doi:10.14720/aas.2022.118.3.2194 Original research article / izvirni znanstveni članek

Evaluation of forage maize yield and soil organic matter content under green manure cultivation

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Received April 29, 2021; accepted August 08, 2022.
Delo je prispelo 29. Aprila 2021, sprejeto 8. avgusta 2022

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Abstract: To investigate the effect of different green manures from Gramineae and Brassicaceae families on yield, some agronomic traits of forage maize, overgrowth with weeds and soil organic matter, an experiment was conducted based on a randomized complete block design with three replications for three consecutive years (2017-2020) at the Agricultural and Natural Resources Research and Education Centre of Southern Khorasan. Experimental treatments included control (without application of green manure) and application of green manures from the cultivation of barley, triticale, canola, arugula with their optimum and twice optimum densities. The results showed that barley and triticale at twice optimum density with 865.7 and 802.9 g m^{-2}, respectively, had a higher green manure dry mass at the time of returning to the soil. Just before maize cultivation, soil organic matter with an average of 0.73 % was higher in barley green manure at twice optimum density compared to other treatments. Based on the results, the highest maize forage yield with 45.7 and 44.9 t ha^{-1} were achieved after treatment with barley green manure in twice optimum and optimum density (22.8 and 20.7 percent more than control treatment) and after that triticale in both densities, and canola and arugula at twice optimum density had the highest yield.

Key words: barley; triticale; canola; arugula; forage maize; production; weeds

Ovrednotenje pridelka silažne koruze in vsebnosti organske snovi v tleh v razmerah zelenega podora

Izvleček: Za ovrednotenje učinka različnega zelenega podora iz družin trav in križnic na pridelek in nekatere komponente pridelka silažne koruze, poraslosti s pleveli in vsebnosti organske snovi v tleh je bil izveden popolni naključni bločni poskus s tremi ponovitvami v treh zaporednih rastnih sezonah (2017-2020) na posestvu Agricultural and Natural Resources Research and Education Centre of Southern Khorasan. Obravnavanja v poskusu so obsegala kontrolo (brez uporabe zelenega podora) in uporabo zelenega podora z ječmenom, trtikalo, oljno ogrščico in rukvico, z optimalno in dvakrat optimalno gostoto setve. Rezultati so pokazali, da je imelo zeleno gnojenje z ječmenom in tritikalo pri dvakratniku optimalne setve, 865,7 in 802,9 g m^{-2}, večjo suho maso zelenega podora. Pred začetkom setve koruze je bila suha masa organske snovi v tleh, poprečno 0,73 g, večja pri zelenem gnojenju z ječmenom pri dvakratni optimalni gostoti kot pri drugih obravnavanjih. Največji pridelek silažne koruze, 45,7 in 44,9 t ha^{-1}, je bil dosežen pri zelenem gnojenju z ječmenom pri dvakratniku optimalne gostote setve in optimalni gostoti setve (22,8 in 20,7 odstotkov več kot pri kontrolnem obravnavanju) in potem pri tritikali pri obeh gostotah setve ter pri dvakratniku optimalne gostote setve pri oljni ogrščici in rukvici.

Ključne besede: ječmen; tritikala; oljna ogrščica; rukvica; silažna korura; pridelek; pleveli

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1 INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal grain in the world, after wheat and rice, providing nutrients for humans and animals and serving as a basic raw material for the production of starch, oil, protein, alcoholic beverages, food sweeteners, and fuel (Bouis and Welch, 2010).

With the increasing population and increasing human need for chicken and eggs, the area under maize cultivation is increasing. According to the World Food Program, the annual production of maize is about 1.06 billion tons, and the largest producers in the world, the United States and China, together account for 58 % of this amount (FAO, 2020). In 2020, the area under maize cultivation in Iran was 200,000 hectares with a production of 1,400,000 tons, while its domestic consumption in the country was equal to 8,900,000 tons in this year and the gap between annual production and demand was provided with an import of 7,500,000 tons (USDA, 2020). One of the important limiting factors for the development of animal husbandry and the production of livestock materials is the provision of fodder to feed the country's livestock. In such a way that the import of fodder and fodder grains constitute considerable several imported items of the country. In this regard, the importance of forage production is increasingly felt.

