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ORIGINAL PAPER

INFLUENCE OF NITROGEN DOSE AND PLANT DENSITY ON THE YIELD AND QUALITY PROPERTIES OF DUAL PURPOSE BARLEY GROWN UNDER THE MEDITERRANEAN CLIMATIC CONDITIONS

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Abstract

Dual-purpose barley cultivation has become popular in recent years, especially in regions with restrictions on growing roughage. Despite its growing popularity, proper nitrogen doses and plant densities in the cultivation of dual-purpose barley are yet to be determined. Hence, this study was carried out at the Hatay Mustafa Kemal University, on research fields in the 2019-2020 and 2020-2021 growing seasons, in order to follow the effect of different nitrogen doses (0, 60, 120 and 180 kg ha^{-1}) and plant densities (450, 550 and 650 plant m^{-2}) on dual-purpose barley. To evaluate the performance of dual-purpose barley under different nitrogen doses and plant densities, properties of forage yield, quality, nutritive value, grain yield, yield characteristics and grain quality were investigated. The applied nitrogen doses and plant densities affected some parameters of the forage yield, quality and nutritive value, and grain yield. Better forage yield was obtained from dual-purpose barley fertilized with nitrogen doses of 120 kg ha^{-1} and 180 kg ha^{-1} at 550 plant m^{-2} and 650 plant m^{-2} plant densities. Similar results were obtained in terms of the forage quality and nutritive value of dual-purpose barley. In general, yield and yield characteristics of grain obtained from dual-purpose barley were not affected by nitrogen doses or plant densities. However, plant growing years affected some characteristics related to the yield, and this result was explained by meteorological factors. Thus, the most appropriate nitrogen dose and plant density were determined to be 120 kg ha^{-1} and 550 plant m^{-2}, respectively, for dual purpose barley cultivation in regions with the Mediterranean climate.

Keywords: barley cultivation, forage yield, grain yield, nitrogen fertilization, plant density.

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INTRODUCTION

Most of the areas around the Mediterranean Sea, including the southern regions of Turkey, are characterized by low and erratic precipitation, especially in spring and summer. This makes the management of pastures and the cultivation of forage crops for livestock both difficult and costly throughout the year. The general strategy used by farmers on unirrigated farmlands since ancient times has been to grow annual forage crops by autumn sowing so as to make the most of winter rains. For the same reason, cereals sown in autumn are widely used for fodder, grazing and silage when harvested during the dough stage (Delogu et al. 2002).

The regrowth and seed yielding capacity of cereals sown in autumn after harvesting in the early stages of vegetation has led to the dual-purpose cultivation of these plants in different parts of the world. Winter cereals grown for fodder and grain can ensure animal nutrition and crop production from the same land area, so both food and fodder can be obtained (Dove, Kirkegaard 2014). Therefore, dual-purpose cultivation of cereals is widely used as a sustainable alternative in Southern America (MacKown, Carver 2005), Australia (Bell et al. 2014) and in the Mediterranean countries (Francia et al. 2006). Until today, dual-purpose cultivation has been researched in various environments and its effect on grain yield has been investigated. However, studies on the yield and quality of dual purpose cultivation forage crops are rare.

Cereals constitute the most important source of feed, especially for small ruminants in summer and winter seasons (Ryan et al. 2008). Therefore, dual-purpose cultivation offers significant advantages in meeting the feed deficit, especially for animal husbandry in the Mediterranean countries such as Turkey. In the Mediterranean basin, where the winter climate is mild and the spring is dry, barley, oat and triticale are generally preferred instead of wheat in dual-purpose cultivation (Francia et al. 2006). It has been reported that yield and quality in dual-purpose cultivation are affected by factors such as grazing or mowing time, plant type or variety, plant density and nitrogen fertilization (Atis, Akar 2018). It has been reported in various studies that grain yield decreases in dual purpose barley and triticale cultivation after grazing (Bonachela et al, 1995, Royo, Tribo 1997).

