

Full Length Research Paper

Suitable management for nitrogen fertilizer consumption and harvesting time of forage yield of pearl millet (*Pennisetum glaucum*) in Shirvan region

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In order to determine the best management of nitrogen fertilizer application and harvest time of forage yield of pearl millet, a field experiment carried out in the Agriculture Researches Center of Shirvan, Iran during 2007 growing season. The experiment was conducted in split plot as complete randomized block design with four replications. The treatment comprised five levels of nitrogen fertilizer as Urea (0, 80, 160, 240 and 300 kg/ha) in the main plots and four levels of harvest (at the stages of 12 to 14 leaves, booting, 50% flowering and seed doughing) in the sub plots. In this research, we measured factors such as stem height, diameter stem, the weight ratio of leaf to stem, and dry forage yield. The results showed that the effect of fertilizer and harvest time were significant on all factors measured. So that the most stem height, diameter stem was achieved from application of 300 kg/ha nitrogen. The highest the weight ratio of leaf to stem obtained from application of 80 kg/ha nitrogen. Interrace treatments of harvest time, the highest stem height, diameter stem were obtained from harvesting in seed doughing stage. The highest weight ratio of leaf to stem was achieved from harvesting at the stage of 12 to 14 leaves. Also, the driest forage yield was obtained from the application of 300 kg/ha nitrogen and harvesting at the stage of seed doughing. The value of correlation coefficient showed that forage yield had a positive and significant correlation with all the factors. Among these factors, the highest correlation was observed with stem height ($r=0.86^{**}$).

Key words: Pearl millet, Nitrogen fertilizer, harvesting time, dry matter.

INTRODUCTION

Considering the present pasture in our country (Iran), they have been exposed to severe destruction and erosion because of high grazing by domestic animals and different drought, so they cannot be responsible for present domestic animals. The cultivation of suitable forage plants including millet can be consider as a suitable solutions for nutrition of present domestic animals, decrease of our country forage import and finally protection of postures because of low water requirement.

Pearl millet (*Pennisetum glaucum*) is an important plant from *Geraminacea* family which can play an important

role in the case of lack of forage removal in summer especially when it is alternated with autumn cultivated plants which is harvested in spring or in early summer due to its different abilities including high heat tolerance, efficient use of moisture, high forage production, ratio of leaf weight to stem height, the possibility of direct grazing by animals because of deficit of cyanidric acid poisonous matter, high quality of forage, and the ability of suitable digestion and the possibility of removing the different folds for appearance of millet abilities. These abilities are required by the plant for suitable management in the cultivated and harvested operating performance (Ghanbari et al., 2011b; Paygozar et al., 2009; Tavassoli et al., 2010a; Ahmadi et al., 2011). Among the used inputs, the amount of nitrogen fertilizer (Esmaeilian

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Table 1. chemical characteristics of soil.

pH	EC (ds/m)	Total N (%)	P (ppm)	K (ppm)	Ca (meq/lit)
7.9	4.14	0.019	1.76	268	14.4

et al., 2011), plant density (Ghanbari et al, 2011a) and harvesting time (Parhamfar, 2006) have an important role in millet yield. Ali (2010) studied the effect of nitrogen fertilizer application and plant density on pearl millet. In this research is used of 4 hectares. the results showed that the increase of nitrogen fertilizer application from 60 to 150 kg which is caused to the increase of yield and the weight of 1000-seeds, plant height and earing length, the weight of seed in earing and the number of earing in each square meter. The results of researches Gascho et al. (1995) and Tavassoli et al. (2010b) showed that the increase in the rate of nitrogen consumption have a significant effect on yield, height, and also the length of millet earing. In an experiment which was done by Maman et al. (2004) in the North east of Nebraska, for determining of the rate of optimum nitrogen on the pearl millet, fertilizer of 0, 45, 95 and 125 kg/ha was used. Results showed that except the level of 125 kg/ha, the response of millet to usage level of nitrogen fertilizer has been linear. Amodu et al. (2001) in the North of Nigeria reported that the yield and quality of millet is not only under effect of nitrogen fertilizer application but is under effect of harvesting time. They also reported that the best harvesting time for millet is seed doughing stage. The results of this research also showed a positive correlation between increasing the age of plant and plant yield. Rostamza (2009) showed that the interaction effect of nitrogen fertilizer and harvesting on dry matter is significant on foraged pearl millet. So that harvesting in the seed doughing stage and the treatment of 250 kg/ha nitrogen has obtained the highest yield of dry matter.

