Effect of oat-fenugreek intercropping ratios, Nitrogen fertilizer and gebberellic acid on quantitative and qualitative of forage

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Abstract
To investigate the yield and quality of forage in mixed intercropped of Oat and fenugreek, an experiment was conducted as split split plot using randomized complete blocks design with three replications in August 2015 in Dehloran in Ilam province. In this experiment four nitrogen levels including:0, 75, 150 and 225 kg N. ha^{-1} were assigned to main plots, Spraying with 5 gr of powder contains 18% gibberellic acid in two levels including: With gibberellicacid and no gibberellic acid were assigned to sub-plots and five levels of replacement ratios of mixed intercropped (100% Oat), (75% Oat +25% fenugreek), (50% Oat +50% fenugreek), (25% Oat +75% fenugreek), (100% fenugreek) were randomized in sub sub-plots. Results showed that the highest Dry matter forage yield (2933 kg.h), ADF and NDF were obtained from 100% Oat, 150 kg N. ha^{-1} And application of gibberellic acid. The highest crude protein content and dry matter digestibility were obtained from 100% fenugreek, application of 150 kg N. ha^{-1} and application of gibberellicacid. The highest water Soluble carbohydrates were obtained from 100% fenugreek, application of 150 kg N. ha-1 and application of gibberellicacid And highest Ash content of forage were obtained from 100% fenugreek, Without the use of nitrogen and gibberellicacid. In general, by increasing the ratio of oat culture in intercropping, the dry matter yield of forage increased and the Increasing the ratio of Fenugreek crop cultivation in intercropping forage quality increased. But the highest forage yield and forage quality were observed in pure crop.
Keyword: CP, ASH, yield, DMD, intercropping ratios

Introduction

As the world's population continues to grow, the ecological balance will continue to deteriorate, so we must take action to increase agricultural production and preserve the environment. So far, various measures have been taken to increase crops and horticulture, such as the use of technology, genetics, chemical fertilizers, and plant toxins, but the application of these measures has only been able to meet part of our need for food on a regional basis. Therefore, food supply should be at the top of the agenda while preserving the environment. One of the ways that brings us closer to this goal is the cultivation of mixed plants (Najafi et al., 2005). Mixed cultivation increases diversity in an agricultural ecosystem and enables the establishment of interrelationships between different crops (Sastava et al., 2004). Many researchers have reported the advantages of intercropping over monoculture (Schenny et al., 2010; Zardari, 2011) which increase yield per unit area, use resources more efficiently, reduce pest problems, increase system stability and provide better nutrition. Becomes human and animal (Innocent et al., 2014).

Blend cultivation of legumes and wheat is recognized as one of the most important agricultural systems applicable in many developed countries, which is of special importance for the diversity of crops and increase profits per unit area and time (Nakhzari_Moghaddam Et al., 2013). In many mixed culture experiments, the components of the mixture are a species of legume and a species of wheat, which in most cases have a superior performance over a single vessel (Liturgidis et al., 2011). In mixed cultivation of beans and wheat from wheat and legumes, it was observed that mixed cultivation improves forage quality. In this culture method, the content of crude protein and water-soluble carbohydrates (WSC) increased and the content of neutral detergent (NDF) and acidic fibers (ADF) decreased (Ghanbari-Benjar and Lee, 2003). The results of experiments have shown that legumes are self-sufficient in mixed culture in terms of nitrogen content and are able to transfer some nitrogen to the accompanying weeds at the same time. This issue is one of the desirable characteristics in sustainable agricultural communities (Ghanbari et al., 2016). The positive effect of nitrogen chemical fertilizers on the performance of fenugreek has been reported by various researchers (Tonster et al., 2011; Dadarsan et al., 2015). Also, some researchers have reported the use of gibberellic acid hormone on increasing the quantitative and qualitative traits of mung bean plant (Kikha et al., 2016).

Fenugreek (Trigonella foenum-ecum L.) is an annual plant of the legume family that has forage, medicinal and spice uses (Mohammadabadi et al., 2011).

Oats (Avena sativa L.) is a plant from the Poaceae wheat family among cereals for producing dry fodder for livestock consumption is of very good quality (Khan et al., 2012).

