International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

TuEngr Group

PAPER ID: 10A12R

EFFECTS OF SEED PLANTS ON QUANTITATIVE AND QUALITATIVE YIELDS OF VETCH AND BARLEY IN DIFFERENT MIXING RATIOS

Mehdrad Jilani [a], **Hossein Ajam Norouzi** [a*], **Abolfazl Faraji** [b]

[a] *Department of Agronomy and Plant Breeding, Faculty of Agriculture, Gorgan Branch, Islamic Azad University, Gorgan, IRAN.*

[b] *Golestan Agricultural and Natural Resources Research and Education Center, Agricultural Research, Education and Extension Organization (AREEO), Gorgan, IRAN.*

ARTICLEINFO

Article history:
Received 20 May 2019
Received in revised form 10 July 2019
Accepted 26 July 2019
Available online 07 August 2019

Keywords:
Intercropping; Seed plant; Forage yield; Protein yield; Land equivalent ratio; Forage protein content; Rice husk treatment; Traits of seed plant.

ABSTRACT

Cereal-legume intercropping is one of the ways to achieve greater forage production. In order to evaluate the effects of seed plants on quantitative and qualitative yields of vetch and barley forage, a factorial experiment was conducted in a completely randomized block design in paddy fields of Rice Research Institute of Iran (Rasht) during two seasons of 2013-2015. Experimental factors included application of seed plant in two levels (control without vetch and rice husk) and seed ratio (vetch monoculture; barley monoculture; conventional 25% vetch + 75% barley as replacement intercropping; 20% vetch to barley as additive intercropping; 40% vetch to barley as additive intercropping; and 60% vetch to barley as additive intercropping). The traits evaluated included qualitative traits (WSC, ADF and NDF, crude protein, DDM, and RNV) and quantitative traits (forage yield and forage protein yield). The results indicated that forage yield was higher in rice husk treatment (mean 10117 kg/ha) than non-rice husk treatment (9225 kg/ha). The highest forage protein content was obtained from vetch monoculture treatment. The highest forage and protein yield was obtained from additive 40% vetch to barley (11189 kg/ha, 1845 kg/ha, respectively). Among treatments, the additive 40% vetch to barley (mean 1.66) was better in terms of treatment land equivalent ratio. Overall, it seems that additive 40% vetch to barley and rice husk seed plant can be recommended due to increase in most qualitative and quantitative factors in Rasht.

1. INTRODUCTION

Das et al. (2018) in a two-year study of seed plant (none, soil and living mulch) on three forage plants reported that dry weight of three plants increased in mulch treatment and living mulch gained more yield due to increased height and better growth. In an experiment of non-seed plants and straw seed

*Corresponding author (H. Ajam Norouzi). Email: ajamnorozei@yahoo.com

plants of three different plants on maize yield, it was found that application of each of the three plants resulted in higher yield than control (Awopegba et al., 2017). In another experiment in China, seed plants increased corn forage yield (40-60%) compared to control treatment (Zhou et al., 2018). Other scientists have shown that additive intercropping and monoculture of forage grain (Guinea grass) and forage beetle (Sesbania grandiflora) in Indonesian salty and poor soils and mulch (3 ton + 6 ton mulch straw rice per ha) and without mulch (3 ton/ha) increased plant growth, forage yield and forage quality of Guinea grass. On the other hand, additive forage guinea treatment on Guinea grass as well as 6 ton per hectare mulch and without mulch treatment did not affect the quantity and quality of forage (Guinea grass) in saline soil (Kasmati et al., 2007). Experimental results of two types of leaf seed plants (both surface and mixed with soil) on barley in Kenya showed that plant height and biomass weight of the plant increased when using surface seed plants. Mixing mulch increased nitrate release in the soil during the first 4 weeks, although it decreased sharply by week 6. On the other hand, surface mulch caused gradual release of soil nitrate during the barley growth period (Kimiti & Gordon, 2013). Further research has shown that quality and quantity of sorghum forage is affected by the type of sowing (Chattha et al., 2017). Based on a study on monoculture and additive intercropping of triticale with forage vetch (100 to 30, 100 to 40 and 100 to 50 and 100 to 60 and 100 to 70%) in dryland condition, it was reported that maximum dry forage yield was obtained from 70% to 100% triticale (5445 kg/ha) and 60% vetch + 100% triticale (5248 kg/ha) treatment. The highest forage crude protein content was obtained from 70 to 100% triticale. The highest percentage of NDF also belonged to the above treatment. They reported that increasing triticale content in intercropping led to increase in final forage yield. On the other hand, increased intercropping of two plants decreased digestibility and increased fiber. The highest soil equivalence ratio was obtained from 60% vetch to 100% triticale (1.61) intercropping (Nasiri et al., 2015). In an experiment comparing six replacement intercropping treatments with 20% fenugreek/barley additive ratio, it was shown that the highest forage yield (12.8 ton/ha) and land equivalence ratio (1.15) was obtained from 20% fenugreek/barley additive treatment (Tarifi, et al., 2018). Results of intercropping of maize and vetch showed that 25% maize to 75% vetch achieved the highest forage yield and the land equivalence ratio was 1.16 (Mousavian & Seyed Mohamadi, 2015). Due to the lack of documented research on the effect of seed plant in paddy field on autumn forage crops, this study tends to investigate the effect of rice husk seed plant on quantitative and qualitative yield of monoculture and intercropping of barley and vetch forage in paddy fields of Rasht.