The use of chemical fertilizers to produce crops around the world is also increasing (Abril et al., 2007), the continued use of which poses serious risks to the environment and human health (Graham and Vanca, 2000). In Iran, the indiscriminate use of chemical fertilizers, especially nitrogen fertilizers, and the lack of application of organic fertilizers in recent years has been the cause of a significant reduction in the amount of organic matter in agricultural soils (Malakouti, 1999). Soils with more than 3 % organic matter are needed to make suitable soils for plant growth (Pramanik et al., 2004). Additionally, the use of chemical fertilizers does not have a beneficial effect on physical soil properties. Adverse effects of fertilizers and pesticides on the environment have led to more attention and the use of methods without the use of chemicals, and the issue of sustainability in agriculture to be considered. One practical way to meet this goal is to use green manures that can reduce the use of chemical fertilizers.

The application of green manures is one of the management methods of choice in many agricultural productions systems because these fertilizers can reduce soil erosion and improve the physical properties of the soil, increase organic matter and soil fertility, increase nutrient circulation and reduce global warming potentials and finally increase the system stability (Dinnes et al., 2002). Plants used as green manure increase soil water storage in arid lands by increasing water infiltration, reducing evaporation, and improving soil structure. Return of green manures to the soil as a result of microbiological processes increase soil organic matter and release nutrients in plants for plants (Talgre et al., 2009).

In the study of Abdi et al. (2012) the plants of Gramineae (sorghum, millet, and oat), Brassicaceae (arugula), and Leguminosae (white clover, red clover, bersim clover, sainfoin, and vetch) were used as green manure, and the evaluation of soil nutrient changes, and nitrogen mineralization were studied and the highest amount of organic carbon was obtained by returning sorghum forage residues to the soil (1.59 %). The amount of total soil nitrogen in all tested plants increased during different sampling times. The highest amounts of total nitrogen (0.23 %) were obtained by white clover in five months after the return of the remains.

Clement et al. (1995) examined different types of green manures and found that the ratio of lignin and polyphenols to nitrogen and tannins to nitrogen controlled the amount of nitrogen released. On the other hand, the decomposition of green manure and the release of its nutrients depends on soil physical (moisture, temperature, texture, minerals, and pH), chemical (carbon/nitrogen ratio, soil nutrient content), and biological properties (the rate of soil biological activity) (Myers et al., 1994), among which the ratio of carbon/nitrogen has a greater impact on the mineralization of organic matter than other factors. Regarding the effect of red clover, common alfalfa, vetch, and oats as green manure on bioavailable nitrogen, it was observed that the amount of soil nitrogen increased significantly under common alfalfa use and the wheat grain protein content in the next crop was the highest (Maikstenien and Arlauskiene, 2004). It has been reported that in dry winters, nitrate accumulates in topsoil and the cover plant controls nitrate leaching during the early stages of growth, and that vetch is less efficient in leaching control in contrast to barley but increased soil nitrogen storage (Gabriel et al., 2012). Additionally, the combined application of vetch winter cover plant and a small amount of fertilizer can significantly improve the sustainability of low-input maize-based conservation agriculture (Dubeab et al., 2013).

Green manure in Iran is used only in some areas and to a very limited extent. Animal manures are also not stored and used properly. Besides, the high cost of livestock manure and the lack of common use of them have caused organic fertilizers to play a negligible role in increasing fertility and improving Iran soils. This can cause serious problems in agricultural planning and operations, especially in large-scale agriculture. Thus, the purpose of this study was to investigate the effect of Gramineae (barley and triticale) and Brassicaceae (canola and arugula) as green manure in two different densities on the maize yield, weeds growth and percentage of soil organic matter during the periods after adding green manure residues to the soil and finally introducing the desired plant or plants as green manure in the studied conditions.

2 MATERIALS AND METHODS

A field experiment was conducted between 2017 and 2020 at the Agricultural and Natural Resources Research and Education Centre of South Khorasan Province, Birjand, Iran (32° 52′N, 58° 59′E). Before cultivation, a pre-planting composite sample of the soil was taken from a depth of 0-30 cm for determination of particle size distribution, pH, EC and soil organic matter. The results of soil analysis during the years of the experiment are presented in Table 1 and meteorological information during the years of the experiment is also presented in Figure 1.

There were nine treatments in the trial, laid out in a randomized complete block design in three replications. Plants used as green manure included barley (*Hordeum vulgaris* L.), triticosecale (*Triticosecale* spp.), canola (*Brassica napus* L.), and arugula (*Eruca sativa* L.). Experimental treatments included control (none application of green manure) and application of green manures from the cultivation of barley (with optimum density), barley (with twice optimum density), triticale (with optimum density), triticale (with twice optimum density), canola (with optimum density), canola (with twice optimum density), arugula (with optimum density), arugula (with twice optimum density).

