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RESEARCH ARTICLE

Comparison of The Plant Heights and Relative Feed Values of Triticale and Vetch Mixtures Produced by a Hydroponic System

Mine AKMAN[1], Şenol GÜZEL[2], Hıdır GÜMÜŞ[3*]

[1]Burdur Mehmet Akif Ersoy University, Burdur Food Agriculture and Livestock Vocational School, Department of Plant and Animal Production, Horticulture Program, Burdur, Turkey

[2]Burdur Mehmet Akif Ersoy University, Faculty of Science and Literature, Department of Molecular Biology and Genetics, Burdur, Turkey

[3]Burdur Mehmet Akif Ersoy University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Burdur, Turkey*

ABSTRACT

This study was carried out to determine the effects of adding vetch seeds to triticale seeds at different ratios (100% triticale, T100; 90% triticale + 10% vetch, TV10; 80% triticale + 20% vetch, TV20; 70% triticale + 30% vetch TV30) on the shoot and root lengths values and relative feed value of green fodder produced by a hydroponic system. For this purpose, two cereal types (Triticale and vetch), six harvest times (3, 4, 5, 6, 7 and 8 days) and addition of liquid fertilizers (LF-; LF+) were evaluated to determine green fodder production performance. The group harvested TV20% with liquid fertilizer provided the highest triticale shoot height and root length values. The liquid fertilizer ($P=0.004$), days ($P<0.001$) and their interaction ($P=0.004$) significantly influenced the triticale shoot height value. The lowest shoot height and root length values of triticale were obtained in the T100% group. The vetch shoot height and root length values had the greatest improvements for the TV20% group with liquid fertilizer and the least for the TV10% group without liquid fertilizer. The highest value was found in the group of TV20% ($P<0.01$) with liquid fertilizer, and the lowest value was in the group of T100% without liquid fertilizer in terms of the relative feed value (RFV) of green fodder. As a result, the TV20% group with liquid fertilizer showed better green fodder performance than the other groups.

Keywords: Hydroponic system, Green fodder, Triticale, Vetch

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Hidroponik Sistemde Üretilen Tritikale ve Fiğ Karışımlarının Bitki Boyları ile Nispi Yem Değerlerinin Karşılaştırılması

ÖZ

Bu araştırma hidroponik sistemde üretilen tritikale tohumuna farklı oranlarda ilave edilen fiğ tohumlarının (%100 tritikale, T100; %90 tritikale + %10 fiğ, TF10; %80 tritikale + %20 fiğ, TF20; %70 tritikale + %30 fiğ, TF30) yeşil hasıl sürgün ve kök boy değerleri ile nispi yem değerleri üzerine etkilerini belirlemek amacıyla gerçekleştirilmiştir. Bu amaçla, hasıl üretim performansını belirlemede iki tür tane yem (Tritikale ve fiğ), altı farklı hasat zamanı (3, 4, 5, 6, 7 ve 8 günleri) ve sıvı gübre ilavesi (G-;G+) değerlendirilmiştir. Hasat edilen sıvı gübreli TV20% grubu en yüksek sürgün ve kök boyu değerlerini vermiştir. Sıvı gübre ($P=0.004$), günler ($P<0.001$) ve interaksiyonları ($P=0.004$) tritikalenin sürgün boyu değerlerini önemli derecede etkilemiştir. Tritikalenin en düşük sürgün ve kök boyu değerleri T100% grubunda elde edilmiştir. Fiğin sürgün ve kök boyu değerleri en fazla sıvı gübreli TV20% grubunda, en az sıvı gübresiz TV10% grubunda olmuştur. Yeşil hasıl nispi değerleri (NYD) bakımından en yüksek TV20% grubunda en düşük ise T100% grubunda bulunmuştur. Sonuç olarak, yeşil hasıl performansı bakımından sıvı gübreli TV20% grubunun diğer gruplara göre daha iyi olduğu tespit edilmiştir.