With attention to the increasing population, the increasing of nutrient requirement especially protein, the necessity of exploitation of plants with high compatibility degree to climatic and soil conditions of country (Iran), and with a high protein percentage, demands for providing of forage requirement of country more than ever.

With attention to this fact that after harvesting most fields which are under the cultivation of wheat, barley, rapeseed and grain with about 90% of sufficient water are empty from covering, production and there is no second cultivation, so this will cause lack of optimum efficiency from the soil. Unfortunately in spite of this fact, in our country is paid a little attention to production and the management of forage plants in comparison with the other cultivated plants, and for this reason, this research has been studied with following purposes:

(1) Determining the best application level of nitrogen

fertilizer for obtaining high yield of forage in millet.

(2) Determining the most suitable harvested time of forage with suitable quantity.

(3) Introducing millet as a suitable plant for the second cultivation after autumn cultivations in Shirvan region, Iran.

MATERIALS AND METHODS

This experiment carried out in the research field of Agriculture Researches Center of Shirvan, Iran in the growing season 2007 to 2008. The site lies at longitude 57°45' E, and latitude 37°26' N and the altitude of the area is 1067 m above sea level. It has a semi-arid climate, with cold winters and dry and warm summers. The precipitation average of region has been reported about 250 mm^{yr}⁻¹. The soil characteristics of experimentation site is clay-loam in texture, pH = 8.18 and EC = 1.98 ds.m⁻¹ Table 1. Also experiment site was under fallow a year before this experiment.

This experiment was conducted with the use of split plot as complete randomized block design with four replications. Experimental treatments include the application of nitrogen at five levels (0, 80, 160, 240 and 300 kg/ha) in the main plots and at different times of harvesting, including the harvesting at 12 to 14 leaf, booting, 50% flowering and seed doughing stages as sub plots.

In this research, the factors of stem height, stem diameter, the weight ratio of leaf to stem and forage yield was measured. Each block was including 20 plots. The size of each plot was 2.4×4 m² and there was in each plot, 6 rows with a distance of 40 cm and the length of 4 m.

The distance between plots was selected 80 cm, and the distance between blocks was selected 3 m. Before the culture, 150 kg/ha super phosphate triple fertilizer and 100 kg/ha sulfate of potassium was given to experimental plots. And also nitrogen fertilizer from urea source was added to plots with attention to experimental treatments. The application of nitrogen fertilizer was done in three equal parts and three stages. The first stage was at the beginning time of growing, the second stage was at the stage of 12 to 14 leafy and the third stage was at the stage of flowering. The other practices of cultivation (wedding, irrigation, controlling pests and diseases) were done as required. The first harvest was done at the stage of 12 to 14 leaves. The next harvestings was done in booting, 50% flowering, seed doughing stages as well. For determining the yield of dry forage and measuring other factors, 10 plants were selected from each plot randomly. Factors measured were included: plant height, stem diameter, the weight ratio of leafy to stem and the yield of dry forage.

For determining the yield of dry forage, primarily the weight of fresh forage was measured in samples, then transferred to Oven (within a period of 48 h and in temperature of 70°C) and finally the dry weight of millet forage was measured and reported as kg/ha. The data were analyzed using SAS software; mean comparison was done using Duncan Multiple Comparison at 5% probability level.