Cultivation of barley with two densities of 400 and 800, triticale with two densities of 400 and 800, canola with two densities of 70 and 140, and arugula with two densities of 80 and 160 plants per square meter and based on their 1000-grain mass on five 60 cm rows with a length of five meters was done in November of 2017, 2018 and 2019. The distance between the plots was one meter and between the replication was two meters. After planting, irrigation was done and a total of two irrigations were carried out in autumn and one irrigation in spring. In April, the green manures were cut into small pieces using a disk and returned to the soil with plowing.

Considering that weed control by green manure as well as the contribution of green manure in increasing soil organic matter is directly related to the dry mass produced, the biomass of each green manure at the time of return to the soil was evaluated. To estimate the dry mass of green manures, sampling was performed before returning them to the soil. For this purpose, one square meter was randomly taken from each plot and the samples were dried in an oven at 70 °C for 48 hours and then weighed. After returning the green manure the land was left uncultivated and then maize was planted in early summer.

Maize cultivar SC647 was cultivated in the first half of July in 2018, 2019, and 2020 in furrows with a distance of 75 cm and a length of five meters, and a density of 20 plants per square meter. Before planting maize, samples were taken from each plot to measure the amount of soil organic matter. Fertilizers used include 300 kg ha^{-1} urea (50 kg ha^{-1} before planting, 150 kg ha^{-1} at 6-7 leaves stage, and 100 kg ha^{-1} before the emergence of male inflorescence), 100 kg ha^{-1} triple superphosphate (before sowing) and 100 kg ha^{-1} of potassium sulfate (before sowing) were used during the maize growing period based on the dimensions of the plots. During the maize growing season, irrigation was carried out in the first months with an interval of eight days and in the last month with an interval of 10 days, and a total of nine irrigations was carried out. During the growing season, traits such as number of days to emergence of tassels, number of days to emergence of silk, number of rows per ear, number of grain per row, ear length, ear diameter, plant height, and forage yield of maize, as well as weed biomass and weed density, were measured or weighted and recorded. To measure ear length, ear diameter, and plant height by observing the margin effect, five plants were randomly selected and the average of five plants for each of these traits was recorded. The number of rows per ear, the number of grain per row, and the number of grain per ear were counted and recorded in five ears after harvest. A sampling of weeds in maize cultivation was done in 4-6 leaf stage in a quadrate of one square meter in each plot and after determining the density of weeds, these samples were dried at a temperature of 70 degrees in an oven for 48 hours and then weighed. To measure the maize forage yield, the area of one square meter was harvested and the fresh mass of the forage was weighed by observing the margin effect.

After ensuring the homogeneity of variance of experimental error with Bartlett test, the data were analyzed using SAS statistical software based on a randomized complete block design and means comparison based on Duncan test at 5 % probability level.

3 RESULTS AND DISCUSSION

The results of combined analysis of variance for three years of the experiment showed that year had a significant effect at the level of 1 % on the dry mass of green manure, the number of grain per row and weeds dry mass and a significant effect at the level of 5 % on ear

Table 1: The results of soil physiochemical properties

Year	Sand (%)	Silt (%)	Clay (%)	Soil texture	pH	EC (dS.m^{-1})	Organic matter (%)
2017	38	42	20	Loam	7.9	4.79	0.36
2018	40.5	36	23.5	Loam	7.82	4.27	0.49
2019	46.5	36	17.5	Loam	7.85	5.67	0.44