The purpose of intercropping experiments, especially intercropping of plants, is to produce forage, increase yield per unit area and improve crop quality. Most intercropping experiments include legumes and wheat plants. Wheat produces a lot of dry matter, but is poor in protein. In contrast, legumes such as fenugreek are high in protein, so a mixture of wheat and legumes will increase production and improve forage quality (Ghanbari et al., 2016). The purpose of this experiment is to evaluate the effect of different levels of nitrogen and gibberellic acid hormone on the quantity and quality of forage obtained from a mixture of oats and fenugreek for sustainable production of forage crop.

Materials and methods

In this experiment, oat and fenugreek mixed cultivation as alternative series under the influence of different levels of nitrogen fertilizer and gibberellic acid hormone in the crop year (2015-2016) in Dehloran city in the farm of Etka Organization with geographical coordinates of 32 degrees and 38 minutes north And longitude 46 degrees and 26 minutes east, with an altitude of 213 meters above sea level. The soil characteristics of the test site are presented in Table 1. The experiment was conducted in the form of double split plots in a randomized complete block design with three replications in which the application of nitrogen fertilizer in the main plot at four levels (zero, 75, 150 and 225 kg / ha from urea source) Application of Gibberellic Acid in Sub-Plots at Two Levels (No Hormone Consumption and with Hormone Consumption) and Mixed Cultivation Ratios in Sub-Plots at Five Levels: Pure Cultures of Both Plants and 75% Oat Mixed Cultures + 25% fenugreek, 50% oats, 50% fenugreek and 25% oats + 75% fenugreek were considered. Each plot consisted of 12 planting lines at a distance of 20 cm from each other, lines 1 and 12 were considered as margins, and also the first and last half meters of each line were not sampled due to the effect of margins. Sub-plots with a length of four meters and a width of 2.5 meters were considered. The distance of the replicates was two meters from each other, the sub-factors were one meter apart and the sub-factors were half a meter apart. The density of oats was 200 plants per square meter (Soleimani Abiat et al., 2015) and for fenugreek 40 plants per square meter was considered and the distance between the piles was 12.5 cm. Fenugreek seeds were sown in heaps considering the desired density and four seeds were placed in each heap (Mohammadabadi et al., 2011). Depth of planting oats was 3-4 cm (Soleimani Abiat et al., 2015) and for fenugreek was considered 1-2 cm. Cultivation was done linearly (Mohammadabadi et al., 2011). Fenugreek seeds were selected from the native population of Ahvaz and oat seeds were of A. sativa species which were prepared from Pakan Seed Company of Isfahan. The basis of forage harvesting in

Results and discussion

The results of analysis of variance showed that the simple effects of culture ratio, nitrogen fertilizer and gibberellic acid fertilizer as well as the interaction effect of nitrogen fertilizer and gibberellic acid on forage dry matter yield of oats and fenugreek were significant (Table 2). Based on the results of comparing the means, it was found that with increasing the ratio of oats to fenugreek in mixed cultivation, the dry forage yield increased and the ratio of 100% oats to the highest (2933 kg / ha) and 100% fenugreek (1617 kg / ha) Hectares) had the lowest forage dry matter (Table 3). In this regard, Ahmadi et al. (2017) reported similar results in mixed cultivation of oats and clover brisme that increasing the ratio of oats in mixtures with clover caused an increase in forage yield. This can be attributed to saffron for reasons such as higher biomass yield of oats compared to oats. Lamayi Hervani et al. (2012) in mixed cultivation of barley and barley reported that the highest forage dry matter yield was obtained in barley cultivation and mixed crops had a significant advantage over pure cultivation of barley. Genetic potential and adaptability were attributed to environmental conditions. The interaction of nitrogen fertilizer application and gibberellic acid consumption had a significant effect on the forage yield of oats and fenugreek and the highest dry forage yield was obtained in the application of 150 kg nitrogen using gibberellic acid (Figure 1). In this regard, Ghorbani et al. (2011) regarding the use of gibberellic acid in increasing the growth and yield of forage plants and Kiani et al. (2014) on the effect of nitrogen fertilizer on forage yield in intercropping of barley and fennel presented similar results. It is consistent with these results. Gibberellic acid may increase cell division within fenugreek and oat seedling meristems, thereby promoting better plant growth and forage yield. Nitrogen fertilizer also increases the vegetative growth of plants and ultimately increases the yield of dry forage. Kikha et al. (2016) stated that gibberellic acid usually increases greenery, growth and expansion of the root system. And according to some researchers, with increasing nitrogen consumption, dry matter accumulation increases, which indicates the effect of nitrogen on plant growth and increase forage yield (Kikha et al., 2014).