When the plant is grazed or harvested in a dual-purpose cultivation system, nitrogen fertilization is needed again because the nitrogen content in the plant decreases (Pandey 2005, Tian et al. 2012). Therefore, nitrogen fertilizer application is beneficial in dual-purpose cultivation in many environmental conditions after the plant has been grazed or harvested (Pandey 2005, Tian et al. 2012). The plant density is crucial to the success of dual-purpose cultivation as it determines the competition for light, water, and nutrients among plants (Khalil et al. 2011). Forage yield is expected to increase at higher plant density. However, the effect of plant density on grain in dual-purpose cultivation is debatable (Salama 2019). While Hadjichristodoulou (1991) observed stable seed yield with varying plant density, Hajighasemi et al. (2016) reported that grain yield increased with increasing plant density. However, Khalil et al. (2011) reported that lower plant density should be used for high roughage production and grain yield increase in dual-purpose wheat cultivation. With the continued increase in seed costs occurring worldwide, optimizing plant density is crucial for dual purpose barley cultivation. Therefore, the aim of this study was to determine the most appropriate nitrogen dose and plant density for dual-purpose barley cultivation in the Mediterranean climatic conditions.

MATERIAL AND METHODS

Material, site, establishment, experimental design and factors and harvest

Finola, a barley cultivar, was used in the experiment. This study was carried out on a research field of the Hatay Mustafa Kemal University (36°15′13.56″ N 36°30′7.96″ E, 96 m a.s.l.), Hatay, Turkey, in the 2019-2020 and 2020-2021 growing seasons. The soil of the experimental area has clay-silt texture structure, a very low total salt content (0.0078%) and slightly alkaline reaction (7.12 pH). The soil calcium and phosphorus content was moderate (23.42% and 6.40 mg kg^{-1}), while its organic carbon (1.93%) was low. The trial was established on a field where there had been no plant production for at least five years prior to each of the two experimental years.

Monthly total rainfall (mm) and monthly mean temperature (°C) and its long-term data for the experimental area are given in Figure 1. There was a significant difference between the two growing seasons (2019-2020 and 2020-2021) in terms of meteorological factors. The 2020-2021 growing season was warmer compared to the 2019-2020 growing season. In addition, it was determined that the temperature was higher in both growing seasons compared to the long-term data, while the precipitation was quite low.

The experimental design of the study was laid out according to the split plot method in randomized complete blocks. A split plot size was 1.2 m × 5 m with 20 cm row spacing. Barley was sown on 18 November 2019 and 13 November 2020. In the study, no herbicide application was made for weed control, therefore weeds were removed by hand. All treatments were conducted with three replications. The experimental factors were plant densities (450, 550 and 650 plant m^{-2}) and nitrogen (the CH_4N_2O compound was used as fertilizer) doses (60, 120 and 180 kg ha^{-1}). The fertilizer doses were divided into three equal parts and applied at sowing, after cutting and at the flowering stage. Triple superphosphate ($Ca(H_2PO_4)2.H_2O$ (%43-44 P_2O_5)) was applied to the trial area as 60 kg ha^{-1} before sowing. No other fertilizer