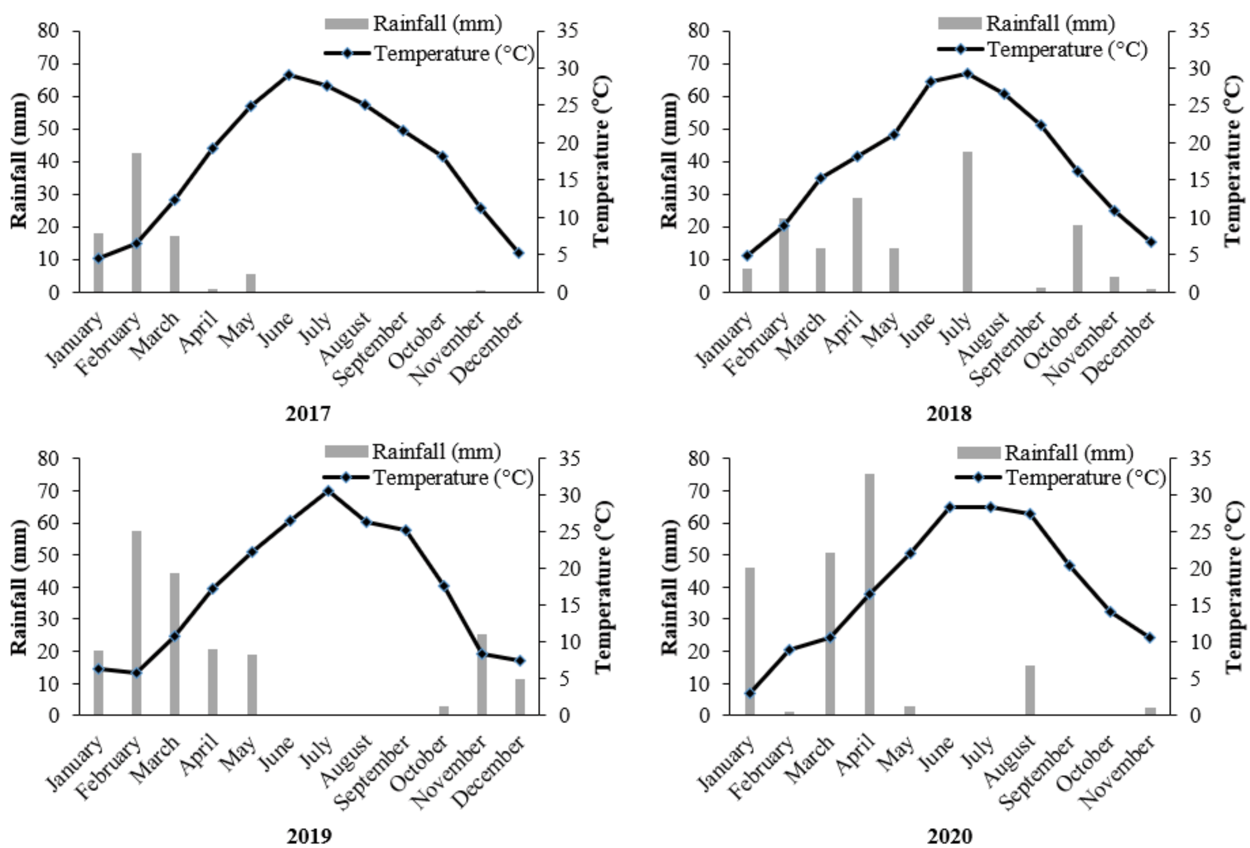

Figure 1: Mean temperature and rainfall during 2017-2020 (Climate data: Iran, Birjand - Tutiempo.net)

length (Table 2). Also, except for the number of days to emergence, the number of days to the emergence of silk and the diameter of the ear, the year had a significant effect on the other studied traits, whereas the interaction of year in green manure was significant only on the dry mass of green manure at the time of return to soil (Table 2).

The results of mean comparing for the year effect showed that the highest dry mass of green manure with an average of 564.4 g m^{-2} and the highest weeds dry mass with an average of 175.6 g m^{-2} were observed in the second year of the experiment (Table 3). The highest number of grain per row with 36.7 grains and an ear diameter of 48.8 mm was also found in the third year whereas the difference in ear length between the third and the second year was not significant (Table 3). According to the meteorological statistics presented in Figure 1, one of the reasons for the better growth of green manures and their higher dry mass when returning to the soil in the spring in the second and third years of the experiment, was more precipitation during the autumn, winter, and spring during these years compared to the first year when the amount of precipitation was lower.