Crude forage protein (CP)

The results showed that the interaction of gibberellic acid and culture ratio and the simple effects of nitrogen and gibberellic acid fertilizer had a significant effect on the amount of crude protein in forage composition (Table 2). Application of nitrogen fertilizer and gibberellic acid increased the amount of crude protein in the composition of oatmeal and fenugreek (Table 5 and Figure 2). In forage production, the amount of protein is very important in terms of quantity and quality in animal nutrition and fenugreek leaves are rich in terms of crude protein. In the present study, it was observed that the application of nitrogen and gibberellic acid fertilizers had a positive and significant effect on increasing the amount of crude protein in fenugreek and oat crops. In this regard, Gholam-Hosseini et al. (2008) reported that the highest protein yield was consumed. The highest amount of nitrogen was obtained, which is consistent with these results. It seems that the application of gibberellic acid and nitrogen fertilizer increased nitrogen in the leaves and increased leaf area, and as a result, increasing the leaf-to-stem ratio increased protein and decreased woody and lignin parts in the forage.

Also, based on the results of this study, it was found that with increasing the ratio of fenugreek cultivation in intercropping, the amount of crude protein increased significantly and the highest value related to this trait (24.31%) was obtained in pure fenugreek cultivation (Figure 2). And as the percentage of fenugreek in the blend mix increased, the amount of forage protein also increased. The reason for this, in addition to the reduction in the percentage of oats, is most likely due to the high percentage of fenugreek protein. Some researchers have attributed the increase in crude protein content to increased nitrogen fixation by the legume plant (Ahmadi et al., 2017). Naghizadeh and Glavi (2012) found that by decreasing the ratio of maize and increasing the ratio of kelp in mixed ratios, up to 100% of khlv cultivation, the forage yield increased by increasing the amount of crude protein.

Percentage of insoluble fibers in acidic detergents (ADF) and neutral (NDF)

Based on the results of analysis of variance, it was found that the simple effects of culture lineage treatments, nitrogen fertilizer levels and gibberellic acid application on ADF and NDF were significant. Based on the results of comparison of means, it was proved that in 100% oat cultivation, the highest amount, and in 100% fenugreek cultivation, had the lowest amount of ADF and NDF, and in mixed crops, the values of these two traits increased with increasing oat cultivation ratio. (Table 3). In this regard, Contras et al. (2006) concluded that the content of NDF and ADF in pomegranate was lower than winter wheat and had a moderate amount in mixing, which is consistent with these results. Due to the fact that legumes have less cellulosic and hemicellulose content than cereals, in addition to increasing the ratio of oats in the mixture, the amount of NDF and ADF in forage also increases. He was placed in the first place.

Based on the available results, the significant effect of nitrogen fertilizer application and gibberellic acid application on the percentage of ADF and NDF was determined, so that with increasing nitrogen fertilizer application from zero to 150 kg / ha, the amount of ADF and NDF increased and with the application of 225 kg N Values related to these traits decreased (Table 4). The results also showed that the application of nitrogen fertilizer, especially the amount of 150 kg per hectare increased NDF and ADF, so it can be inferred that with the use of nitrogen and the addition of oats to the mixture, vegetative growth increased and the plant was somewhat out of grass. And the amount of NDF and ADF has increased. Also, the reason for this increase can be attributed to the replacement of oats with fenugreek and the higher ADF and NDF of oats compared to fenugreek in order to further promote the life cycle of oats compared to fenugreek, compared to Kian et al. (2014). Plant, the percentage of hemicellulose-free cell wall will increase, and this is because as the plant ages, the cell wall becomes thicker and rougher, increasing the amount of crude fiber and lignin.