2. MATERIALS AND METHODS

This factorial experiment was conducted through randomized complete block design with three replications during 2014-2015 and 2015-2016 in Rice Research Institute of Iran in Rasht (coordinates: 37°16′51″N 49°34′59″E, 7 m above sea level). Rasht has a humid climate and annual rainfall is based on a 30-year average of 1320 mm. The mean annual rainfall between planting and harvesting was 1014 mm and the average growth temperature was 11.4°C. Soil texture was clay. Experimental factors at two levels (control without rice husk and with rice husk seed plant) as the first factor as well as different seed ratios at six levels: (vetch monoculture, barley monoculture, conventional 25% vetch + 75% barley replacement intercropping, 20% vetch to barley additive intercropping, 40% vetch to barley additive intercropping, 60% vetch to barley additive intercropping) were considered. Barley seed ratio in additive intercropping was 100% and vetch was added to the treatments in additive ratios. Vetch and barley seed ratio was 110 and 170 kg/ha, respectively. The cultivars used were Behrokh (suitable for temperate regions) for barley and Maragheh for vetch (*Vicia sativa* L.). Each experimental plot had 8 sowing lines and the distance between the rows was 20 cm. The amount of rice husk was calculated in 5 ton/ha and added to the treatments. Forage harvesting was done from the lowest part of the stem to the soil. At harvest time to determine forage yield per unit area by removing sidelines and one meter above and below each plot as a marginal effect, six-line forage in the middle and four meters per plot were harvested and immediately weighed. One kilogram of wet forage was randomly selected to measure forage yield and samples were dried in an oven at 75°C for 48 h and weighed. For measuring qualitative traits such as water-soluble carbohydrate (WSC), acid and neutral detergent fiber (ADF and NDF), digestible dry matter (DDM), relative nutritional value (RNV) and crude protein, near-infrared spectroscopy (NIR) of Forests and Rangelands Research Organization were used. Forage protein yield was also calculated by multiplying the forage crude protein by forage yield. To evaluate usefulness of intercropping, land equivalence ratio (LER) was calculated using the following formula.

$$\text{LER} = \frac{Yij}{Yii} + \frac{Yji}{Yjj} \quad (1),$$

where Yij is yield of first plant in intercropping; Yii is yield of first plant in monoculture; Yji is yield of second plant in intercropping; Yjj is yield of second plant in monoculture.

SAS software (version 9.1) was used for statistical analysis of data and drawing charts. LSD test ($p<0.05$) was also used to compare the mean.