The results of mean comparison of the traits showed that at the time of return to the soil, barley and triticale green manure at twice optimum density treatment with 865.7 and 802.9 g m^{-2}, respectively, had higher dry mass compared with other treatments (Table 3). After control or none green manure cultivation, canola, and arugula treatments had the lowest dry mass at the optimum density at the time of return to the soil, so that their dry mass was about 55 percent lower compared to barley green manure at twice optimum density (Table 3). Means comparison for the interaction effect of year in green manure also showed that barley green manure treatment with twice optimum density in the second year with an average of 937 g m^{-2} had the highest dry mass among other treatments, but not statistically different with barley green manure treatments with twice optimum density in the third year and triticale with twice optimum density in the second and third year. In contrast, canola, and arugula green manures with averages of 291.1 and 314.7 g m^{-2} in the first year had the lowest dry mass among other treatments, respectively (Table 4). Naturally, the more residues returned to the soil, the more organic will be added to the soil. Abdi et al. (2012) also reported in their study that compared to the green manures of sorghum, millet, oats, arugula, and several types of clover, sorghum produced the highest fresh and dry mass of shoots and consequently it has also led to the production of higher organic carbon in the soil.

In terms of the number of grain rows per ear, barley green manure had the highest rate at the optimum density with an average of 16.6 rows and there was no statistically significant difference between this treatment with barley and arugula treatments with twice optimum density, whereas control treatment with 14.1 rows had the lowest amount (Table 3).

There was no significant difference in the number of grain per row between barley, triticale, canola, and arugula green manures, but these treatments were significantly superior to the control (Table 3).

The number of grains per ear had the lowest values in control and canola with optimum density treatments, while barley with optimum density and then barley and arugula with double optimum density was in the superior statistical group in this regard (Table 3). Maize ear length was higher in barley green manure treatments at both twice and optimum densities and also arugula at twice optimum density (Table 3).

Barley green manure in twice optimum density with an average of 212.5 cm had the highest plant height among other treatments and resulted in a 16.5 % increase in maize plant height compared to the control treatment and its difference with barley treatments with optimal density, triticale and canola with twice optimum density and arugula with both densities and twice the density were not statistically significant (Table 3). It seems that these treatments provided more access to nutrients to the plant than other treatments and an increased in ear length and plant height are observed. Evaluation of legume winter cover crops in maize cultivation also showed a 37 % increase in maize plant height (Miguez and Bollero, 2005). Increasing the ear length in the application of green manure is consistent with the results of Ghasemi et al. (2016).

According to the results, the lowest amount of maize forage with 37.2 t ha^{-1} was related to the control treatment or no green manure cultivation, and barley green manure at twice optimum density with 45.7 t ha^{-1} had the highest maize forage which had no significant difference with barley in optimum density treatment with 44.9 t ha^{-1}. Also, after them, triticale green manure in both density and canola and arugula at twice optimum density had higher forage yield and there was no statistically significant difference between them (Table 3). Barley at optimum and twice optimum density leads to an increase of 20.7, 22.8 %, triticale at optimum and twice optimum density leads to an increase of 14.5 and 14.8 %, canola at optimum and twice optimum density leads to an increase of 10.2 and 14.8 % and finally arugula at optimum and twice optimum density led to an increase of 9.7 and 18.3 % in the yield of maize forage compared to the control treatment (Table 3). The increase in maize forage yield as a result of the return of the mentioned green fertilizers can be justified by increasing the soil organic matter and the availability of nutrients for the next crop as well as improving the biological and physical properties of the soil. In addition to improving soil structure and nutrient accumulation in soil surface layers (Cherr et al., 2006), green manure has been reported to be the most important source for bacterial activity, and bacteria are more efficient in these conditions (Orhana et al., 2006). The use of organic fertilizers by increasing soil organic matter strengthens the properties of aggregates, microbial activity, soil quality, crop fertility, and storage capacity of nutrients such as nitrogen, phosphorus, potassium, zinc, and iron in the soil (Wei and Liu, 2005).

The predominant weeds in the maize field included *Amaranthus retroflexus* L., *Portulaca oleracea* L., *Convolvulus arvensis* L., and *Alhaji camelorum* L. The results of the experiment showed the superiority of barley and triticale green manures in controlling weeds in the maize field. Namely, the barley treatment at twice optimum density with 54.2 g m^{-2} and triticale in twice optimum density with 83.8 g m^{-2} had the lowest weeds dry mass, respectively (Table 3). Barley and triticale at twice optimum density resulted in a reduction of 85.3 % and 77.2 % in weeds dry mass compared to the control (Table 3). The highest weeds density and weeds dry mass of 155.9 plants m^{-2} and 368.8 g m^{-2} were obtained from control treatment or no cultivation of green manure, followed by canola and arugula at the optimum density. Plants with high biomass and more shading can control weeds well. One of the reasons for the decrease in the weeds density and their dry mass in green manure treatments compared to fallow has been reported to be the sharp reduction of