Forage soluble carbohydrates (WSC)

The results of analysis of variance showed that the interaction of nitrogen fertilizer and mixing ratio, nitrogen fertilizer and gibberellic acid as well as the simple effects of these treatments in intercropping had a significant effect on soluble carbohydrates in forage (Table 2). Comparison of means showed that the highest amount of soluble carbohydrates in forage (17.9%) in the treatment of pure oats and the application of 75 and 150 kg of nitrogen fertilizer and the lowest amount (8.7%) in the treatment of pure fenugreek And was obtained without the application of nitrogen fertilizer (Figure 3). The interaction of nitrogen fertilizer and gibberellic acid had a significant effect on water soluble carbohydrates and the highest amount of soluble carbohydrates was allocated to 150 kg nitrogen treatment and application of gibberellic acid (Figure 4).

Studies have shown that soluble carbohydrates are one of the most important components in determining the quality of forage, which is responsible for providing energy for rumen microorganisms and maintaining the health of the gastrointestinal tract of animals (Litorogidis et al., 2006). With increasing the share of oats in intercropping, the amount of soluble carbohydrates had an increasing trend. In general, it can be said that cereals have more soluble carbohydrates than legumes, and in this study, the increase of oats in the mixture had a significant effect on the increase of soluble carbohydrates. In this regard, in the cultivation of corn and mung bean, the most The percentage of water-soluble carbohydrates was obtained from pure corn and the lowest percentage from pure mung bean (Nakhzari-Moghaddam et al., 2009). Regarding the significant effect of nitrogen and gibberellic acid fertilizer, Tarighi et al. (2018) by examining the effect of different ratios of barley and fenugreek mixed crops under nitrogen fertilizer pointed out the importance of nitrogen fertilizer in increasing soluble carbohydrates. Soluble carbohydrates are considered to improve soil texture and the gradual release of absorbable nitrogen into the soil, because when nitrogen is gradually absorbed by the plant, it intensifies the photosynthetic activity of the plant and the storage of carbohydrates in the plant organs.

Fodder ash (ASH)

The results of analysis of variance showed that the effects of culture ratio, gibberellic acid and nitrogen fertilizer on the percentage of forage ash were significant at the level of 1% probability (Table 2). Also, the results of comparing the means in Table 3 showed that the highest percentage of forage ash (8.55%) was obtained in pure fenugreek cultivation and the lowest (6.61%) was obtained in pure oat cultivation. Application of nitrogen fertilizer and gibberellic acid had a negative effect on increasing forage ash and treatments without nitrogen application and no application of gibberellic acid showed the highest amount of forage ash (Tables 4 and 5).

The amount of forage ash indicates the amount of minerals in plant tissues and these elements are necessary and important for the activity of body cells in terms of their effect on animal metabolism. Grain fodder often indicates mineral deficiency. In the present study, the use of nitrogen fertilizer and gibberellic acid increased the vegetative growth of both plants and reduced the ash content of both plants due to the increase of lignin tissues. In this study, with increasing the ratio of fenugreek cultivation in mixed cultivation, the amount of forage ash had an upward trend. Shakeri et al. (2019) in mixed cultivation of cowpea and corn beans showed that by decreasing the proportion of maize in mixed treatments and increasing the share of beans, cowpea was added to the percentage of forage ash, which is consistent with these results. In another study, corn-bean mixture cultivation improved forage quality in terms of ash content compared to pure cultivation, which may be due to better absorption of elements in mixed cultivation than pure cultivation (decade). Dead et al., 2011).