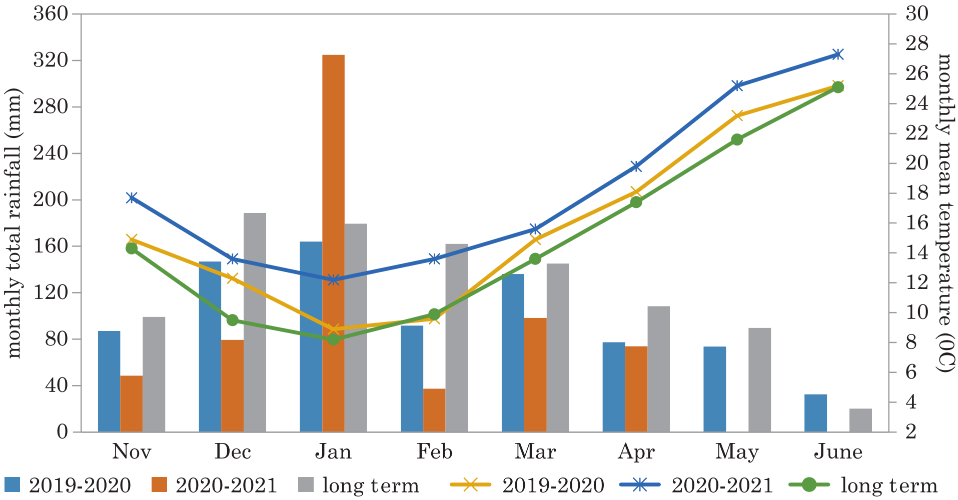

Fig. 1. Monthly total rainfall (mm) and monthly mean temperature (°C) during the vegetation period of dual-purpose barley and long-term data (1981-2020) in experimental field (all data were obtained from the nearest weather stations)

was not used. Plant densities and nitrogen doses were set in the main and split plot, respectively.

In order to obtain forage, barley grown in the different treatments was cut 90 days after emergence (Zadoks 30 stage) in both years (Zadoks et al. 1974). In order to obtain grain from regenerated barley, the cereal was harvested and threshed manually on 30 June in 2020 and on 25 June in 2021.

Forage characteristics

Plant height (PH) measurements at the date of cutting for forage were taken on 10 randomly selected plants from each plot at harvest. Weighing was done after harvesting for fresh forage yield (FFY) in barley harvested for forage, and 500 g samples for each treatment were separated from the weighed plant material and dried in an oven at 65°C. Dried samples were weighed and dry forage yield (DFY) was calculated on the basis of the dry matter share in the fresh yield weight. Crude ash (CA) and crude protein (CP) content of the forages was determined according to the AOAC (1990). In addition, crude protein yield (CPY) was calculated based on the forage yield. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) analyses were made according to Van Soest et al. (1991). Dry matter digestibility (DMD), dry matter intake (DMI) and relative feed value (RFV) of the forages were calculated according to the following formulas:

$$DMD\% = 88.9 - (0.779 \times ADF\%),$$

$$DMI\% = 120/NDF\%,$$

$$RFV = DMD\% \times DMI\% \times 0.775.$$

Grain yield and related properties

Plant height (PH) measurements were taken on 20 randomly selected plants from each plot at the threshing time. To determine grain yield and yield characteristics, spike length (SL), spikelet number per spike (SNS), grain number per spike (GNS), thousands-kernel weight (TKW), hectoliter weight (HW) and grain yield (GY) properties were investigated according to Genç et al. (1989). Biological yield (BY) was determined after cutting the plants at the threshing stage, and harvest index (HI) was calculated according to the following formula given by Afridi et al. (2010):

$$HI=(GY/BY)\times 100.$$

Crude ash (CA) and crude protein (CP) content of the grain was determined according to the AOAC (1990). In addition, crude protein yield (CPY) was calculated based on the grain yield.

Statistical analyses

All numerical data obtained from this study were subjected to analysis of variance according to the model created according to the sources of variation in the split plots of completely randomized blocks. Following this step, the Tukey pairwise comparison test was applied to the features found to be important at the highest 5% significance level via JMP software. The features of the interactions that were found to be important were visualized with bar graphs.

RESULTS

Forage characteristics

While the effect of nitrogen doses on PH at the cutting date for forage was found to be significant ($p<0.01$), the effect of plant densities and all interactions was found to be insignificant (Table 1). With the effect of nitrogen doses, the PH of dual-purpose barley at the cutting date for forage varied between 33.83 cm and 38.22 cm (Table 2). As the nitrogen doses increased, the PH continued to rise.