Anahtar kelimeler: Hidroponik sistem, Yeşil hasıl, Tritikale, Fiğ

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ORCID ID; *MA: 0000-0001-6521-8420, ŞG: 0000-0002-5811-7979, HG: 0000-0001-7077-1036*

*Corresponding author e-mail: hgumus@mehmetakif.edu.tr

INTRODUCTION

A hydroponic system is a method of growing plants without soil (Sarıçiçek et al. 2018). It was first applied in 1860 in England under the name of "Nutriculture", as an alternative to traditional agriculture. The efficiency of soilless agriculture technology at every moment of the year is widely used in agriculture and livestock businesses today (Sneath and Mclntosh 2003, Hussain et al. 2014). Soil or a nutrient medium is not used in hydroponic systems or incubation rooms to produce green feeds. The appropriate light, temperature, humidity, etc. are necessary for adequate germination. When the conditions are met, it is possible to produce green feeds (Kılıç 2016, Sneath and Mclntosh 2003). The roots interlock and take the appearance of a carpet after the grains are germinated. The green parts reach 20-25 cm in 6-8 days, and 6-10 times more green fodder can be obtained (Sneath and Mclntosh 2003, Sarıçiçek et al. 2018). Soil-supported cultivation of crops requires a lot of tools and equipment, labor, time and a large area, and there are also risks arising from climatic conditions. It is possible to obtain grass in a few days with hydroponic systems in a germination machine (Sarıçiçek et al. 2018). It has been reported in some studies that the nutritional values of green feeds grown were the best on the 7th day (Akbağ et al. 2014, Saidi and Omar 2015). After that day, energy levels and organic matter contents decreased, and the amount of structural carbohydrates increased (Gebremedhin et al. 2015, Karaşahin 2014, Fazaeli et al. 2012). During the germination process, with conversion of starch to sugar, the ash content of crops increases, and the dry matter and starch levels decrease (Peer and Leeson 1985). The yield and quality of the green feed that is produced depend on the grain type and quality, temperature, fertilizer contribution, moistening time and thickness and density of the grain spread on the tray (Sarıçiçek et al. 2018). Green feed produced in hydroponic systems has a disadvantage of a high water ratio, and it may pose a risk of mold and fungus development (Sarıçiçek et al. 2018). Especially in ruminant feeding, the low dry matter content may be a limiting factor (Gümüş and Bayır 2020). Although barley is a commonly used grain feed in this system (Emam 2016, Fazeli et al. 2011, Fazali et al. 2012, Karaşahin 2016), there also have been studies on the nutritional values and plant heights of green feeds produced with sorghum, wheat (Al-Karaki and Al-Hasimi 2012) or oats (Gümüş and Bayır 2020). However, the feed quality is generally determined according to their physical appearance and chemical rate, and the relative feed value (RFV) (Moore and Undersander 2002).

This study was carried out to investigate the effects of adding different amounts of protein-rich vetch seeds to triticale seeds, and to determine the day-to-day changes in the plant height and relative feed values of green fodder and increase the values with inorganic fertilizers.