Digestible Dry Matter (DMD)

Based on the results of analysis of variance, dry forage digestibility (DMD) was affected by the simple effects of all three treatments (Table 2). With increasing fenugreek cultivation ratio in mixed cultivation, forage digestibility increased and its highest amount (73.14%) was observed in pure fenugreek cultivation (Table 3). Application of nitrogen fertilizer and gibberellic acid-hormone increased forage digestibility so that by applying 150 kg / ha nitrogen fertilizer from urea source, forage digestibility increased from 61.37% in control treatment to 66.07. Acid also increased forage digestibility by about three percent compared to treatment without gibberellic acid. (Tables 4 and 5). High digestibility improves the efficiency of nutrient conversion by the animal. In addition, digestibility is the most important trait for increasing livestock weight and milk production. In the present study, this was important in intercropping. The highest amount was in pure fenugreek and the lowest in pure oats. Had. The reason for the high digestibility of fenugreek compared to oats can be attributed to the high ratio of leaf to stem and herbaceous stem due to low ADF and NDF. Some researchers have reported low levels of digestible nutrients in a plant with a high hemicellulose-free cell wall (Litorogdis et al., 2011). According to the results of these researchers, low digestibility and high hemicellulose-free cell wall can be generalized to the results of the present experiment. According to the results of this study, in addition to the treatment ratio of two other factors, namely nitrogen levels and the use of gibberellic acid, also had a significant effect on increasing forage digestibility, which is consistent with the results of Kiani et al. (2014) in barley and fennel intercropping.

Table 1. Physical and chemical properties of soil in the test area during2016-2017

soil pattern	Phosphorus ($mg.kg^{-1}$)	Nitrogen (%)	potassium ($mg.kg^{-1}$)	Organic matter (%)	PH	Electrical conductivity ($\mu mhos.cm^{-1}$)	Depth of soil to a pan (cm)	Year
Clay	6	0.08	188	0.65	7.65	4.1	0–30	2016

Table 2. Analysis of variance of dry matter yield and forage quality traits of oat and fenugreek compounds in nitrogen and gibberellic acid fertilizer treatments.

(ms)								
Dry matter performance	(CP)	(ADF)	(NDF)	(WSC)	(ASH)	(DMD)	Degrees of freedom	Sources of changes
١٤٩٦/٢٦	٠/١١	٠/٣٥	٠/١٤	١/٣٥	٠/٠٨	٢/١٣	٢	Block
١٤٤٣٠٣٠**	١٠٧/٣٦**	٣٩/٢٥**	٥٥/٧٩**	٢٣٢/٨٢**	١٠/٢٦**	١٣٣/٨٧ **	٣	Nitrogen
٦٥٣٣/٥٧	٠/٦٩	٠/٤٤	٠/٤٣	٠/٠٩	٠/١٨	٠/٨٥	٦	The main error
٤٨٢٥١٤/٧٢**	١٧٠/١٩**	٠/٥٦ **ns**	٠/٠٧ **ns**	٣٨/٩٣**	١٦/٢٤**	١٥٥/٠٩ **	١	gibberellic acid
٢٣٠٢٥/٧١*	١/٨٦ **ns**	٠/٠٥ **ns**	٠/٠١ **ns**	١/٥٩**	٠/٧٧ **ns**	١/٠٩ **ns**	٣	Nitrogen * gibberellic acid
٤٣٦٩/٥٠	٠/٦٣	٠/١٥	٠/٤٩	٠/١٩	٠/٢٩	٠/٧٦	٨	Sub-error
٧١٠٧٣٠٣/٢٥ **	٢٥٦/١٣**	٦٤/٣٤**	٢٩٧/٦٨ **	٥٩/٠٧**	١٥/٨٧**	/٤٦ ١٨٩١**	٤	Cultivation ratio
٨٧٠٠/٧٧ **ns**	٢/٠٦ **ns**	٠/٠٣ **ns**	٠/٥٣ **ns**	٠/٩٩**	٠/١٤ **ns**	٠/٧٣ **ns**	١٢	Nitrogen * Cultivation ratio
٨٤٨/٧١ **ns**	٣/٢٧*	٠/٠٢ **ns**	٠/٠١ **ns**	٠/٤٦ **ns**	٠/٢٢ **ns**	٠/٧٨ **ns**	٤	Gibberellic acid * Cultivation ratio
٣٤٥/٤٤ **ns**	٠/٩٠ **ns**	٠/٠٤ **ns**	٠/٠١ **ns**	٠/٣٨ **ns**	٠/٠٥ **ns**	٠/٢٦ **ns**	١٢	* Cultivation ratio
٥٦٦٨/٥٧	١/٢٣	٠/٤٤	٠/٤٩	٠/٣٢	٠/١٥	٠/٦٤	٦٤	Sub-error