3. RESULTS AND DISCUSSION

3.1 WATER SOLUBLE CARBOHYDRATES

The results of the two-year composite analysis showed that seed plant × mix ratio interaction was significant on soluble carbohydrate traits (Table 1). Comparison of means indicated that control treatment without rice husk seed plant and 40% vetch to barley (21.04%) recorded the highest and the treatment with rice husk seed plant and vetch monoculture (13.14%) recorded the lowest soluble carbohydrate (Table 2). Soluble carbohydrates, which constitute a large part of unstructured carbohydrates, are one of the most important components of forage quality, whose task is to provide energy to rumen microorganisms and maintain digestive health of livestock (Tufail et al., 2019). In the study of maize + mungbean intercropping, the researchers reported that the cereal family had more water-soluble carbohydrates than legumes. Therefore, vetch ratio appears to decrease carbohydrates in intercropping (Nakhzari Moghadam, et al., 2009). The results of experimental maize and poplar intercropping showed that intercropping reduces WSCs compared to maize monoculture (Naghizadeh & Galavi, 2012). Similar results were reported regarding the effects of legumes on forage carbohydrate in intercropping (Najafabadi, et al., 2017; Fatminic, 2017). In another experiment the highest (71.6%) soluble carbohydrate content was obtained from barley monoculture and the lowest content (49.7%) was obtained from fenugreek monoculture (Tarifi, et al., 2018). One study found that intercropping cereals and legumes increased concentration of soluble carbohydrates compared to monoculture (Fathminick, 2017).

Table 1: Composite analysis of the calculated traits of seed plant and vetch and barley seed ratios in agricultural farms of Rasht during 2014-2015.

Source of variation	Df	WSC	ADF	NDF	DDM	RNV	Crude protein	Forage yield	Forage protein yield
Year	1	0.43ns	5.55ns	0.48ns	15.7*	199.4**	39.26**	151617ns	454517.6*
Repetition/Year	4	54.76	0.03	52.5	0.94	933.8	6.30	1377456	59088.6
Seed plant	1	104.1**	0.08ns	14.7ns	1.08ns	163.7ns	2.89ns	14311250**	260184.9ns
Seed ratio	5	11.07**	6.37**	37.6**	22.8**	1593.8**	75.33**	62953463**	1088928.2**
seed plant×seed ratio	5	43.73**	4.62*	16.0*	3.44ns	250.4*	4.36ns	1271474ns	70233.2ns
Year×seed plant	1	1.82ns	0.02ns	0.21ns	0.37ns	0.39ns	1.0ns	4966ns	7474.6ns
Year×seed ratio	5	0.21ns	0.02ns	0.20ns	0.24ns	2.36ns	0.46ns	192575ns	25394.6ns
Year×seed plant×seed ratio	5	0.94ns	0.02ns	0.17ns	0.30ns	8.1ns	1.54ns	270275ns	25669.6ns
Error	44	1.27	1.67	4.79	2.27	106.9	5.50	1157305	10599.2
Coefficient of variation	-	6.48	3.11	6.23	2.66	6.84	14.26	11.47	20.91

ns: non-significant; * and ** significant at 5% and 1%.

Table 2: Comparison of mean of effect of seed plant and vetch and barley seed ratios on calculated traits in agricultural farms of Rasht during 2014-2015

Treatment	WSC (%)	ADF (%)	NDF (%)	DDM (%)	RNV (%)	Crude protein (%)	Forage yield (kg/ha)	Protein yield (kg/ha)	LER
Year									
2014-2015	17.32	41.87	35.05	57.05a	152.80a	17.18a	97.17	1633.9a	-
2015-2016	17.47	41.31	35.21	56.12b	149.48a	15.70b	9625	1475.0b	-
Seed plant									
Without seed plant	18.60a	41.56	35.58	56.71	149.64	16.63	9225b	1494.3	1.57
With seed plant	16.19b	41.62	34.68	56.46	152.65	16.24	10117a	1614.5	1.67
Seed ratio									
Vetch monoculture	15.93	40.82	32.90	58.94a	168.77	20.97a	5129c	1075.1b	-
Barley monoculture	16.60	41.77	36.97	55.15c	139.30	13.29c	9820b	1301.0b	-
25% vetch + 75% barley replacement	17.82	42.23	33.49	57.41b	160.93	16.25b	10275b	1680.8a	1.52
20% vetch added to barley	17.71	42.18	36.03	55.86c	144.62	15.80b	10400ab	1644.1a	1.54
40% vetch added to barley	17.72	42.0	36.96	56.34bc	142.39	16.57b	11189a	1844.6a	1.66
60% vetch added to barley	16.61	40.54	34.44	55.80c	150.96	15.76b	11214a	1781.3a	1.66

In each column, the treatments having at least one letter in common do not have a significant difference in LSD at 5% probability level.