RESULTS AND DISCUSSION

The height of stem

The analysis of variance showed that the effect of different rates of nitrogen fertilizer and also the time of harvesting and the interaction effect of these two factors were significant on stem height of millet (P<5%) Table 2.

Table 2. Analysis of variance for yield and growth characteristics of millet.

SOV	df	Plant height	Stem diameter	The weight ratio of leaf to stem	Dry forage yield
		Mean square			
R	3	0.437	0.201	0.012	0.186
Nitrogen fertilizer	4	1568.42*	11.97*	5.06*	116.43*
Ea	12	5.93	3.67	0.191	1.99
Harvest time	3	30481*	2.94*	5.08*	662.34*
Nitrogen×Harvest	12	231.45*	3.15*	4.90*	2.81*
Eb	36	9.82	1.10	3.22	1.65
CV	-	16.12	11.2	19.7	17.01

*, **Significantly different at the 5% and 1% levels of probability, respectively; n.s non significant. df = Degree of freedom.

Table 3. Mean comparison for yield and growth characteristics of millet.

Treatment	Plant height (cm)	Stem diameter (mm)	The weight ratio of leaf to stem	Dry forage yield (kg/ha)
Nitrogen fertilizer (kg/ha)				
0	73.74 ^d	5.41 ^c	1.14 ^a	3121.67 ^d
80	91.12 ^c	7.13 ^d	1.09 ^a	5046.19 ^c
160	115.23 ^b	7.79 ^b	0.92 ^b	5976.32 ^b
240	119.41 ^b	8.56 ^a	0.92 ^b	6844.81 ^a
300	132.25 ^a	8.99 ^a	0.87 ^b	7132.52 ^a
Harvest time				
12-14 leafy	60.11 ^c	6.33 ^c	1.25 ^a	2958.79 ^d
Booting	100.01 ^b	7.25 ^b	1.10 ^b	4731.55 ^c
50% flowering	120.67 ^a	7.41 ^b	0.81 ^c	6004.73 ^b
Seed doughing	122.89 ^a	8.02 ^a	0.76 ^c	7454.11 ^a

Mean followed by similar letters in each column, are not significantly different at the 5% level of probability.

The results of mean comparison of main effects showed that 300 kg/ha nitrogen fertilizer with 132.25 cm had the highest and 0 kg/ha nitrogen fertilizer with 73.74 cm had the lowest average of plant height (Table 3). Mainly, the reason for the increasing stem height by the effect of the application of nitrogen fertilizer is related to the effect of nitrogen accumulated in vegetative growth and the cell divisions in plant tissue especially stem. Rostamza (2009) showed a positive correlation between the rate of urea application and height of plant in range of 0 to 225 kg/ha.

Among the different times of harvesting, the treatment and harvesting at the seed doughing stage had the highest height of plant, while the lowest height of plant was obtained from the treatment and harvesting at 12 to 14 leaf stage.

Of course there is no significant difference between harvesting in seed doughing stage and 50% flowering stage (Table 2). In the length of growth period of plant with increasing age of plants, the height of plant would increase until it reaches the stage of reproduction phase. The height of stem in seed doughing stage was twice as

much at the 12 to 14 leaf stage. The results of this research are similar to research results of Amodu et al. (2001).

The study of interaction effects showed that the highest (159.98 cm) and the lowest (63.74 cm) of plant heights were obtained from the application of 300 kg/ha nitrogen fertilizer and harvesting at seed doughing stage and lack of fertilizer application and harvesting at 12 to 14 leaf stage respectively (Figure 1).

Stem diameter

The effect of different levels of nitrogen fertilizer was significant in probability level of 5% on millet stem diameter (Table 2).

The mean comparison of data showed that the most stem diameter with average of 8.99 mm obtained from treatment of 300 kg/ha nitrogen fertilizer and the lowest of stem diameter with average of 5.41 mm was achieved from treatment of 0 kg/ha nitrogen fertilizer (Table 3).