The effects of nitrogen doses and plant densities on FFY were statistically significant (Table 1). With the effect of nitrogen doses, the FFY of dual-purpose barley increased from 18.55 Mg ha^{-1} to 21.96 Mg ha^{-1} (Table 2). There was no statistical difference between the nitrogen dose applications of 120 kg ha^{-1} and 180 kg ha^{-1}. FFY values in the plant density treatments varied between 19.22 Mg ha^{-1} and 21.45 Mg ha^{-1}. Similar to the effect of nitrogen dose, FFY of dual-purpose barley improved as plant density increased.

Table 1

Effects of years, nitrogen doses, plant density and their interactions on some forage yield and quality parameters of dual-purpose barley

Source of variance	PH	FFY	DFY	CA	CP	CPY	NDF	ADF	ADL	DMD	DMI	RFV
Years (A)	ns	ns	ns	*	ns	ns	**	ns	ns	ns	*	*
Nitrogen Doses (B)	**	**	*	ns	*	**	ns	ns	ns	ns	ns	ns
A×B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Plant Densities (C)	ns	*	ns	ns	ns	ns	ns	*	ns	*	ns	ns
A×C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
B×C	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns
A×B×C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

PH – plant height, FFY – fresh forage yield, DFY – dry forage yield, CA – crude ash, CP – crude protein, CPY – crude protein yield, NDF – neutral detergent fiber, ADF – acid detergent fiber, ADL – acid detergent lignin, DMD – dry matter digestibility, DMI – dry matter intake, RFV – relative feed value, ns – not significant, ** $p<0.01$, * $p<0.05$.

While the effect of nitrogen doses on DFY was statistically significant ($p<0.05$), the effects of years, plant densities and all interactions were insignificant (Table 1). As the nitrogen dose increased from 60 kg ha^{-1} to 180 kg ha^{-1}, the DFY of dual-purpose barley advanced from 3.59 Mg ha^{-1} to 4.13 Mg ha^{-1} (Table 2). However, there was no statistical difference between the nitrogen doses of 120 kg ha^{-1} and 180 kg ha^{-1}.

The CA content of dual-purpose barley forages was influenced by years, but not by the treatments and interactions (Table 1). CA was determined as 13.01% in 2020 and 14.39% in 2021 (Table 2). Effects of nitrogen doses on the CP content were statistically significant ($p<0.05$) whereas the other treatments and interaction were not significant. CP ranged from 22.61% and 25.64% and as the nitrogen dose increased, the CP content of dual-purpose barley forage improved (Table 2). There was no statistically significant difference between nitrogen doses of 120 kg ha^{-1} and 180 kg ha^{-1}. CPY was affected statistically by nitrogen doses and B×C (nitrogen doses×plant densities) interaction. The highest CPY was obtained from the 550 plant m^{-2} plant density treated with 180 kg ha^{-1} of nitrogen, whereas the lowest value was determined in 450 plant m^{-2} plant density treated with 60 kg ha^{-1} nitrogen (Figure 2).

The effects of the experimental years on NDF were statistically significant but the effects of nitrogen doses, plant densities and interactions were not significant (Table 1). The NDF content was 45.09% in 2020 and 40.34% in 2021 (Table 2). Plant densities influenced significantly the ADF content of dual-purpose barley forage, while years, nitrogen doses and interactions were not significant in this respect (Table 1). The ADF content among the plant densities ranged from 21.70% to 22.56%. The ADF content was determined at 450, 550 and 650 plant m^{-2} plant densities, and it was higher at higher plant densities (Table 2). The ADL content was not affected by any treatment and interaction (Table 1).