Table 2: The results of analysis of variance for investigated traits

		Mean squares												
Source of Variation	df.	Green manure dry mass	No. of days to emergence of tassels	No. of days to emergence of silks	No. row per ear	No. grain per row	No. grain per ear	Ear length	Ear diameter	Plant height	Forage yield	Weeds dry mass	Weeds density	Soil organic matter
Year	2	179642**	23.19 ns	43.90 ns	37.16 ns	155.85**	22694 ns	105.92*	376.9 ns	2218.5 ns	246.2 ns	11219.9**	391.66 ns	0.138 ns
Block (Year)	6	3719.4	4.88	11.07	0.74	2.92	2557.69	9.11	35.79	668.71	0.68	420.82	400.91	0.002
Green manure	8	583358**	4.73 ns	10.06 ns	4.55**	21.62**	17751.2**	28.81**	28.87 ns	1280.6**	58.64**	86129.5**	10243.9**	0.052**
Green manure*Year	16	5970.1*	0.92 ns	2.46 ns	0.22 ns	0.41 ns	491.7 ns	1.87 ns	0.69 ns	42.82 ns	7.05 ns	544.29 ns	275.65 ns	0.0006 ns
Residual error	48	2951.5	25.08	25.86	0.73	4.85	2883.08	4.76	27.02	150.87	6.41	533.59	206.70	0.002
Coefficient of variation	-	10.78	8.03	7.25	5.62	6.39	10.53	7.94	11.34	5.86	5.97	14.20	21.39	7.93

* and ** are significantly different at α = 0.05 and α = 0.01, respectively and ns is non-significant

Table 3: The results of mean comparison for effects of year and green manure on investigated traits

Year	Green manure dry mass (g m^{-2})	No. of days to emergence of tassels	No. of days to emergence of silks	No. row per ear	No. grain per row	No. grain per ear	Ear length (cm)	Ear diameter (cm)	Plant height (cm)	Forage yield (t ha^{-1})	Weeds dry mass (g m^{-2})	Weeds density (plant m^{-2})	Soil organic matter (%)
2017-2018	411.3 b	61.4 a	68.7 a	15.6 a	31.9 c	498.7 ab	25.3 b	41.6 b	204.9 a	38.9 b	139.1 b	65.6 a	0.51 b
2018-2019	564.4 a	63.3 a	71.2 a	14.0 b	34.8 b	487.8 b	27.8 ab	47.1 ab	220.2 a	44.5 a	175.6 a	64.5 a	0.64 a
2019-2020	536.7 a	62.3 a	70.6 a	16.2 a	36.7 a	542.5 a	29.3 a	48.8 a	204.0 a	43.8 a	173.1 a	71.5 a	0.63 a
Green Manure													
Control	0.0 f	62.9 a	71.4 a	14.1 c	31.0 b	424.3 c	25.0 c	42.7 a	185.7 c	37.2 c	368.8 a	155.9 a	0.47 e
Barley optimum density	599.7 b	62.6 a	69.9 a	16.6 a	36.5 a	584.6 a	29.9 a	46.3 a	216.3 a	44.9 a	90.5 d	58.0 b	0.63 bc
Barley twice optimum density	865.7 a	63.3 a	71.7 a	15.6 ab	35.2 a	530.5 ab	30.0 a	49.1 a	221.5 a	45.7 a	54.2 e	57.0 b	0.73 a
Triticale optimum density	552.5 bc	62.8 a	70.7 a	14.9 bc	34.2 a	494.5 bc	26.6 bc	45.8 a	195.3 bc	42.6 ab	101.3 d	55.6 b	0.59 cd
Triticale twice optimum density	802.9 a	61.3 a	68.6 a	14.9 bc	35.2 a	508.9 b	27.5 abc	47.3 a	216.7 a	42.7 ab	83.8 d	52.7 b	0.68 ab
Canola optimum density	379.6 e	61.3 a	68.9 a	14.9 bc	33.6 ab	482.9 bc	26.1 bc	45.7 a	206.3 ab	41.0 b	228.5 b	57.8 b	0.54 d
Canola twice optimum density	467.6 d	62.8 a	70.7 a	15.1 bc	34.8 a	508.1 b	26.7 bc	46.0 a	215.5 a	42.7 ab	174.7 c	48.2 b	0.58 cd
Arugula optimum density	378.2 e	62.4 a	70.1 a	15.2 bc	34.4 a	505.2 b	26.3 bc	44.4 a	211.8 a	40.8 b	212.2 b	68.1 b	0.54 d
Arugula twice optimum density	491.0 cd	61.7 a	69.7 a	15.9 ab	35.5 a	548.1 ab	29.1 ab	45.1 a	218.4 a	44.0 ab	149.7 c	51.5 b	0.59 cd