3.2 ACID AND NEUTRAL DETERGENT FIBER

Composite analysis of soluble fibers showed that the effect of year and seed plant was not significant. The interaction of seed plants was significant in the mixing ratios (Table 1). The highest ADF was obtained from rice husk seed plant and mixing ratio of 25% vetch and 75% barley (mean 43.20%), while rice husk seed plant and mixing ratio of 60% vetch to barley (mean 39.95%) recorded the lowest content of ADF (Table 3). One of the important factors affecting energy or total digestible nutrients is ADF, the percentage of which is commonly used to estimate digestibility (Tarifi, et al., 2018). Experimental results showed that monoculture had higher content of ADF (Aqababa Dastjerdi, et al., 2014). As content of barley increases, forage digestibility decreases, so that pea monoculture often has the least ADF content and is milder. In the study of replacement and additive intercropping of fenugreek to barley, it was reported that the highest ADF was obtained in barley monoculture and the least content was obtained in fenugreek monoculture (Tarifi, et al., 2018).

The results indicated that year and seed plant had no significant effect on NDF, while seed plant×mixing ratio interaction was significant (Table 2). The lowest content (32.90%) of NDF was recorded from vetch monoculture and the highest content (36.97%) was recorded from barley monoculture (Table 2). The results were predictable since legumes were lower in cellulose and hemicellulose than cereals. Comparison of interaction showed that barley monoculture without rice husk seed plant had the highest (38.60%) and vetch monoculture with rice husk seed plant had the lowest (32.10%) ADF (Table 3). NDF has been identified as an indicator of plant cell wall expression as well as an important factor in determining animal feed intake (Aydemir, 2018). In the past, only the percentage of crude fiber was evaluated for ruminants, while currently it has been found that this criterion does not fully determine the digestibility in most cases (Aydemir, 2018).

Table 3: comparison of mean of seed plant×seed ratio interaction on the evaluated traits in agricultural farms of Rasht during 2014-2015

Treatment	**Seed plant × seed ratio**	WSC (%)	ADF (%)	NDF (%)	DDM (%)	RNV (%)	Crude protein (%)	Forage yield (kg/ha)	Protein yield (kg/ha)	LER
Without seed plant	Vetch monoculture	18.71^{b}	40.44^{ae}	33.70^{ca}	59.42	165.6^{a}	21.20	4956	1051.8	-
	Barley monoculture	18.82^{d}	41.46^{bcd}	38.60^{a}	55.57	134.2^{d}	13.68	9753	1416.0	-
	25%vetch + 75%barley replacement	19.17^{b}	43.35^{abc}	35.53^{bc}	56.58	168.4^{a}	15.70	9494	1668.6	1.44
	20%vetch added to barley	16.75^{d}	41.26^{cde}	31.77^{d}	57.46	141.3^{cd}	17.53	9911	1534.4	1.51
	40%vetch added to barley	17.10^{cd}	42.70^{ab}	36.47^{ab}	55.29	139.8^{cd}	15.46	10322	1665.8	1.57
	60%vetch added to barley	21.04^{a}	41.13^{cda}	37.43^{ab}	55.91	148.5^{bc}	16.26	10917	1710.1	1.66
With seed plant	Vetch monoculture	13.14^{f}	41.20^{cde}	32.10^{d}	58.46	171.9^{a}	20.74	5303	1098.3	-
	Barley monoculture	18.39^{b}	42.07^{abc}	35.33^{bc}	54.73	144.4^{bcd}	12.89	9889	1268.0	-
	25%vetch + 75%barley replacement	14.05^{ef}	43.20^{a}	33.35^{cd}	55.03	153.2^{b}	15.82	11055	1693.0	1.60
	20%vetch added to barley	18.88^{b}	41.64^{bcd}	35.22^{bc}	57.36	148.0^{bc}	14.98	10889	1753.7	1.58
	40%vetch added to barley	18.31^{bc}	41.66^{bcd}	35.60^{bc}	56.43	145.0^{bcd}	16.14	12055	2078.5	1.76
	60%vetch added to barley	14.40^{e}	39.95^{e}	36.48^{ab}	56.76	153.4_{b}	16.88	11511	1964.1	166

In each column, the treatments having at least one letter in common do not have a significant difference in LSD at 5% probability level.