Table 2

Mean values of some forage yield and quality parameters and the comparison results depending on years, nitrogen doses and plant densities

Items	Years		Nitrogen doses (kg ha^{-1})			Plant densities (plant m^{-2})		
	2020	2021	60	120	180	450	550	650
PH	29.49±0.51	42.47±1.05	33.83±1.90^{b}	35.88±1.59^{b}	38.22±1.96^{a}	35.28±2.03	36.01±1.63	36.64±1.92
FFY	15.40±0.46	25.67±1.33	18.55±1.66^{b}	21.09±1.70^{a}	21.96±1.79^{a}	19.22±1.81^{b}	20.93±1.88^{ab}	21.45±1.49^{a}
DFY	3.39±0.10	4.47±0.20	3.59±0.22^{b}	4.07±0.23^{a}	4.13±0.21^{a}	3.70±0.25	4.00±0.25	4.09±0.18
CA	13.01±0.10^{b}	14.39±0.13^{a}	13.57±0.21±	13.70±0.23	13.82±0.21	13.62±0.23	13.69±0.17	13.79±0.25
CP	24.73±0.43	23.29±0.38	22.61±0.47^{b}	23.77±0.30^{ab}	25.64±0.52^{a}	24.42±0.53	23.92±0.56	23.69±0.49
CPY	0.84±0.03	1.05±0.05	0.81±0.06	0.96±0.05	1.05±0.06	0.90±0.06	0.96±0.07	0.97±0.05
NDF	45.09±0.50^{a}	40.34±0.39^{b}	43.01±0.76	42.60±0.80	42.54±0.84	41.94±0.76	43.38±0.79	42.83±0.81
ADF	22.09±0.22	22.40±0.16	22.18±0.25	22.35±0.21	22.20±0.25	21.70±0.25^{b}	22.56±0.19^{a}	22.47±0.21^{a}
ADL	3.85±0.20	2.24±0.15	2.82±0.26	3.24±0.33	3.09±0.28	3.04±0.35	3.34±0.24	2.76±0.27
DMD	71.70±0.17	71.45±0.13	71.63±0.20	71.49±0.17	71.61±0.20	72.00±0.20^{a}	71.33±0.15^{b}	71.40±0.17^{b}
DMI	2.67±0.03^{b}	2.98±0.03^{a}	2.80±0.05	2.83±0.05	2.84±0.06	2.88±0.05	2.78±0.05	2.82±0.05
RFV	148.43±1.94^{b}	165.16±1.76^{a}	155.72±2.84	157.03±3.07	157.62±3.23	160.54±2.94	153.83±2.92	156.00±3.08

PH – plant height (cm), FFY – fresh forage yield (t ha^{-1}), DFY – dry forage yield (t ha^{-1}), CA – crude ash (% DM), CP – crude protein (% DM), CPY – crude protein yield (t ha^{-1}), NDF – neutral detergent fiber (% DM), ADF – acid detergent fiber (% DM), ADL – acid detergent lignin (% DM), DMD – dry matter digestibility (%), DMI – dry matter intake (%), RFV – relative feed value, ^{a,b} – mean values with different superscripts have significant differences