Means followed by similar letters in each column are not significantly different at p = 5 % based on Duncan test.
Barley optimum and twice optimum densities: 400 and 800 plants m^{-2}, respectively
Triticale optimum and twice optimum densities: 400 and 800 plants m^{-2}, respectively
Canola optimum and twice optimum densities: 70 and 140 plants m^{-2}, respectively

Table 4: The results of mean comparison for interaction effect on the dry mass of investigated green manures (g m^{-2})

Green Manure	2017-18	2018-19	2019-20
Control	0 ^{k}	0 ^{k}	0 ^{k}
Barley optimum density	482.4 ^{egf}	678.3 ^{bc}	638.4 ^{c}
Barley twice optimum density	738.6 ^{b}	937.0 ^{a}	921.6 ^{a}
Triticale optimum density	430.4 ^{efgh}	638.9 ^{c}	588.1 ^{cd}
Triticale twice optimum density	632.4 ^{c}	921.7 ^{a}	854.7 ^{a}
Canola optimum density	291.1 ^{j}	443.6 ^{efgh}	404.1 ^{ghi}
Canola twice optimum density	375.9 ^{hij}	529.2 ^{de}	497.8 ^{defg}
Arugula optimum density	314.7 ^{ij}	417.2 ^{fgh}	402.6 ^{ghi}
Arugula twice optimum density	436.4 ^{efgh}	513.9 ^{def}	522.7 ^{de}

Means followed by similar letters in each column are not significantly different at p = 5 % based on Duncan test.
Barley optimum and twice optimum densities: 400 and 800 plants m^{-2}, respectively
Triticale optimum and twice optimum densities: 400 and 800 plants m^{-2}, respectively
Canola optimum and twice optimum densities: 70 and 140 plants m^{-2}, respectively
Arugula optimum and twice optimum densities: 80 and 160 plants m^{-2}, respectively

light reaching the lower parts of the plant canopy in these treatments, reducing the weeds photosynthetic activity of and thus reducing their density (Bilalis et al., 2009). Residues mixed with the soil of green plants with allelopathic effects (Ohno et al., 2000), stimulation of soil pathogens (Conklin et al., 2002), impact on nutrients access (Gallandt et al., 1999), increase crop growth, and improving its competitiveness with weeds (Boquet et al., 2004) can reduce weed density and growth. A report states that non-legume species such as canola and rye are suitable if the main purpose of using cover crops is to control weeds (Campiglia et al., 2009).

The amount of soil organic matter in barley green manure treatment with twice optimum density with an average of 0.73 was higher than other treatments. Since the highest biomass produced among green manures was related to this treatment, the higher amount of soil organic matter in this treatment can be attributed to this factor. After this treatment, triticale with twice optimum density and barley with optimum density was in the second and third ranks in terms of soil organic matter (Table 3). The high percentage of organic carbon in these treatments is probably due to the larger volume of soil-derived residues in these treatments. In the study of Ghaffari et al. (2013), rye, barley and triticale treatments with three times planting density and rye with normal density increased 26, 25, 21, and 25 % of soil organic carbon content, respectively, compared to the control treatment. In some studies, an increase in soil organic carbon content due to the application of green manure compared to the conventional low-input system (without fertilizer) has been reported (Clark et al., 1998). It has been reported that the return of green manure plants to the soil increases carbon, organic matter, total nitrogen, and soil fertility, which occurs as a result of microbiological processes and causes the release of nutrients for plants (Talgre et al., 2009).

4 CONCLUSIONS

Based on the results, the highest maize forage yield with 45.7 and 44.9 t ha^{-1} was obtained from barley green manure at twice optimum density and its optimum density, followed by triticale at both density and canola and arugula at twice optimum density. Due to severe organic matter deficiency in many soils of South Khorasan province, cultivation of green manure plants before maize cultivation, depending on the type of green manure selected and its density can increase maize forage yield by 9.6 to 20.7 % compared to not cultivating them. Reducing weeds in the soil will be another advantage of growing green manure before maize cultivation.

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