The effect of different levels of harvest was significant

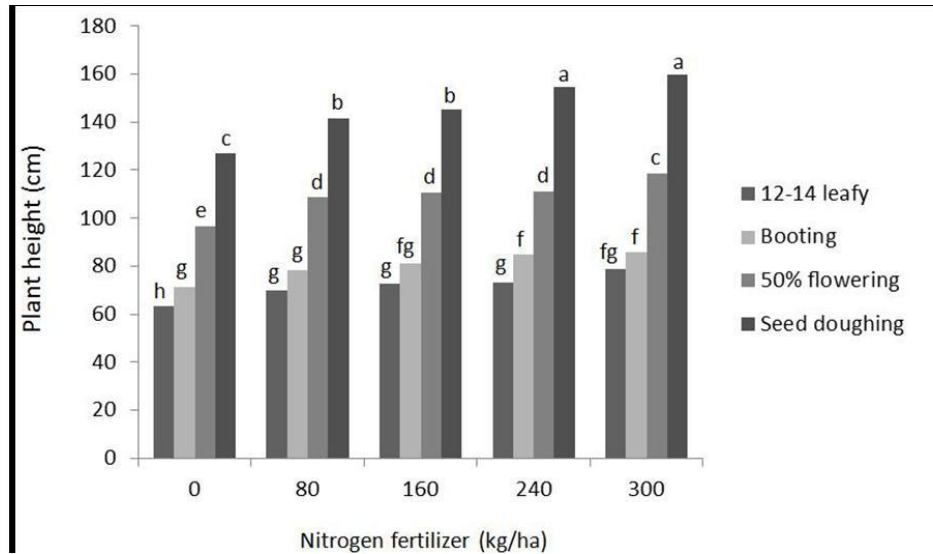


Figure 1. Interaction effect of nitrogen fertilizer and harvest time on plant height. Mean followed by similar letters in each column, are not significantly different at the 5% level of probability.

on stem diameter at 5% probability level (Table 2). The results showed that the maximum stem diameter (8.02 mm) was observed at the stage of seed doughing, while the lowest stem diameter (6.33 mm) was observed at the stage of 12 to 14 leaves (Table 3). Generally, the stem diameter increased with the relay at the time of harvesting. Amodu et al. (2001) reported the results similar to this experiment.

The interaction effect of these two factors was significant on stem diameter ($P < 5\%$) (Table 2). The results showed that the highest amount of stem diameter was achieved from consumption of 300 kg/ha nitrogen fertilizer and harvesting in seed doughing stage and the lowest amount of it obtained from consumption of 80 kg/ha nitrogen fertilizer and harvesting in booting stage (Figure 2).

The weight ratio of leaf to stem

The weight ratio of leaf to stem was under the effect of nitrogen fertilizer factor, harvest time factor and the interaction effect of these two factors in probability level of 5% (Table 2).

The results of mean comparison showed that the lack of nitrogen fertilizer consumption (0 kg/ha) (control) was the highest (1.14), and levels of nitrogen fertilizer (300 kg/ha) have the lowest (0.87) average of the weight ratio of leaf to stem (Table 3).

Also, among the different times of harvest, the stage of 12 to 14 leaves with the average of 1.25 had the highest weight ratio of leaf to stem, while the lowest weight ratio was obtained at the stage of seed doughing with the average of 0.76 (Table 3).

Many researchers reported the reduction of the weight ratio of leaf to stem with increasing plant age in forage plants (Tolera and Sundstol, 1999). In forage plants beginning the stage of reproductive growth, leaves production were stopped while the stem growth continued continuously and consequently the weight ratio of leaf to stem reduced (Birch and Stewart, 1989). It seems that transferring the materials from leaf and losing more aged leaves could be the main reason for changes in material allocation (Wilman and Rezvani, 1998).

