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Effects of different harvesting times on the yield and protein content of Bami alfalfa under micronutrient foliar application in Kerman region

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Abstract

Application of an appropriate harvesting time in forage crops plays an important role in yield production, so that if the crop is not harvested timely, the yield decreases even in case of foliar application. Effects of different harvesting times on the yield and protein content of Bami alfalfa were investigated here under foliar application in a split-split plot experiment in time unit based on complete random block designs with four replications in Shahid Zendeh Rooh Kerman Agricultural Research Center (10 km of Jopar road) during 2013 crop year. The Bami cultivar used here was harvested in four different cuttings. The uppermost yields were respectively 6.98, 8.5, 9.3, and −10 for fresh forage, and 24.85, 29.86, and 29.4 for the dry matter. The highest leaf-to-stem ratio was obtained in the first cutting. The first and second cuttings contained the highest (29.73%) and lowest (24.85%) dry matter contents, respectively. Dry forage yield was uppermost (6 t/ha) in the first cutting. Protein levels varied in different cuttings, with the second and fourth cuttings having the highest value (18%). The interaction of Bami alfalfa in different cuttings revealed the superiority of the second cutting to the other ones. This cultivar also had the highest values in some traits among the other cuttings; as a result, Bami cultivar can be superior to other cuttings in Kerman region.

Keywords: Cutting, dry matter content, dry forage yield, alfalfa.

Introduction

Alfalfa is one of the most important forage plants that has gained a special importance among forage plants due to its critical role in providing animal feed and animal husbandry. (Heidari Sharifabad, 2003). It has a high digestibility and contains a variety of vitamins and elements, such as phosphorus, and calcium, which improve the quality of produced meat; this plant can also help natural ecosystems due to the biological nitrogen fixation (Bauer & Roof, 2004).

Ecologically, this plant prevents water wastage from the soil and reduces rising the aquifer because of its deep roots and a long growth period.

The rise of population and the supply of required protein necessitate the identification of factors influencing the quantitative and qualitative increase in animal protein. Accordingly, one of the alternatives to compensate for the shortage of fodder is to introduce a compatible and productive cultivar for each region (Karimi, 1990). Forage quality, such as dry matter and protein contents are also of paramount importance. In addition, leaf-to-stem ratio (LSR) is effective in forage quality. Factors such as temperature, light, and nitrogen fertilizer use can influence the digestibility of forage plants (Ardakani, 2013).

Among factors affecting the yield, the type of nutrition and the availability of nutrients, and harvest time and season are considered as important factors in forage quality (Heidari Sharifabad, 2003). Structural tissues in the plant increase with ripening over time, resulting in elevated carbohydrates and reduced crude protein content and forage digestibility (Lahouti, 2010).

Alfalfa leaves have good digestibility, but the stem is less digestible due to the presence of lignified material and a thick cell wall. With increasing plant growth, the digestibility of leaves remains constant, while this ratio decreases in the stem over time along with decreased LSR as well (Maruin et al., 2010).

Other characteristics of alfalfa include frequent harvesting and post-harvest regrowth potential or grazing at different phenological stages (Fajeria et al., 2002). In the present experiment, the Bami alfalfa contained the highest values in most traits in the first cutting.

(Iranmanesh, 1995) observed the highest number of traits in the second cutting. In general, there are reports about foliar application of nutrients and its effect on different cuttings in terms of various indicators such as fresh and dry forage yields and dry matter and protein contents. Even so, studies in this field are scarce, particularly in southeastern Iran (Kerman region). Moreover, effects of different cuttings on the qualitative and quantitative traits of Bami alfalfa have not been investigated in the tropical region of Kerman. This study, therefore, was performed for the selection and introduction of the best harvest time for maximum forage and protein yields in Kerman region.

Materials and methods

This research was carried out in the farm of Shahid Zendeh Rouh Agricultural Research Center (10 km of Kerman-Jopar road), located at 32° 25′ N with an altitude of 1755 m above sea level, during spring 2013. Based on the climatic classification, the region has a subtropical climate with an average temperature of 15 °C, and rainfall is mostly recorded in spring and autumn.

Foliar application was performed with Fe, Zn, and Mn micronutrients at a level of 4/1000 based on soil test results (Table 1).