3.3 DIGESTIBLE DRY MATTER

The results showed that the effect of year was significant on DDM (Table 1). A comparison of means showed that the first year of the experiment (57.05%) was significantly better than the second year (56.12%) (Table 2). The effect of seed plant was insignificant on DDM but the effect of seed ratio was significant (Table 1). Results showed that vetch monoculture had higher (58.94%) DDM than other treatments and the lowest matter (55.15%) was obtained from barley monoculture (Table 2). Overall, vetch monoculture without rice husk seed plant recorded the highest (59.42%) and barley monoculture with rice husk seed plant recorded the lowest (54.73%) DDM (Table 3). A DDM is a part of forage that is absorbed by the animal at a certain level of its consumption and is useful for the animal if its content is above 50% (Najafabadi, et al., 2017). According to results of an experiment, the lowest content of DDM was obtained from forage maize monoculture and increased with increasing vetch ratio, so that the highest content (53.4%) was obtained from forage maize×vetch (Javanmard, et al., 2014). The above results indicated higher vetch digestibility and the higher the vetch contribution to forage, the higher forage digestibility.

3.4 RELATIVE NUTRITIONAL VALUE

Results indicated that seed plant×seed ratio interaction was significant on RNV (Table 1). Overall, vetch monoculture without rice husk seed plant (171.9%) recorded the highest and barley monoculture without rice husk seed plant (134.2%) recorded the lowest values (Table 2). The results also showed that there was no significant statistical difference between most of the intercropping treatments. RNV is one of the important factors for qualitative evaluation of forage. It was reported that the increase in RNV of forage in intercropping compared to monoculture was 3 to 22.7% (Wang et al., 2012). In another experiment, it was noted that forages with RNV>151% had premium quality (Majidi Dizaj, et al., 2014). Therefore, it can be concluded that most intercropping forage obtained from the above study is of high quality.

3.5 CRUDE PROTEIN

The results of the composite analysis showed significant effect of crude protein on year and the first year (17.18%) was better than the second year (15.70%) (Table 2). Among the experimental factors, only seed ratio had a significant effect (Table 1). Among the tested ratios, vetch monoculture provided the highest protein content (20.97%) and the lowest crude protein content (13.29%) was obtained from barley monoculture (Table 2). Given that the leaves were more plentiful and edible and stems were thinner, increased crude protein content was not unexpected in the vetch monoculture. Crude protein is a combination of real protein and non-protein nitrogen compounds that are essential for growth and lactation. Other studies also observed an increase in crude protein in intercropping than monoculture (Klimek Kopyra et al., 2015). Since crude protein has a direct relationship with nitrogen content of the plant, more stabilization, and availability of nitrogen may increase nitrogen uptake for barley intercropping. Reportedly percentage of nitrogen stabilized by legumes was transferred to maize in intercropping (Khalesi, 2017). Another experiment showed that intercropping legumes and grains such as wheat and triticale increased forage protein content and ultimately improved feed quality. In their study, adding lentils to forage composition increased protein content (Wang et al., 2012).

3.6 DRY FORAGE YIELD

Dry forage yield is one of the most important indices in forage cultivation, with many of the results such as successfulness being measured based on that. Results showed that the effect of year was not significant on dry matter yield (Table 1). The effect of seed plant was significant on dry forage yield and dry forage yield was better in rice husk seed plant treatment (10117 kg/ha) compared to the treatment without rice husk seed plant (9225 kg/ha) (Table 2). There was also a significant difference between seed ratio treatments; as expected, vetch monoculture with average forage yield of 5129 kg/ha had the lowest and 40% vetch + 60% barley additive intercropping had the highest dry forage yield (Table 2). Overall, 40% vetch added to barley with mulch (12055 kg/ha) obtained the highest and vetch monoculture without rice husk seed plant (4956 kg/ha) obtained the lowest dry forage yield (Table 3).