This research also improved a negative relation between dry matter yield and the weight ratio of leaf to stem in the plant of forage millet. Birch and Stewart (1989) reported that the highest of weight ratio of leaf to stem was obtained in a treatment that had received the lowest amount of nitrogen. In this research with the increase of nitrogen fertilizer, the weight ratio of leaf to stem reduced from 1.04 to 0.84.

The interaction effect of different levels of nitrogen fertilizer and harvest time showed that in each 5 levels of nitrogen fertilizer with delaying in harvest from the stage of 12-14 leafy to seed doughing stage was observed a 260 percent reduction in the weight ratio of leaf to stem. As the highest weight ratio of leaf to stem (1.49) was achieved from treatment of harvest in the stage of 12-14 leafy and the lack of consumption of nitrogen fertilizer and the lowest amount of it (0.54) obtained from treatment of harvest in seed doughing stage and lack of nitrogen fertilizer consumption (Figure 3).

Dry forage yield

The results of variance analysis showed that factors of

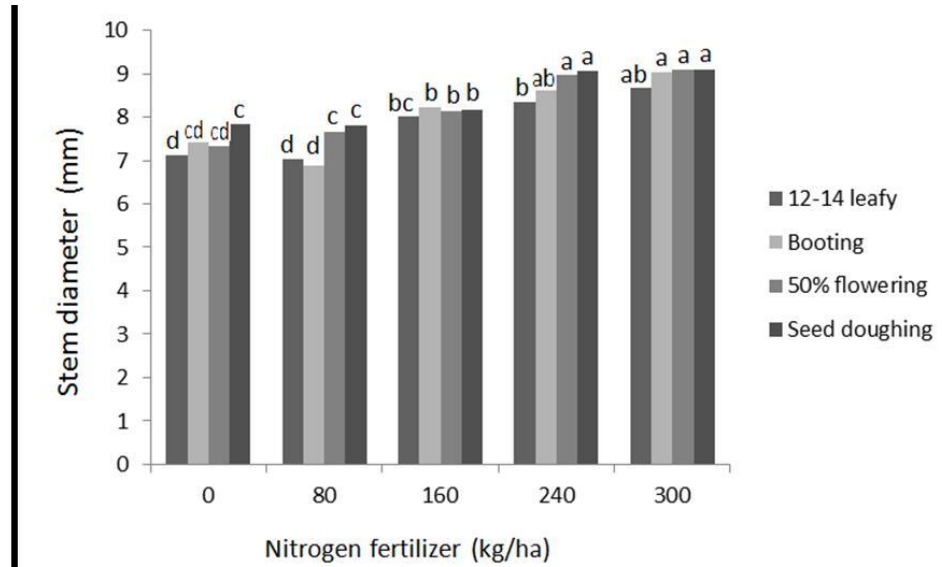


Figure 2. Interaction effect of nitrogen fertilizer and harvest time on stem diameter. Mean followed by similar letters in each column, are not significantly different at the 5% level of probability.

