth degree days of five ecotypes of cocksfoot ( *Dactylis glomerat)* by effect of cold treatment in15th and 30th of seedling ages in three stages including: vegetation, flowering and maturity.

| Name of ecotype | Vegetation | | | Flowering | | | Maturity | | |
|---|---|---|---|---|---|---|---|---|---|
| | Control | 15th | 30th | Control | 15th | 30th | Control | 15th | 30th |
| Bijar | 795 c | 980 b | 1040 a | 2188 a | 1971 b | 1968 b | 2750 a | 2582 b | 2573 b |
| Ardebil | 687 c | 916 b | 936 a | 2209 a | 1925 bc | 2031 b | 2771 a | 2526 c | 2656 b |
| Karaj | 969 a | 949 a | 936 b | 2255 a | 1832 c | 2038 b | 2798 a | 2466 c | 2633 b |
| Hamedan | 712 c | 944 b | 980 a | 2213 a | 1966 c | 2067 b | 2775 a | 2576 c | 2673 b |
| Foreign | 727 c | 900 b | 920 a | 2169 a | 2030 b | 2001 b | 2735 a | 2640 b | 2626 b |
| Means | 778 | 938 | 962 | 2207 | 1945 | 2021 | 2766 | 2558 | 2632 |

Means of each columns followed by the same letters had no significant differences (P≤0.05) based on DMRT method.

Table 5: Effect of cold treatment in15th and 30th of seedling ages on forage quality of cocksfoot ( *Dactylis glomerat* ) compare with control

| Treatment | DMD% | CP% | WSC% | ADF% | ASH% |
|---|---|---|---|---|---|
| 15 days age | 59.66 a | 24.18 c | 13.26 b | 24.18 a | 8.30 a |
| 30 days age | 57.92ab | 20.13 b | 13.20 c | 28.12 b | 8.23 b |
| Control | 59.90a | 40.30 a | 14.18 a | 24.28 c | 8.11 c |

Means of each columns followed by the same letters had no significant differences (P≤0.05) based on DMRT method.

Table 6: Interaction of cold treatment in15th and 30th of seedling ages on forage quality of five ecotypes of cocksfoot (*Dactylis glomerat*) compare with control

| Name of ecotype | DMD% | CP% | WSC% | ADF% | ASH |
|---|---|---|---|---|---|
| Bijar | 57..93b | 18.44 d | 11.89 e | 30.06 a | 7.94 d |
| Ardebil | 59.43 ab | 21.30 a | 13.99 c | 29.23 c | 8.34 c |
| Karaj | 61.76 a | 19.40 b | 14.49 b | 26.51 d | 8.76 a |
| Hamedan | 58.25 d | 17.52 e | 13.77 d | 29.58 b | 7.76 e |
| Foreign | 58.42 c | 18.12 d | 14.88 a | 18.85 e | 8.34 b |

Means of each columns followed by the same letters had no significant differences (P≤0.05) based on DMRT method.

Table 7: Interaction of cold treatment in15th and 30th of seedling ages on forage quality of five ecotypes of cocksfoot (Dactylis *glomerat*) compare with control

| Treatment | Ecotype | DMD% | CP% | WSC% | ADF% | ASH% |
|---|---|---|---|---|---|---|
| 15 days age | Bijar | 54..75c | 18.17b | 10.16e | 33.45a | 7.5d |
| | Ardebil | 60.90ab | 19.34a | 13.20d | 28.05c | 9.09a |
| | Karaj | 64.69a | 17.32bc | 15.60b | 23.00e | 8.46ab |
| | Hamedan | 60.85ab | 19.00ab | 14.69c | 26.56d | 7.85c |
| | Foreign | 57.09b | 17.35bc | 16. 21a | 29.83b | 8.40b |
| 30 days age | Bijar | 57.60b | 18.58bc | 11. 38e | 30.23b | 8.09c |
| | Ardebil | 58.14b | 23.96a | 13.72bc | 30.92a | 8.48ab |
| | Karaj | 62.24a | 19. 27b | 11.56d | 26.28.d | 9.13a |
| | Hamedan | 59.31ab | 20.86ab | 13.34b | 28.97c | 8.46b |
| | Foreign | 52.29c | 18.89bc | 16. 0a | 16. 08e | 6.99d |
| Control | Bijar | 61.40ab | 18.53ab | 14.02c | 26.70c | 8.24c |
| | Ardebil | 59.25b | 20.49ab | 15.40b | 28.72b | 7.21d |
| | Karaj | 58.34b | 21.50a | 16.31a | 30.24a | 8.50b |
| | Hamedan | 54.60c | 19.63b | 13.29d | 23.21d | 6.96e |
| | Foreign | 65.89a | 18.13c | 12.06e | 22.52e | 9.63a |

However, there were found significant differences for that trait in 30th days of seedling age (Table 1). The peduncle length of Bijar, Hamadan and foreign ecotype were in order 31.48, 28.56 and 28.63 cm, were higher than the other two ecotypes (Table 2). By the effect of cold treatment on 15th and 30th seedling age, length of peduncle was higher for ecotypes of Bijar, Hamadan and foreign ecotype compare with other two ecotypes (Table 3).

Data also exhibited that both fresh and dry weight of mature plants were increased by the effect of cold treatment on 15th and 30th seedling ages when compare with control (Table 1). Table 2 showed that fresh weight was higher for ecotypes of Bijar, Karaj and foreign ecotype, but it was lower for ecotypes of Ardebil and Hamadan. Dry weight of Ardebil was higher than other 4 ecotypes (Table 2). With effect of cold treatment on 15th and 30th of seedling ages, fresh weight Hamadan ecotype was in order 49.06 mg and 42.46 mg and it was increased by comparing of control (Table 3). Also by the effect of cold treatment on 15th seedling age, the fresh weight of Hamadan ecotype was higher than other ecotypes (Table 3). The fresh weight of Karaj ecotype was higher than other ecotypes by the effect of cold treatment on 30th seedling age and also it was increased about 19% than control.