MATERIAL and METHOD

The research was conducted in a steel hydroponic chamber within the Agriculture, Livestock and Food Research and Application Center of MAKU. This chamber was composed of two blocks; each block consisted of 7 shelves and 2 rows. Each block of the chamber unit contained 98 acrylonitrile butadiene styrene trays to produce green fodder. A temperature of 18-19 °C, relative humidity of 60%, lighting time and light color of 12 hours and yellow light, irrigation time and frequency of 90 seconds 120^{-1} minute, and liquid fertilizer (NPK) amount of 675 ppm were applied during the study, and the growing period was designed as 8 days. The contents of the green feed production cabin, irrigation system, trays and necessary tools were disinfected with 10% formaldehyde before planting. To minimize the risk of mold formation, 50 ml of sodium hypochlorite was added to the irrigation water every day. Tap water was used as a source of the irrigation system. Seeds were pre-soaked for 24 hours to accelerate germination. This study evaluated two forage crops which were triticale (*Triticosecale Wittmack)* and vetch *(Vicia sativa L.)*. The effects of the treatments (100% triticale, T100; 90% triticale + 10% vetch, TV10; 80% triticale + 20% vetch, TV20; 70% triticale + 30% vetch TV30), with liquid fertilizing (TV10%+LF, TV20%+LF, TV30%+LF) or without liquid fertilizing (TV10%–LF, TV20%–LF, TV30%–LF) and different growing times (3^{rd}, 4^{th}, 5^{th}, 6^{th}, 7^{th} and 8^{th} days) on the green fodder shoot heights, root lengths and relative feed values were examined in the study. The seeding rate applied in this study was about 1000 g/tray. The trays were imbedded on the shelves of the hydroponic chamber. All experiments were carried out with 4 replicates. A total of 32 trays (4 groups x 4 subgroups x 2 with/without liquid fertilizer) were used in the steel hydroponic chamber. The shoot heights and root lengths of 6 green feeds randomly selected from each group were measured using a tape measure until the harvest day (day 8^{th}) to determine the growth rate. The relative feed value (RFV) of the green feeds was calculated according to the method described by Rocateli and Zhang (2014).

The data was evaluated using the MIXED procedure of SAS (version 9.4, SAS Institute, Carry, NC) with the fixed effects of treatment, day, fertilizer, and their two- and three-way interactions. Each sample was included as random effects. The PDIFF statement was used for multiple comparisons as a post-hoc test. All data are reported as least square means with SEM

in tables via LSMEANS statement. The significance level was assumed at P< 0.05 for main effects.

RESULTS

The highest triticale shoot height value was found in TV20%+LF, and the lowest was in TV30%–LF. The liquid fertilizer (P=0.004), days (P<0.001) and their interaction (P=0.004) significantly influenced the triticale shoot height value. The triticale root length reached the highest value with a mean of 6.851 cm in the TV20%+LF group, while the TV30%–LF reached the lowest root length value with a mean of 6.236 cm. There were significant effects of the treatments (P=0.002) and days (P<0.001) for the triticale root lenght, and there was no significant interaction effect (P=0.37). In the meantime, the shoot height and root length values of the vetch were found to be lower in all groups in comparison to the triticale. The vetch's green fodder was examined in terms of shoot height, while the highest value was found as 3.0 cm in the group of TV30%+LF, and the lowest value was found as 2.853 cm in the group of TV10%–LF. The vetch's roots length in the TV20%+LF group was the highest among all groups. The days significantly influenced the vetch shoot height and root length (P<0.001). Neither the treatments (P=0.05) nor the interaction of the treatments and days (P=0.05) significantly affected the vetch's shoot height and root length values. The highest value was found in the group of TV20%+LF (P<0.01), and the lowest value was in the group of T100%–LF in terms of the relative feed value (RFV).