Table 1. Results of soil analysis at the study site

Soil texture	Clay (%)	Silt (%)	Sand (%)	EC (Ds/m)	Acidity	Organic C (%)	N (%)	K (mg/ng)	P	Soil depth
Loam-sand	19	13.5	66.8	1.64	7.5	0.48	0.31	100	6.5	0-30
Loam-sand	18	11.5	65	2.01	7.6	0.8	0.39	175	4.2	30-60

Planting operations included plowing, two perpendicular passes of disk harrow, land leveling, plotting, and preparing the experiment map were done on a land fallowed for 2 years. Foliar application was performed to provide the nutrients needed by the plant after harvesting each cutting when the plant grew 20 cm and possessed enough leaves.

The experiment was performed as a split-split plot design in unit time in complete random blocks with four replications. The main factor was Bami alfalfa and the secondary factors were foliar application and harvesting stages. Seeds of Bami alfalfa, prepared from Kerman Agricultural Research Center, were washed by ethanol 70% for 2 min, disinfected at the surface by 1% sodium hypochlorite for 3 min, and then washed with distilled water.

Each experimental unit contained six planting lines with a length of 5 m and 30 cm distance between planting lines. A distance of 1 m was determined between plots to pass through the plots and perform operations. Irrigation was done separately for each replication, with the first irrigation immediately after planting and then once every seven days after establishment of the plants.

To measure fresh and dry forage yields, forage was harvested from the middle of each plot and the fresh crop was weighed immediately after harvest.

Plant height was 15-20 cm at harvest time. Forage was harvested at the beginning of the flowering stage when 5-10% of the plants were flowering in the field. In order to obtain dry weight, the plants were crushed and then two 100 g samples were transferred to the laboratory and placed at 75 °C until they reached a constant weight. The samples were weighed every few days, and the weights were measured with a precise scale after reaching a constant weight.

A sample with a mean of 100 g was obtained as a gross number for statistical analysis. Dry matter content (dry forage content per 100 g of fresh forage) was calculated using the LSR.

The nitrogen content of protein in the samples was calculated using the Kjeldahl method by the following equation.

Protein content (%) = 6.25% × nitrogen content (%) (Kouchaki, 1985).

Data analysis and analysis of variance (ANOVA) were performed using Minitab, Excel, and SAS software. Mean values were compared with Duncan's method at 5% probability level. Excel and Word were used to draw graphs and tables, respectively.

Results and Discussion

Leaf to stem ratio (LSR)

Based on the interaction of foliar application and cuttings, the highest (1.57 g/m^2) and the lowest (0.58 g/m^2) LSR values were obtained with Mn foliar application in the first and the fourth cuttings.

No significant differences were observed in the second and third cuttings (Table 2). The significant interaction between Bami alfalfa and cuttings on the LSR corresponds to that of Marvin (2004), who found that alfalfa quality was dependent on forage harvest times and environmental conditions, and that the plant growth stage in each cutting had a significant effect on forage quality.

In general, LSR is one of the important quality factors in alfalfa that directly affects digestibility. At higher LSRs, forage absorbs more nutrients and has a higher digestibility, meaning that a high LSR increases the digestibility (Ardakani, 2013). (Heidari Sharifabad, 2003) reported that an increase in the yield of Yazdi alfalfa in the third cutting was associated with a decrease in LSR.

The climatic conditions of different regions at the time of harvest, harvest management, and the time of nutrient foliar application are generally LSR-affecting factors that can also change the quality of forage. Additionally, unfavorable environmental conditions reduced LSR values in the cuttings. (Ane et al., 2004) found that more dry matter was allocated to the stem with the final stages of the growing season.

It can be concluded that Bami alfalfa is different in terms of adaptability to environmental conditions with foliar application of micronutrients; moreover, plant growth and successive harvests change the LSR. In this study, it was observed that

LSR values had different potentials in various cuttings, and no distinction was made in the last cuttings when the plant was exposed to cool air due to the tropical nature of this region and the compatibility of this cultivar with the region.

Table 2. ANOVA results for the traits of alfalfa cultivars

		MS				
Sources of variations	**df**	**LSR**	**Dry matter (%)**	**Fresh forage yield**	**Dry forage yield**	**Protein (%)**
Replication	3	0.14	14.80	1.10	0.59	0.03
Micronutrient	4	0.37*	19.10*	229.09**	11.13**	0.23**
Error	12	0.13	6.02	14	1.9	0.01
Cutting	3	7.29**	252.25**	353.5**	38**	1.19**
Cutting × micronutrient	12	0.22**	4.29**	13.70**	1.78**	0.08**
Error	135	0.07	2.60	1.52	0.31	0.05
CV (%)		37.64	5.19	7.70	12.79	1.15

Dry matter

The interaction of Bami alfalfa and cuttings showed that the highest percentage (556 g/m^2) of dry matter belonged to the first cutting (Table 3). (Karimi, 1990) observed that genetic and internal differences in cell structure and their chemical composition were the most important factors in differences between cultivars in terms of dry matter contents. They found that increasing air temperature and heat stress in the third cutting led to increased dry matter. At the same time, the night temperature decreases and respiration decreases, but the high night temperature reduced dry matter content in the second cutting. It seems that the different reactions of alfalfa to nutrients and changes in air temperature in different cuttings resulted in differences and effects on photosynthesis and respiration rates.