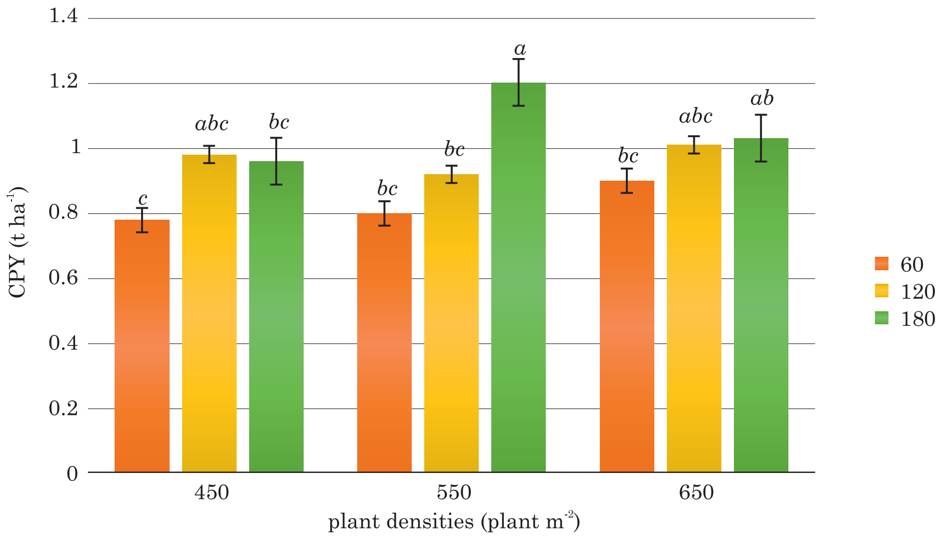

Fig. 2. Crude protein yield variations of forage in dual-purpose barley depending on the interaction of nitrogen doses and plant densities

The effect of plant densities on DMD was statistically significant but the other treatments and interactions were insignificant in this respect (Table 1). DMD values of dual-purpose barley forage varied between 71.33% and 72.00% (Table 2). The highest DMD was determined in the 450 plant m^{-2} plant density treatment, while the lowest value was in 550 plant m^{-2}. DMI and RFV characteristics were influenced by the year-related effect but not by the treatments and interactions (Table 1). DMI was 2.67% in 2020 and 2.98% in 2021 (Table 2). RFV was 148.43 in 2020 and 165.16 in 2021.

Grain yield and related properties

PH was not affected by any treatments and interactions (Table 3). The effect of years on BY and SL was statistically significant, while the effects of the treatments and interactions were insignificant (Table 3). In 2020 and 2021, the BY was 19.98 Mg ha^{-1} and 15.01 Mg ha^{-1} while the SL was 6.93 cm and 5.70 cm, respectively (Table 4). SNS was not influenced by any treatment and interaction (Table 3). The effect of years on the GNS and TKW was statistically significant, but the effect of the treatments and interactions was insignificant (Table 3). In 2020 and 2021, GNS was 47.54 and 40.39 while TKW was 49.35 g and 41.08 g (Table 4). HW and GY were not affected by any treatment and interaction (Table 3). HI was statistically affected by years, like the GNS and TKW (Table 3). The treatments and interactions did not influence the HI parameter. HI was 0.32 in 2020 and 0.25 in 2021 (Table 4).

The effect of nitrogen doses on the CA content of dual-purpose barley grain was statistically significant (p<0.01), while the effects of the other parameters and interactions were insignificant (Table 3). The CA content

Table 3

Effects of years, nitrogen doses, plant density and their interactions on some grain yield and quality parameters of dual-purpose barley

Source of variance	PH	BY	SL	SNS	GNS	TKW	HW	GY	HI	CA	CP	CPY
Years (A)	ns	*	*	ns	*	*	ns	ns	*	ns	*	ns
Nitrogen doses (B)	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	**	ns
A×B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	ns
Plant densities (C)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
A×C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
B×C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
A×B×C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

PH – plant height, BY – biological yield, SL – spike length, SNS – spikelet number in spike, GNS – grain number in spike, TKW – thousands-kernel weight, HW – hectoliter weight, GY – grain yield, HI – harvest index, CA – crude ash, CP – crude protein, CPY – crude protein yield, ns – not significant, ** $p<0.01$, * $p<0.05$

varied between 2.31% and 2.65% among the nitrogen doses (Table 4). The highest CA content was obtained from the application of 120 kg ha^{-1} nitrogen, whereas the lowest value was determined at the 180 kg ha^{-1} nitrogen application. CP was statistically affected by years, nitrogen doses and A×B (years×nitrogen doses) treatments, but CPY was not influenced by any treatment and interaction (Table 3). While the highest CP content was obtained from the 180 kg ha^{-1} nitrogen dose in 2021, the lowest value was recorded in 2020 with the 120 kg ha^{-1} nitrogen dose (Figure 3).