.ns and * and ** are insignificant and significant at the probability level of 5% and 1%, respectively

Table 3 - Comparison of average dry matter yield and some forage quality traits of oat and fenugreek compounds

(kg. ha^{-1})	**ADF (%)**	**NDF (%)**	**ASH (%)**	**DMD (%)**	Cultivation ratio (%)
٢٩٣٣**a**	٣٢/٦٣**a**	٤٧/٥**a**	٦/٦١**e**	٥٠**e**	oats %١٠٠
٢٦٢٠**b**	٣١/٣٤**b**	٤٦/١٨**b**	٧/٠٥**d**	٦٠/٩٣**d**	oats + 25% fenugreek %٧٥
٢١١٢**c**	٣٠/٣١**c**	٤٤/٢٨**c**	٧/٥٧**c**	٦١/٧٤**c**	oats + 50% fenugreek %٥٠
١٨٤٥**d**	٢٩/٢١**d**	٤١/٩٩**d**	٨/٢٧**b**	٦٩/١٤**b**	fenugreek + 25% oats %٧٥
١٦١٧**e**	٢٨/٥٥**e**	٣٨/٦٣**e**	٨/٥٥**a**	٧٣/١٤**a**	fenugreek %١٠٠

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Table 4: Comparison of mean forage quality traits of oat and fenugreek compounds in nitrogen fertilizer treatments

Insoluble fibers in ADF (%) acid detergents	Insoluble fibers in NDF neutral (%) detergent	(%) Total ash, ASH	Dry matter digestibility of (%) DMD	Nitrogen fertilizer (kg. ha-1)
٢٩/٣٥c	٤٢/٦٧c	٨/٢٢a	٦١/٣٧c	0
٣٠/٣٠b	٤٣/١٦b	٧/٩٨a	٦١/٨٨c	۷۵
٣٢/٠٢a	٤٥/٧٢a	٧/٠٠b	٦٦/٠٦a	۱۵۰
٢٩/٩٧b	٤٣/٣١b	٧/٢٣b	٦٢/٦٥b	۲۲۵

Table 5 - Comparison of mean forage quality traits of oat and fenugreek compounds in gibberellic acid treatments

Crude protein (%)	Whole ash (%)	Dry matter digestibility (%) of DMD	gibberellic
١٩/٠١a	۷/۲۴b	٦٤/١٢a	With gibberellic acid
١٦/٦٣b	٧/٩٨a	٦١/٨٥b	No gibberellic acid

In each column, the averages that have common letters are not significantly different at the 5% probability level based on the LSD test.

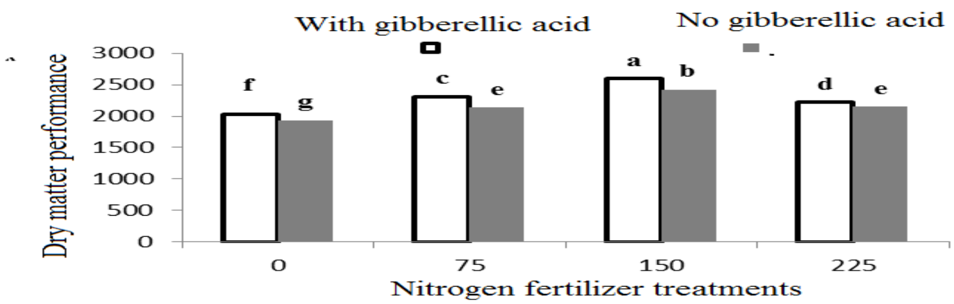

Figure 1- Comparison of mean forage dry matter yield of oat and fenugreek compounds in nitrogen and gibberellic-fertilizer reciprocal treatments