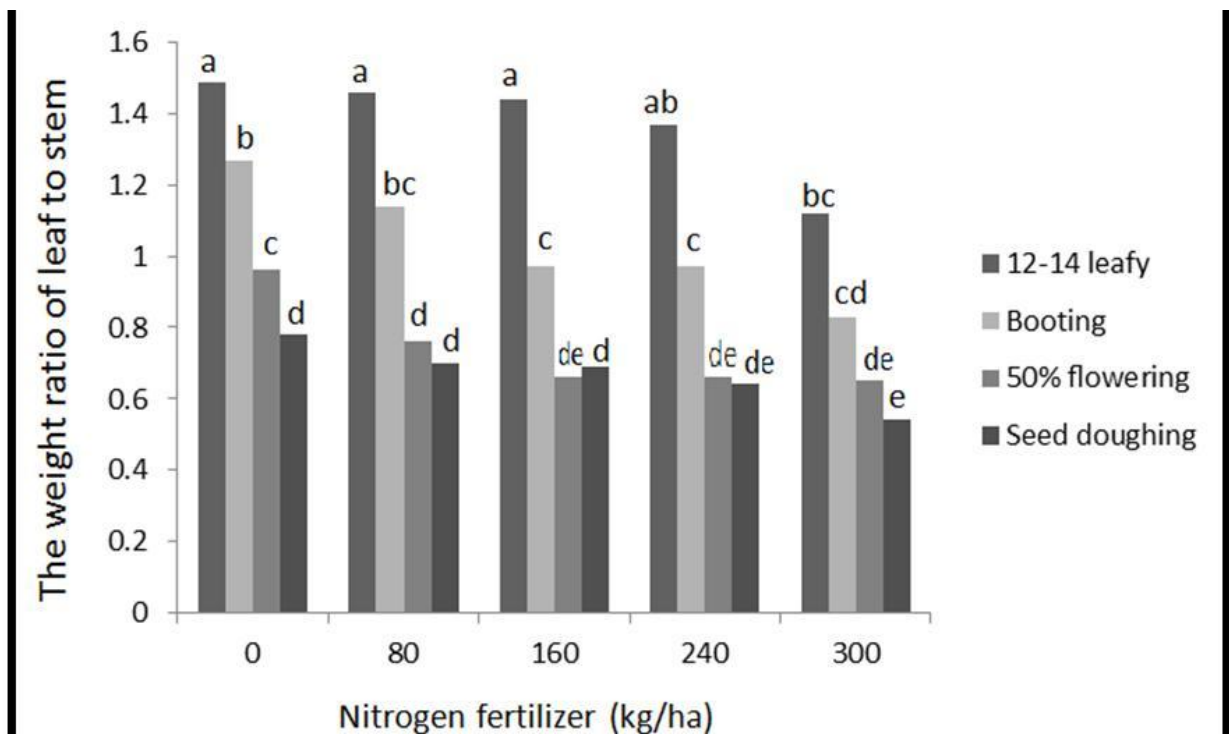


Figure 3. Interaction effect of nitrogen fertilizer and harvest time on the weight ratio of leaf to stem. Mean followed by similar letters in each column, are not significantly different at the 5% level of probability.

nitrogen fertilizer, different times of harvest and interaction effects of nitrogen fertilizer and different times of harvest was significant in probability level of 5% on dry forage yield (Table 2). The mean comparison of main

effects show that the level of 300 kg/ha nitrogen fertilizer had the highest average of forage yield with 7132.52 kg/ha and lack of nitrogen fertilizer consumption (control) had the lowest average of forage yield with 3121.67