Increase of dry forage yield in 40% forage vetch + barley additive treatment indicated that environmental factors such as sunlight were used better in this composition and the light passing through at early stages of growth from barley canopy because of proper distance between the leaves penetrated into the vegetation and well used by the clover to spread the canopy. In the study of monoculture and intercropping of triticale and Vicia villosa, it was also reported that 50% vetch + 50% intercropping had better forage yield than monoculture in an experiment on maize and clover (Nasiri, et al., 2015). Triticale had the highest dry matter yield (8850 kg/ha) and protein yield (1412.2 kg/ha) (Shobairi, et al., 2011). Researchers have attributed the increase in dry forage production in intercropping treatments to complimentary use of water, nutrients, and light due to differences in morphology and physiology of these plants such as height, depth of root development, and thin and broadleaf and photosynthesis of the plants (Moradi, et al., 2015).

3.7 FORAGE PROTEIN YIELD

The results of the composite analysis of data indicated that forage protein yield was not significant in additive or replacement intercropping, but there was a significant difference between years of experiment (Table 1). The first year (1633.9 kg/ha) was better than the second year (Table 2). There was a significant difference between seed ratios (Table 1). Monoculture of vetch and barley had the lowest forage protein yield due to lack of forage yield and crude protein deficiency, respectively. There was no significant difference between intercropping treatments. Overall, the highest forage protein yield was obtained from 40% vetch added to barley with rice husk seed plant (2078.5 kg/ha) and the lowest yield was obtained from vetch monoculture with control without mulch (1051.8 kg/ha) (Table 3). In another experiment, the highest forage protein yield was obtained from 30% vetch + 100% triticale additive intercropping (Nasiri, et al., 2015). A similar report has found a dramatic increase in crude protein yield due to legume-grass intercropping (Yang et al., 2018). Since forage protein yield is obtained by multiplying the crude protein by forage yield, the increase in protein yield in intercropping may be related to their better dry forage yield. Because dry forage yields appear to have a greater contribution in protein yield. One of the major advantages of legume-grass intercropping is the increase in crude protein yield over grass monoculture (Najafabadi, et al., 2017). In the experiment of the effect of monoculture and different ratios of maize-bean intercropping on quantitative and qualitative yield of forage, it was reported that crude protein yield was better in intercropping than monoculture and the highest dry forage yield was obtained from 65% vetch + 35% oat (Nazari et al., 2014). It was also reported that the highest crude protein yield was obtained from 50% barley + 50% fennel intercropping (1528.2 kg/ha) (Kiani, et al., 2014). Another study also showed that 50% vetch + 50% barley treatment obtained higher protein yields than monoculture (Molla et al., 2018).

3.8 LAND EQUIVALENCE RATIO

The treatment with mulch (1.67) was also higher than the treatment without mulch (1.5) (Table 2). Among the intercropping treatments, 40% and 60% additive intercropping (1.66) obtained the highest and thus it is recommended. Overall, rice husk seed plant and 40% vetch + 60% barley additive intercropping is better and recommended. The results showed that the land equivalence ratio of dry matter showed the superiority of two 40% + 60% additive treatments. The results showed ecological superiority of intercropping and efficient use of growth resources. The superiority due to inter-species competition is less than intra-species competition. An experiment reported that 75% barley + 25% vetch intercropping (1.51) achieved the highest land equivalence index (Hervani & Dizaj, 2012). In another study, the highest land equivalence ratio was obtained from 60% vetch to 100% triticale (1.61) intercropping (Nasiri, et al., 2015).

4. CONCLUSION

In the present study, the results showed that seed plants had no effect on most qualitative traits. Based on the results, higher ratio of vetch improved forage quality due to higher quality traits. Among seed ratios, 40% vetch + 60% barley recorded the highest land equivalence ratio for the calculated yields. In the present study, land equivalence ratio was higher in the treatment with rice husk seed plant due to better seedling establishment. The results also indicated that all intercropping treatments had higher forage protein yield than monoculture and were divided into separate statistical groups. However, no significant differences were observed between the intercropping treatments. Since the highest forage yield was obtained from 40% vetch + barley with rice husk seed plant, this treatment achieved the highest land equivalence ratio. In addition, 40% vetch + barley with rice husk seed plant can be introduced as a better treatment due to most quantitative traits. Regarding the importance of sustainable agriculture and quality of forage source and the importance of availability of forage for livestock feeding and the importance of comparative indices, additive intercropping and intercropping in rice husk seed plant is recommended for cultivation in paddy fields of Rasht.