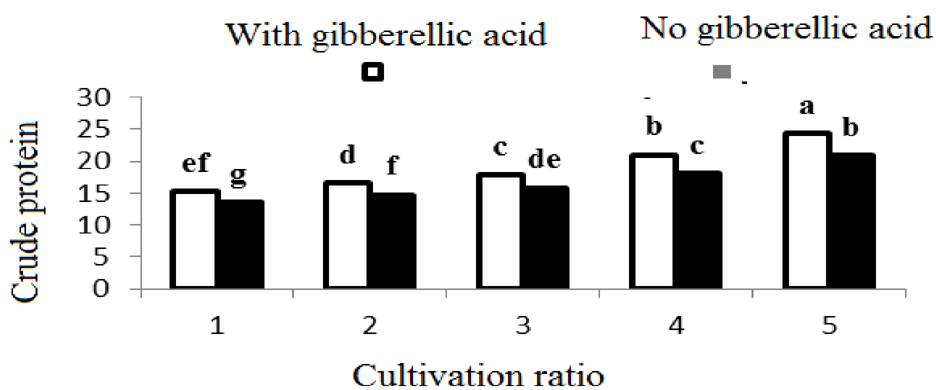

Figure 2 - Comparison of mean crude forage protein of oat and fenugreek combinations in gibberellic acid-reciprocal treatments and cultivation ratio (1-5 numbers for 100% oats, 75% oats + 25% fenugreek, 50% oats + 50%, respectively) Fenugreek is 75% fenugreek + 25% oats and 100% fenugreek).

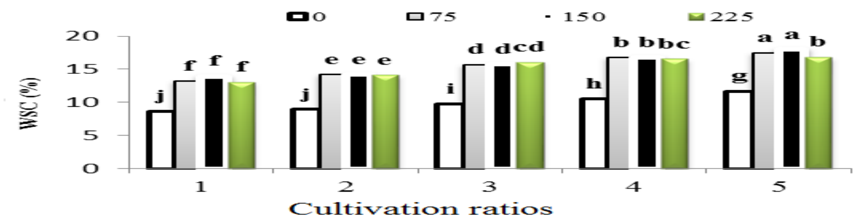

Figure 3 - Comparison of the mean interactions of nitrogen fertilizer and culture ratio on water-soluble carbohydrates of oatmeal and fenugreek forage compounds (numbers 1 - 1 for 100% oats, 75% oats + 25% fenugreek, 50% oats, respectively) + 50% fenugreek, 75% fenugreek + 25% oats and 100% fenugreek).

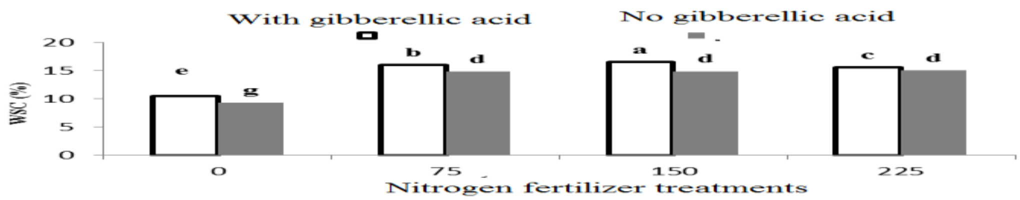

Figure 4 - Comparison of mean water soluble carbohydrates of oat and fenugreek compounds in nitrogen and gibberellic acid reciprocal treatments

Conclusion

The results of this experiment showed that fenugreek plant had higher protein content, dry matter digestibility and forage ash percentage than oats and the highest amount related to these traits was allocated to pure fenugreek cultivation. Also, the highest yield of forage dry matter, water-soluble carbohydrates, insoluble acidic and neutral detergent fibers were obtained in 100% oat cultivation ratio. The higher the amount of oats in cultivation ratios, the higher the yield of forage dry matter, insoluble and neutral detergent fibers and its compaction ratio increased. It seems that the presence of fenugreek in mixed culture with oats increases the quality of the mixture because the higher the amount of fenugreek in mixed culture, the higher the protein content in the mixture and the lower the amount of insoluble acidic and neutral fibers. As a result, its quality and palatability increase, which can ultimately increase the variety and stability of the intercropping system. In general, 75% oats + 25% fenugreek were superior in terms of forage yield and 75% fenugreek + 25% oats were superior in terms of forage quality. Application of nitrogen and gibberellic acid fertilizer had a positive effect on the quantitative and qualitative characteristics of forage except forage ash content. Oats and fenugreek are more suitable.

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