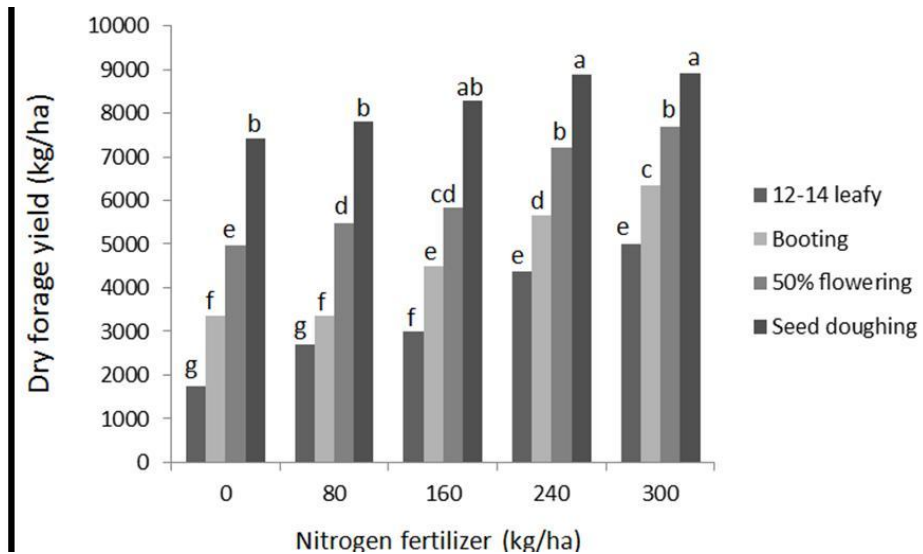


Figure 4. Interaction effect of nitrogen fertilizer and harvest time on dry forage yield. Mean followed by similar letters in each column, are not significantly different at the 5% level of probability.

Table 4. Correlation coefficients of factors under study.

Data	Plant height	Stem diameter	The weight ratio of leaf to stem	Dry forage yield
Plant height	1			
Stem diameter	0.42	1		
The weight ratio of leaf to stem	-0.83**	-0.41	1	
Dry forage yield	0.86**	0.61**	-0.80**	1

*, ** Significantly different at the 5 and 1% levels of probability respectively.

kg/ha (Table 3).

Ali (2010) in a research on the pearl millet under of 4 levels of nitrogen fertilizer (60, 90, 120 and 150 kg/ha) showed that with increasing of fertilizer consumption from 60 to 150 kg/ha, the plant yield would increase. Aghaalikhani (2007) reported that with the increasing of nitrogen consumption from 200 to 400 kg/ha, wet and dry forage yield of millet would increase 17.5 and 23.83% respectively.

The mean comparison of different times of harvest of dry forage yield showed that the highest and the lowest dry forage yield were obtained at the seed doughing stage with an average of 7454.11 kg/ha and 12 to 14 leaf stage with average of 2958.79 kg/ha respectively (Table 3).

These results show that with the delaying in harvest time, dry matter yield increased. Ajayi et al. (1998) showed the maximum of dry matter yield of millet obtained in seed doughing stage. The similar results were reported by Amodu et al. (2001).

The study of interaction effects showed that the most

dry forage yield was seen at the stage of seed doughing and application of 300 kg/ha nitrogen fertilizer (Figure 4).

Correlative relations of studied factors

The estimation of correlation coefficients of factors under study was shown in Table 4. The table showed observation between dry forage yields with plant height. There is a significant and positive correlation ($r = 0.86^{**}$) and it means that dry forage yield has increased with the increasing of plant height. Among all of the studied factors, the height of plant with the dry matter yield had the most correlation of positive and significant.

Between the stem diameter with dry forage yield, a positive and significant relation ($r = 0.61^{**}$) was observed. But there is a negative and significant relation between the weight ratio of leaf to stem with dry forage yield ($r = -0.80^{**}$). Moreover a negative and significant relation was absolved among the weight ratio of leaf to stem with other factors, as well.

Conclusion

1. Millet showed a positive reaction to the usage of nitrogen fertilizer, as the forage yield of millet increased with increasing nitrogen fertilizer.
2. Dry matter yield of millet increased with the delaying in harvest time, so that dry forage yield in seed doughing stage was twice as much booting stage.
3. Generally considering the results of research, the best harvest time and nitrogen fertilizer amount for obtaining the highest forage yield in millet was recommended as harvesting at seed doughing stage and consumption of 280 kg/ha nitrogen fertilizer.