5. ACKNOWLEDGEMENT

The authors gratefully acknowledge the Rice Research Institute of Iran for their contributions.

6. REFERENCES

Aqababa Dastjerdi, M., Amini Dehghi, M., Chaichi, M. & Basaghzadeh, Z. (2014). The effect of different fertilizer systems on nutritional and qualitative traits of forage and intercropping of perennial alfalfa (Medicago Sativa L.) and fennel (Foeniculum Vulgare L.). Journal of crop improvement, 16(1), 111-125.

Awopegba, M., Oladele, S., & Awodun, M. (2017). Effect of mulch types on nutrient composition, maize (Zea mays L.) yield and soil properties of a tropical Alfisol in Southwestern Nigeria. Eurasian Journal of Soil Science, 6(2), 121-133.

Aydemir, S. K. (2019). Maize and soybean intercropping under different seed rates of soybean under the ecological condition of Bilecik, Turkey. International Journal of Environmental Science and Technology, 16(9), 5163-5170.

Chattha, M. U., Iqbal, A., Hassan, M. U., Chattha, M. B., Ishaque, W., Usman, M., & Ullah, M. A. (2017). Forage yield and quality of sweet sorghum as influenced by sowing methods and harvesting times. Journal of Basic and Applied Sciences, 13, 301-306.

Das, H., Kundu, C. K., Bandyopadhyay, P. K., Bandyopadhyay, S., & Bandopadhyay, P. (2018). Effect of mulching practices on growth and yield of forage crops under rainfed ecosystem. Journal of Applied and Natural Science, 10(1), 266-271.

Fateminick, F. (2017). Investigating the effect of corn and mung intercropping on the yield and quality of Vigna Radiata in the climate of Shoush city. Journal of Research in Ecology, 5 (1), 582-592.

Javanmard, A. et al. (2014). Evaluation of cell concentration, cell wall without hemicellulose, total digestible nutrient content, dry matter intake and specific lactation energy of forage maize in intercropping. Journal of Crop Production and Processing, 14(4), 175-189.

Khalesi, A. (2017). Effect of different intercropping patterns on dry matter production as well as forage quality of corn and cowpea. Studies of Biological Sciences and Biotechnology, 3(1), 21-29.

Kiani, S. M. et al. (2014). Evaluation of quantitative and qualitative yield of forage in intercropping of barley and fennel at different nitrogen levels. Journal of crop improvement, 15(4), 973-986.

Kimiti, J. M., & Gordon, A. M. (2013). Mulch inoculation and placement influenced barley (Hordeum Vulgare) growth and soil nitrate levels.

Klimek-Kopyra, A., Kulig, B., Oleksy, A., & Zajac, T. (2015). Agronomic performance of naked oat (Avena nuda L.) and faba bean intercropping. Chilean Journal of agricultural research, 75(2), 168-173.

Kusmiyati, F., Sumarsono, S., Karno, K., & Pangestu, E. (2013). Effect of mulch and mixed cropping grass-legume at saline soil on growth, forage yield and nutritional quality of guinea grass. Journal of the Indonesian Tropical Animal Agriculture, 38(1), 72-78.

Lamei Hervani, J., & Alizadeh Dizaj, K. (2012). Selecting the best Vicia villosa+barley+Triticale intercropping under dryland conditions of zanjan. Dryland agriculture, 1(1), 17-39.

Majidi Dizaj, H., Mazaheri, D., Sabahi, G., & Mirabzadeh, M. (2014). Evaluation of forage yield and quality in alfalfa and sainfoin intercropping. Iranian Journal of Crop Sciences, 16(1), 51-61.