DISCUSSION

Alternative methods are being developed to meet the lack of quality roughage in Turkey. As an alternative to traditional agriculture, fresh green fodder can be produced 365 days a year regardless of the climatic conditions in hydroponic farming systems (Kılıç 2016). A green fodder production chamber is a closed system. Environment parameters such as temperature, humidity, lighting values, the pH and EC values of water, and the pressure of the irrigation system can be adjusted in hydroponic systems according to the desired values. These parameters are important for a healthy plant and faster growth. Green fodder production rooms are harvested by up to 15-20 cm daily (Palande et al. 2017). The results of this study showed that the mean shoot height and root length values of the triticale green fodder in the TV20%+LF treatment were significantly higher than those in the TV10% and TV30% treatments. The highest mean green fodder root length value was recorded in TV20%+LF, followed by TV30+LF and TV10%+LF (Table 1). In a study conducted by Emam (2016) with barley *(Giza 127 variety)* green fodders, it was stated that the harvest reached a shoot height of 10.10 cm at day 7 of harvesting. The shoot heights of the triticale and vetch green fodder in this study ranged between 11.55 cm and 6.85 for TV20%+LF at day 8 of harvesting. Gümüş and Bayır (2020) reported that the green fodder height of barley was 17.75 cm, and the green fodder height of the oat was 12.22 cm at day 7 of harvesting in a hydroponic chamber system. Saha et al. (2016) determined the height value of a plant in an aquaponic system as 14% higher than produced in a hydroponic system in their study. Natsheh (2020) stated that the salinity in tap water also showed an important succession rate in shoot height with an increase tendency from 15 to 20.19 cm at the end of their study. It was found that green fodders of barley, corn and wheat produced in a hydroponic chamber system showed the shoot height and root length measures of 17.00 and 12.00 cm, 15.00 and 15.00 cm and 10.80 and 5.80 cm, respectively, and significant differences were found among the tested green fodders (Karaşahin 2015). In this study, the effects of the liquid fertilizer applications on the shoot height of the triticale green fodder were found to be statistically significant in comparison to the control group. The outcome of the current study was in agreement with Karaşahin (2016), who stated that the height of corn green fodder produced in a hydroponic chamber system increased by approximately 38% with the use of fertilizers. As expected, the liquid fertilizer affected the shoot heights and root lengths in this study. The vetch structure is prone to bending problems in field studies, and it has been proposed to grow vetch with grains such as barley, wheat, triticale (Acar et al. 2017), oats and rye (Yolcu et al. 2009, Aşcı et al. 2020). In this study, the best root length value for the triticale and vetch was found in the TV20%+LF group. Kuşan et al. (2019) stated that the heights of the green fodder of triticale, barley, wheat, oat and rye were measured as 16.08 cm, 17.47 cm, 14.21 cm, 13.90 and 11.67 cm, respectively, on the 8th day in a hydroponic chamber system. The vetch shoot height value had the greatest improvements for TV20%+LF and the least for TV10%–LF. We think that the shoot height responded to the vetch amount, such that, the shoot heights were increased by increasing the application of the vetch amount in the treatments. During the present experiment, it was determined that the shoot height and root length values of the vetch irrespective of liquid fertilizer were lower than the triticale shoot height and root length values. Addition of the liquid fertilizer insignificantly increased the shoot height and root length values of the vetch green fodder. Similar findings were reported by Karaşahin (2017), who found that growing barley green fodder with (*Hordeum vulgare L.conv. distichon, two-row barley*) an inorganic fertilizer and an organic fertilizer had an insignificant effect on the shoot heights and root lengths. RFV is widely used by the United States to measure the feed value of alfalfa. For alfalfa in full bloom, the RFV value is taken as 100, and the quality of the feed falls below this value. At

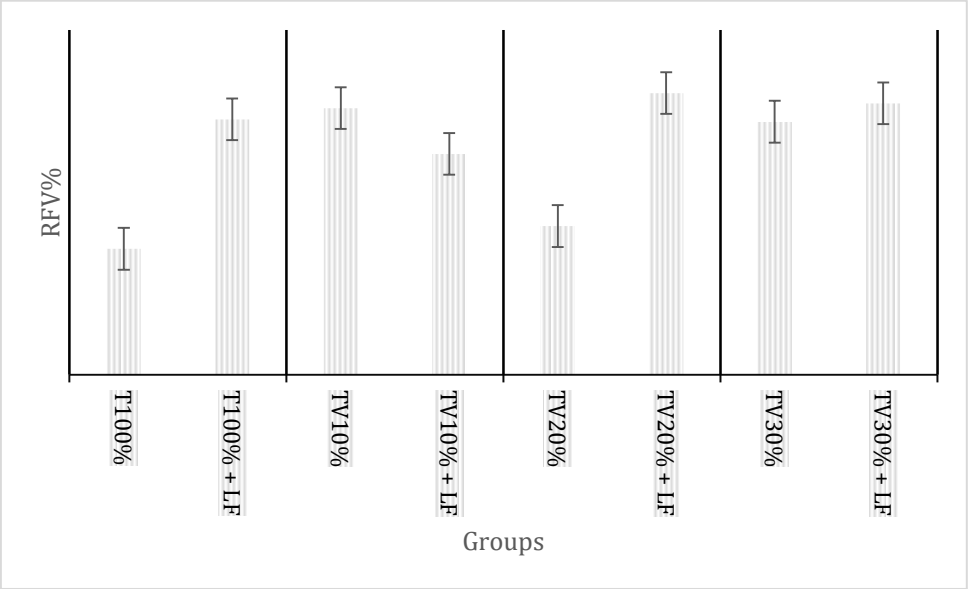
the end of the experiment, the RFV value was found to be the highest in the TV20%+LF group to which the liquid fertilizer was added, whereas it was the lowest in the T100%–LF group. Gümüş and Bayır (2020) stated that the highest RFV of barley and oat green fodders produced in a hydroponic system was found in the barley green fodder. In a comparison of a hydroponic system and a soil system conducted by Sarıçiçek et al. (2018), it was identified that the highest RFV was in the hydroponic system.