REFERENCES

- Ahmadi AA, Ghanbari A, Sirousmehr A, Siahsar B, Asgharipour M, Tavassoli A (2011). Effect of irrigation with wastewater and foliar fertilizer application on some forage characteristics of foxtail millet (*Setaria italica*). *Int. J. Plant Physiol. Biochem.*, 3(3): 34-42.
- Ajayi O, Owonubi JT, Oyoubisere EO, Zarafi AB (1998). Climatic, edaphic and biological factors limiting millet yield in Niagara Agriculture. Maiduguri, Nigeria. 21-24 April, pp. 9-36.
- Ali EA (2010). Grain Yield and Nitrogen Use Efficiency of pearl Millet as Affected by Plant Density, Nitrogen Rate and Splitting in Sandy Soil. *American-Eurasian J. Agric. Environ. Sci.*, 7(3): 327-335.
- Amodu JT, Kallah MS, Onifade OS, Omokanye AT, Adeyinka AI (2001). The effect of harvesting at different growth stages on yield and quality of three late maturing pearl millet accessions in northern Nigeria. *Trop. Grasslands*, 35: 175-179.
- Birch CP, Stewart D (1989). The effect of nitrogen fertilizer rate and timing on the yield of hybrid sorghum from serial harvest. *Australian sorghum*, 12: 142-149.
- Esmailian Y, Ghanbari A, Babaeian M, Tavassoli A (2011). Influence of organic and inorganic fertilizers and wastewater irrigation on yield and quality traits of corn. *American-Eurasian J. Agric. Environ. Sci.*, 10(4): 658-666.
- Gascho GJ, Menezes RSC, Hanna WW, Hubbard RK, Wilson JP (1995). Nutrient Requirements of Pearl Millet. In *Proc. Natl. Grain Pearl Millet Symp. 1st*, Tifton, GA. Univ. of Georgia, Tifton, pp.: 92-97.
- Ghanbari A, Siahsar BA, Tavassoli A, Esmailian Y, Babaeian M (2011b). Effect of uniconazole and cycocel on growth, yield and nutrients uptake of pearl millet under drought stress condition. *American-Eurasian J. Agric. Environ. Sci.*, 10(5): 857-862.
- Ghanbari A, Nasirpour M, Tavassoli A (2011a). The evaluation of ecophysiological characteristics of millet (*Anicum miliaceum* L.) and cowpea (*Vigna unguiculata* L.) in Intercropping. *J. Agroecol.*, 2(4): 1-12.
- Maman N, Stephen C, Galusha T, Max D (2004). Hybrid and nitrogen influence on pearl millet production in Nebraska. *Agronomy J.*, 91(25): 737-743.
- Parhamfar T (2006). Effect of macro and micro fertilizers and harvest time on yield and quality of foxtail millet (*Setaria italica*). MSc thesis. University of Zabol, Iran, p. 102.
- Paygozar Y, Ghanbari A, Heydari M, Tavassoli A (2009). Effect of foliar application of certain micronutrients on qualitative and quantitative characteristics of pearl millet (*Pennisetum glaucum*) under drought stress. *J. Agric. Sci.*, 3(10): 67-79.
- Rostamza M (2009). Production and quality of pearl millet in different stages of vegetative growth under drought stress and nitrogen fertilizer. Ph.D. thesis. University of Tehran, Iran, p. 179.
- Tavassoli A, Ghanbari A, Ramezan D, Mousavi M, Nik, (2010b). Effect of organic and inorganic fertilizers on quantity and quality characteristics of pearl millet (*Panicum miliaceum* L.) and red bean (*Phaseolus vulgaris* L.) in intercropping. *J. crop weed ecophysiol.*, 4(15): 1-16.
- Tavassoli A, Ghanbari A, Ahmadi MM, Heydari M (2010a). The effect of fertilizer and manure on forage and grain yield of millet (*Panicum miliaceum*) and bean (*Phaseolus vulgaris*) in intercropping. *Iranian J. Agro. Res.*, 8(2): 96-114.
- Tolera A, Sundstol F (1999). Morphological fractions of maize stover harvested at different stages of grain maturity and value of different fraction of the stover. *Anim. Feed Sci. Technol. J.*, 81: 1-16.
- Wilman DP, Rezvani M (1998). *In vitro* digestibility and neutral detergent fiber and lignin content of plant parts of nine forage species. *J. Agric. Sci.*, 131: 69-77.