Molla, E. A., Wondimagegn, B. A., & Chekol, Y. M. (2018). Evaluation of biomass yield and nutritional quality of oats–vetch mixtures at different harvesting stage under residual moisture in Fogera District, Ethiopia. Agriculture & Food Security, 7(1), 88.

Moradi, P., Asghari, J., Mohsenabadi, G. & Samizadeh, H., 2015. Evaluation of quantitative and qualitative yield of forage in maize + wax bean + cucurbita pepo intercropping. Journal of crop improvement, 17(3), 683-699.

Mousavian, N., & Seyed Mohamadi, A. (2015). Effect of nitrogen and cultivation patterns on morphological traits and growth index in intercropping corn and sunflower. Crop Physiology, 26, 105-120.

Naghizadeh, M., & Galavi, M. (2012). Evaluation of forage quality in intercropping of maize (Zea mays L.) and poplar (Lathyrus sativus L.) affected by bio-chemical phosphorus fertilizers. Agricultural Ecology, 4(1), 52-62.

Najafabadi, A., Jalilan, J., & Zardoshti, M. (2017). The effect of intercropping patterns on some quantitative and qualitative traits of safflower and cattle fodder in high and low input systems. Journal of crop improvement, 19(2), 445-460.

Nakhzari Moghadam, A. et al. (2009). Effect of intercropping corn and green mung on yield, land equivalence ratio and some quality traits of forage. Iranian Journal of Field Crop Science, 40(4), 151-159.

Nasiri, B., Darai-Mofrad, A., & Hosseinian, H. (2015). Evaluation of quantity and quality of forage in intercropping of triticale and vetch in rainfed conditions. Research in agronomic ecosystems, 1(2), 37-48.

Nazari, S. et al. (2014). Effect of different harvesting times on yield and quality of corn forage under intercropping conditions with leguminous plants. Journal of Iranian Field Crop Research, 12(2), 237-245.

Shobairi, S. S. et al. (2011). Evaluation of yield and quality of forage in monoculture and intercropping of vicia villosa and triticale. Iranian Journal of Crop Sciences, 13(2), 269-281.

Tarifi, S., Fateh, A., & Aynehband, A. (2018). The effect of different ratios of intercropping barley

(Hordeum vulgare) and fenugreek (Trigonella foenum- graecum L.) under nitrogen fertilizer effects on dry matter quantity and quality. Crop production, 11(1), 23-35.

Tufail, M. S., Krebs, G. L., Southwell, A., Piltz, J. W., & Wynn, P. C. (2019). Seeding rate effects on yield components and forage quality of Agaitti Berseem-2002–an improved variety of berseem clover. Journal of Crop Improvement, 1-14.

Wang, L., Gruber, S., & Claupein, W. (2012). Optimizing lentil-based mixed cropping with different companion crops and plant densities in terms of crop yield and weed control. Organic Agriculture, 2(2), 79-87.

Yang, C., Fan, Z., & Chai, Q. (2018). Agronomic and economic benefits of pea/maize intercropping systems in relation to N fertilizer and maize density. Agronomy, 8(4), 52.

Zhou, Y., Xiong, D., Jizong, Z., Fenglu Z., and Lifeng. Z. (2018). Effects of plastic film mulching on rainfall storage and water use in forage maize fields in the cold and arid areas of Northern China. Academia Journal of Agricultural Research, 6 (10), 1-9.

Mehrdad Jilani is a PhD Candidate in Agronomy at the Faculty of Agriculture, Gorgan Branch at Islamic Azad University, Gorgan, Iran. He received his Master's degree in same major from Takestan Branch at Islamic Azad University, Takestan, Iran. He is interested in Plant and Crop Research.

Dr. Hossein Ajam Norouzi is an Assistant Professor at the Department of Agronomy and Plant Breeding, Gorgan Branch, Faculty of Agriculture, Islamic Azad University Gorgan, IRAN. He is interested in Crop, Plant, and Soil.

Dr.Abolfazl Faraji is a Researcher (Academic) at Golestan Agricultural and Natural Resources Research and Education Center, Agricultural Research, Education and Extension Organization (AREEO). He earned his PhD from the University of the Philippines Los Baños.

Note: This article is extracted from a doctoral dissertation of the first author.