Table 1. Shoot height and root length of green fodders

Tablo 1. Yeşil hasılların sürgün ve kök uzunlukları

Groups	T100%		TV10%		TV20%		TV30%		SEM	T	LF	D	TxD	TxLF	TxDxLF
Triticale	LF–	LF+	LF–	LF+	LF–	LF+	LF–	LF+							
SH	6.389	6.715	6.529	6.625	6.506	6.772	6.350	6.725	0.109	0.93	0.004	<.0001	0.37	0.39	0.004
RL	6.261	6.304	6.315b	6.319b	6.583a	6.851a	6.236b	6.516b	0.114	0.002	0.06	<.0001	0.71	0.38	0.12
Vicia S.	LF–	LF+	LF–	LF+	LF–	LF+	LF–	LF+	SEM	T	LF	D	TxD	TxLF	TxDxLF
SH	-	-	2.853	2.931	2.906	2.919	2.969	3.000	0.06	0.29	0.83	<.0001	0.01	0.64	0.84
RL	-	-	4.152b	4.272b	4.327ab	4.485ab	4.397a	4.465a	0.09	0.05	0.92	<.0001	0.05	0.48	0.16

T100%: Triticale 100%, TV10: Triticale 90%+ Vetch 10%, TV20: Triticale 80%+Vetch 20%, TV30: Triticale 70%+Vetch 20% SH: Shoot height, RL: Root lenght
T: Treatments, LF: Liquid fertilizer, D: Days, TxD: Treatments x Days, TxLF: Treatments x Liquid fertilizer, TxDxLF: Treatments x Days x Liquid fertilizer



T100%: Triticale 100%, TV10: Triticale 90%+ Vetch 10%, TV20: Triticale 80%+Vetch 20%, TV30: Triticale 70%+Vetch 20%, LF: Liquid fertilizer

Figure 1. Relative feed values of green fodders
Şekil 1. Yeşil hasılların nispi yem değerleri

CONCLUSION

Using a hydroponic chamber system is a technique for germinating seeds such as wheat, barley and maize to produce a high nutritional value in fodder used in animal nutrition. In terms of animal nutrition, using green fodder could be a limiting factor because of its low-level dry matter. This approach may be incorrect in based on the comparison of green fodder and seeds in terms of dry matter. As a result, green fodder, which has been recommended as alternative forage, is used in animal nutrition, especially in the winter season. The shoot height and root length values of green fodder affect the nutritional values of green fodder such as dry matter, crude protein, NDF and ADF. Based on the results of this study, the TV20+LF group showed better shoot height, root length and RFV results under the hydroponic chamber system than the other groups. Regardless of the group, addition of the liquid fertilizer had numerically greater shoot height and root length value improvements than the groups without addition of the liquid fertilizer. Seed type, mixing ratios of seeds, harvest time and quantity of liquid fertilizer could have affected the hydroponic performance. So, more studies are needed to investigate the hydroponic performance of producing different seeds under a hydroponic chamber system.

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Ethical Statement

This study does not present any ethical concerns.

Conflict of Interest

The authors declare that there is no conflict of interest.

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