DISCUSSIONS

Forage characteristics

Nitrogen doses promoted the plant height of dual-purpose barley harvested at an early stage (Zhadoks 30) to obtain forage (Table 2).Actually, in many studies, it has been reported that plant height increases depending on the increase in a nitrogen dose (Gözübenli, Konuşkan 2010, Kaplan et al. 2016). As the nitrogen dose and plant density increased, the fresh forage yield of dual-purpose barley increased (Table 2). Similarly, Hajighasemi et al. (2016) reported that fresh forage yield increased as the plant density and nitrogen dose increased in dual-purpose barley cultivation. Dry forage yield of dual-purpose barley improved as the nitrogen dose increased (Table 2). In some studies where various nitrogen doses were tested, the dry matter accumulation in plants advanced with the increasing nitrogen dose (Rahman et al. 2014, Kaplan et al. 2016). The cCrude ash content of the dual-purpose barley forage was higher than reported by Amanullah et al. (2014) because dual purpose barley was cut earlier. On the other hand, Nand et al. (2019)

Table 4

Mean values of some grain yield and quality parameters and the comparison results depending on years, nitrogen doses and plant densities

Items	Years		Nitrogen doses (kg ha^{-1})			Plant densities (plant m^{-2})		
	2020	2021	60	120	180	450	550	650
PH	104.05±1.25	95.01±0.99	97.64±1.78	100.08±1.74	100.87±1.70	100.32±1.69	98.98±1.78	99.29±1.82
BY	19.98±041^{a}	15.01±0.52^{b}	16.69±0.96	17.95±0.87	17.84±0.60	18.40±0.91	17.09±0.77	16.99±0.77
SL	6.93±0.08^{a}	5.70±0.15^{b}	6.61±0.18	6.19±0.18	6.16±0.24	6.31±0.22	6.45±0.18	6.20±0.22
SNS	47.94±0.78	42.72±1.02	47.20±1.44	43.92±1.26	44.87±1.00	46.24±1.09	45.21±1.38	44.54±1.34
GNS	47.54±0.73^{a}	40.39±0.95^{b}	45.69±1.52	42.73±1.30	43.48±1.12	45.26±1.11	43.76±1.54	42.89±1.34
TKW	49.35±0.27^{a}	41.08±0.57^{b}	44.98±1.25	44.83±1.06	45.84±1.10	45.54±1.06	45.33±1.09	44.78±1.27
HW	6.32±0.04	6.29±0.04	6.33±0.05	6.33±0.04	6.25±0.04	6.31±0.05	6.30±0.04	6.31±0.05
GY	5.03±0.19	4.78±0.19	4.62±0.28	5.17±0.25	4.92±0.14	5.13±0.27	4.82±0.21	4.76±0.22
HI	0.32±0.01^{a}	0.25±0.01^{b}	0.28±0.01	0.29±0.01	0.28±0.01	0.29±0.01	0.29±0.01	0.28±0.01
CA	2.35±0.07	2.66±0.04	2.55±0.08^{a}	2.65±0.07^{a}	2.31±0.07^{b}	2.59±0.07	2.52±0.08	2.40±0.09
CP	9.61±0.08	11.09±0.21	9.96±0.18	10.16±0.23	10.93±0.31	10.43±0.28	10.44±0.29	10.18±0.22
CPY	0.48±0.02	0.53±0.03	0.46±0.03	0.53±0.03	0.54±0.02	0.54±0.03	0.51±0.03	0.49±0.03

PH – plant height (cm), BY – biological yield (t ha^{-1}), SL – spike length (cm), SNS – spikelet number in spike, GNS – grain number in spike, TKW – thousands-kernel weight (g), HW – hectoliter weight (kg), GY – grain yield (t ha^{-1}), HI – harvest index, CA – crude ash (% DM), CP – crude protein (% DM), CPY – crude protein yield (t ha^{-1}); ^{a,b} – mean values with different superscripts have significant differences