Significant differences in different cuttings in terms of dry matter content were also reported by researchers. (Iranmanesh, 1995) detected that the quality traits of alfalfa were dependent on the time of forage harvest and environmental conditions, in particular temperature and light, and the stage of foliar application according to plant needs. (Heidari Sharifabad, 2003) reported that alfalfa forage had maximum quality in early cuttings.

Fresh forage yield

The interaction of Bami alfalfa and cuttings revealed that the first cutting had the highest value (10.5) of forage production (Table 3). Bami cultivar was reported to have a good yield due to the large number of stems per unit area, leaf area index, and high plant height (Akhoondi & Safarnejad, 2003).

The highest levels of fresh forage were obtained in the first (10.5) and second (9.3) cuttings, respectively (Table 3). In this study, temperature changes appear to have a direct effect on the absorption of nutrients and forage levels in different cuttings, and the stress caused by the reduction of root nutrients in the final cuttings can reduce plant forage production. In the first cutting, the plant seems to have undergone more growth period and temperature conditions are more favorable for plant growth. In the second and third cuttings, increased nocturnal respiration led to decreased nutritional reserves of the root and stem, thereby preventing maximum production of forage.

Dry forage yield

The interaction of Bami alfalfa and cuttings showed that dry forage yield was uppermost (6.4 t/ha) in the first cutting (Table 3). No significant differences were observed in some cuttings in terms of dry forage yield, and sometimes the yields of the second and third cuttings were even higher than that of the first cutting (Table 3).

It seems that foliar application time depending on plant needs and the control of nutrient deficiency based on plant morphological traits can be effective on yield. Better quantitative and qualitative yields of Bami alfalfa in the first cutting result from a favorable temperature and more suitable ecological conditions. High quality forage can be harvested from this cutting through the supply of nutrients.

As alfalfa is generally a long-day plant, its exposure to cold temperatures in the first cutting prolongs the plant vegetative growth and increases the plant height compared with subsequent cuttings at the same time, which can explain the increased dry matter yield (Heidari Sharifabad, 2003).

Air temperature and decreased plant growth period and nutrition affect the yield of alfalfa cuttings. For this reason, increasing nocturnal and diurnal temperatures and consequently declined nutritional reserves in the plant led to decreased yields of final cuttings; as a result, alfalfa enters the reproductive stage that reduces forage yield (Akhoondi & Safarnejad, 2003). It can be argued that because Bami alfalfa made better use of nutrients in the initial cuttings, it had faster growth and higher yield, whereas it faced a decrease in nutrients and therefore a decrease in dry forage yield in the final cuttings.

Protein content

The results showed that the second and fourth cuttings contained the highest protein contents (Table 3). The high protein content in the initial cuttings seems to be associated with greater ability of the plant to absorb soil nitrogen and produce leaves. It is concluded that an improvement in the quantitative index, such as fresh and dry forage, leads to a decrease in quality traits, such as protein content, which is in line with that of Marvin (2004).

Table 3. The effect of different cultivars and their interactions

Cutting	LSR	Dry matter (%)	Fresh forage	Dry forage
1	1.56 bd	29.70 be	10.65 bc	6.4 b
2	1.34 bf	24.83 fm	9.3 b	5.77 bc
3	1.31 bh	29.78 bd	8.55 cd	5.07 bh
4	0.57 ij	29.3 be	6.98 di	4.26 di

Conclusion

Overall, our results demonstrated that most indicators in the early cuttings were maximal in Bami alfalfa regarding the absorption of nutrients. In fact, a high potential of Bami cultivar in adaptation to Kerman climatic conditions resulted in more dry forage production. In general, high harvest levels and a significant crop yield could be produced with continuous cultivation due to the tropical nature of the region. In conclusion, this cultivar can be effective with proper nutrition, in particular foliar application of micronutrients and availability of nutrients, to meet the plant needs.

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