For flag leaf area, the effect of cold treatment was increased when compare with control (Table 1). The Bijar, Ardebil, Hamadan and foreign ecotypes had higher value for flag leaf area than Karaj ecotype. Flag leaf area of foreign ecotype was increased over 42% from control by effect of cold treatment on 15th seedling age and also it was higher than other ecotypes (Table 3). On 30th seedling age, with effect cold treatment, flag leaf area of Bijar and Ardebil was increase for 5 and 16% from control, respectively (Table 3).

Growth degree days (GDD) of ecotypes were estimated at three phenological stages viz. vegetation, flowering and maturity. At vegetation stage, five ecotypes have gotten more GDD with cold treatment on both 15th and 30th seedling ages than control (Table 4). However, the effect of cold treatment on two 15th and 30th seedling ages on flowering and maturity stages, the GDD of ecotypes were lower than control (Table 4).

**Quality Traits:** With effect of cold treatment on both (15th and 30th) seedling ages, had no effect on the means of DMD and CP (Table 4). Table 5 showed that Karaj ecotype with DMD values of 61.76% had higher values than other ecotypes. In contrast, Bijar ecotype with (57.93) had lower DMD than other ecotypes. The CP of Ardebil ecotype was 21.3 had values higher than the other 4 ecotypes. Whereas the ecotype of Hamadan had lowest values of 17.53. The ecotypes of Bijar, Karaj and foreign ecotype had CP values of 18.43, 19.2 and 18.12, respectively and they ranked as medium group. With effect of cold treatment on 15th seedling stages, there was increasing of DMD for ecotypes of Karaj, Ardebil and Hamadan but DMD of Bijar and foreign ecotype was decreased compare with control (Table 6). Also the effect of cold treatment on 15th seedling age the CP was increased for ecotypes of Karaj and Ardebil (Table 6). There was increasing of DMD for ecotypes of Karaj and Hamadan with effect cold treatment on 30th seedling age compare with control. With effect cold treatment on 30th seedling stage, ecotypes of Ardebil and Hamadan have CP than control (Table 6).

With effect of cold treatment on both seedling (15th and 30th) ages, there was no effect on WSC and ADF for the means five ecotypes (Table 4). Data tabulate in Table 5 showed that the foreign ecotype and Karaj had higher WSC than the other ecotypes. With effect of cold treatment on both (15th and 30th) seedling ages, WSC of foreign were increased by 25% over than control, but ecotype of Bijar had lower values for WSC. With effect of cold treatment on 15th seedling age there was increasing of the means five ecotypes for total ash (Table 4). But by the effect on 30th seedling age, there was increasing of the means five ecotypes only for ash. The ecotype of Karaj had higher of ash content than other ecotypes but ecotype of Hamadan had lower content of ash (Table 5). With effect of cold treatment on two seedlings (15th and 30th) age, ash content of Ardebil and Karaj ecotypes were increased than control. The CP of Bijar was increased by the effect of cold treatment on both seedling stage than control but it ash content was reduced than control.

## DISCUSSION

With effect of cold treatment, ecotypes of Hamadan, Bijar and foreign would preferred than other two ecotypes because their phenological characteristics including plant height, peduncle length, panicle length and fresh and dry weight were higher (Table 3). This result confirmed with result of (Alizadeh and Jafari, 2010) that showed that Hamadan and foreign ecotype had more tiller and leaf area than other three ecotypes by effect of cold treatment compare with control. Three grass species including: *Dactylis.glomerata*, *F.arundinacea* and *Phalaris tuberose* compared by Sambo [12] and his result showed that increasing of leaf area of these species leaded to higher forage production.

With refer of Table 4, growth degree days (GDD) of 5 ecotypes were calculated in three stage including (vegetation, flowering and maturity). During vegetation, the effect of cold treatment on GDD of five ecotypes were higher than control. It means that cold treatment in two stage of seedling has no effect on vegetation stage. However, for flowering stage, all of five ecotypes had lower GDD than control (Table 4). The reason is that for panicle emergence date, all ecotypes trend to early heading than control and it means that the lower temperature was necessary for vernalization for cocksfoot as a cold season grass. With effect of cold treatment, the GDD of seed setting and harvesting of five ecotypes were lower than control (Table 4) and it means the processing of phenology had affected by cold treatment compare with control.

For quality traits, Karaj, Hamadan and Ardebil had more DMD, CP content by effect of cold treatment than control and therefore they evaluated as ecotype with good quality. In addition the foreign ecotype had more WSC content than other one. It was confirmed by (Christie and McElroy, 1995; Gunn and Farrar, 2002; Martiniello and Andrea , 2006) because their result showed that the effects of cold treatment at 4°C caused increasing of leaf area, dry mass, root respiration and carbohydrates of some population of *Dactylis glomerata*.

## CONCLUSION

On the basis of obtained results, the following conclusions have been achieved:-

- From point of phenological characteristics, ecotype of Hamadan, Bijar and foreign ecotype would prefer than two other ones.

- Regarding to quality traits (DMD and CP), Karaj, Hamadan and Ardebil had good quality than other two ecotypes, the foreign ecotype had more feeding value for WSC.
- Calculating of growth degree days (GDD) during phenology is an important factor for the prediction of optimum time sowing, flowering, harvesting and grazing.

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