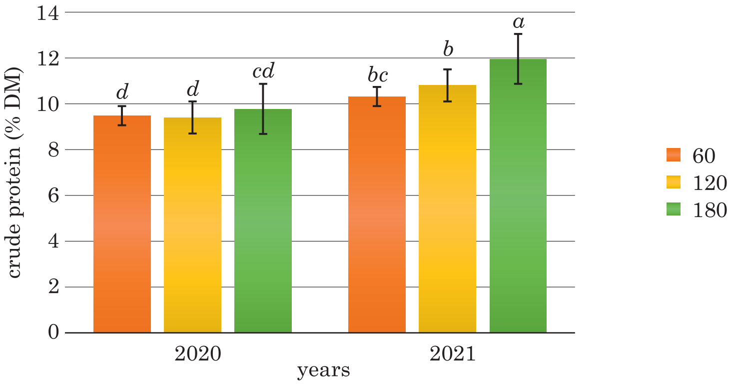

Fig. 3. Crude protein variations of grain in dual-purpose barley depending on the interaction of nitrogen doses and plant densities

reported the results similar to our findings. It has been clearly reported in many studies that as the nitrogen dose applied to the plants increases, the crude protein ratio and protein yield of the forages increases (Delevatti et al. 2019, Ertekin et al. 2021). Neutral detergent fiber and dry matter intake as well as the relative feed value of dual-purpose barley forage were influenced by the years of the experiment because rainfall and temperature were different in both years (Figure 1). Acid detergent fiber and dry matter digestibility of dual purpose barley forage increased depending on the plant densities, and Budaklı-Çarpıcı et al. (2010) reported likewise that the acid detergent fiber of maize plants increased as the plant densities increased. Kır, Ünsal (2020) reported that the dry matter digestibility decreased as the plant densities increased.

Grain yield and related properties

Plant height is a feature that is significantly affected by environmental conditions (Atak et al. 2021). However, plant height was not influenced by any treatment in this study. Biological yield, spike length, grain number per spike, thousands-kernel weight, harvest index and crude protein were affected from years because rainfall and temperature were different for both years (Figure 1). Actually, some researchers have reported that growing years affect yield and yield components in various plants (Budaklı-Çarpıcı et al. 2010, Sadreddine 2016, Hajighasemi et al. 2016). Oscarsson et al. (1998) reported that the grain crude ash content in different barley cultivars varied between %1.9 and %2.5. On the other hand, Cieślik et al. (2017) reported that the ash content was between %1.9 and %2.4 in barley grain under various growing techniques. The crude ash content of grain obtained from dual-purpose barley cultivation was found to be higher than the results reported above. However, the crude ash content obtained from this study was similar to the findings by Griffey et al. (2010). The crude protein ratio determined by many researches was generally found between %10 and %13 in barley grain (Oscarsson et al. 1998, Janković et al. 2011, Sadreddine 2016). The crude protein ratio obtained in this research was similar to the literature reports.

CONCLUSIONS

This study was conducted to determine the effect of different nitrogen doses and plant densities on dual-purpose barley. Better forage yield was obtained from dual-purpose barley with nitrogen doses of 120 kg ha^{-1} and 180 kg ha^{-1} at 550 plant m^{-2} and 650 plant m^{-2} plant densities. The same results were obtained in terms of forage quality and nutritive value of dual-purpose barley. In general, yield and yield characteristics of grain obtained from dual-purpose barley were not affected by nitrogen doses and plant densities. However, plant growing years affected some characteristics related to yield, and this effect was explained by meteorological factors. As a result, the most appropriate nitrogen dose and plant density in dual purpose barley cultivation in the Mediterranean climate regions were determined as 120 kg ha^{-1} and 550 plant m^{-2}, respectively.

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