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Publishers Ethic Rules

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Original Papers:

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The Effects of Cutting Time on Herbage Production and Quality of Buckwheat (*Fagopyrum esculentum Meonch*.) Cultivated in Kahramanmaras Conditions

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Abstract
This research was carried out in the trial area of Kahramanmaras Sutcu Imam University, Faculty of Agriculture, Field Crops Department in the summer production period of 2021 to determine the appropriate cutting time of buckwheat varieties to be grown as animal feed in the ecological conditions of Kahramanmaras province. In the study, Aktas and Gunes buckwheat varieties were cut at five different times. The field experiment was conducted in randomized complete block design in a split plot with three replications. The research results showed that dry herbage yield, dry matter ratio, crude protein ratio, raw ash ratio, neutral detergent ratio, acid detergent fiber ratio, digestible dry matter value and digestible dry matter yield were statistically significantly affected. It was determined that green herbage yield was between 657.6-995.1 kg/da, dry herbage yield 136.8-298.5 kg/da, crude protein ratio 7.51-15.02 %, crude protein yield 17.14-29.72 kg/da, crude ash ratio 9.93-12.97 %, NDF ratio 53.95-66.46 %, ADF ratio 37.26-50.52 %, RFV 70.60-103.25 and the digestible dry matter yield 72.76-150.17 kg/da were between. It can be said that the most suitable cutting time for forage quality of buckwheat to be used in animal feeding in Kahramanmaras conditions is the beginning of flowering.

Key words
Buckwheat, NDF and ADF ratio, herbage yield and herbage quality, animal feeds, protein ratio.

Introduction
One of the greatest fears of humankind today and in the near future is the problem of food insufficiency, our basic need. This concern drives us to find fast and effective alternative sources of food. In order to increase production and quality, resources need to be derived in addition to existing products. The main way to meet the need for food is through agricultural production. Agricultural production is the sum of crop and animal production. In order for people to lead a healthy life, it is a necessity for them to include both plant-based and animal-based foods in their nutrition programs. Plant protein sources are more preferred than animal protein because they are cheaper and more easily accessible. The increase in meat prices also limits people's access to animal protein (Aiking, 2011). One of the most important criteria in determining the level of development of countries is the amount of animal products consumed per capita (Gunes, 2013). In order to meet the increasing consumption of animal products, it is necessary to increase the effective use of production areas, increase the yield of products obtained and increase the number of animals and the yield obtained from animals (Balcı, 2022). Accessibility to cheap and high-quality roughage resources is one of the main problems in animal nutrition. In an enterprise where feed costs constitute 70% of total expenses, 78% of feed expenses are roughage and 22% are concentrate feed (Harmansah, 2018). Increasing the production of roughage and making this production by the enterprises themselves will reduce the cost to a great extent. The increase in subsidies to be made by the state will also positively affect production. Roughages are indispensable feed resources in animal husbandry and it is a fact that there is a serious deficit of quality roughage in animal husbandry in our country. In order to meet the feed needs of our animals, it should be aimed to close the quality roughage deficit. In order to achieve this goal, the possibilities of using alternative roughage resources that we can increase the production and quality should be investigated (Gemalmaz and Bilal, 2016). It has been reported in different studies conducted by various researchers that buckwheat, which is rich in leaf number, can be used as roughage (Surmen and Kara, 2017), its short vegetation period, rapid growth and high herbage yield (Kara and Yuksel, 2014), and its adaptability to different soil conditions (Karafaki, 2017). Buckwheat (Debnath et al., 2008), which is annual and has no kinship ties with cereals, is a plant characterized as pseudocereal and has common areas of use with cereals (Yavuz et al., 2016). It is a plant with a height between 60-150 cm, a large number of branches and flower colours such as white, pink, light green, red (Valenzuela and Smith, 2002). Buckwheat is a plant that can reach higher yields in cool weather and is quickly affected by frosts. In regions with high temperatures, plant height is short and yield is low. It is a suitable plant for short summer months in cold ecologies. Although it can be cultivated in every region of our country, the region with the most favourable climatic conditions for buckwheat is Central Anatolia (Balci, 2022). The need for alternative forage crops with high yield and quality and high adaptability is very high both in our country and worldwide. There are very few studies in which buckwheat plant, which has high potential under suitable ecological conditions, is evaluated as feed. Our study and similar studies are of great importance directly in animal nutrition and indirectly in human nutrition. Harvest time is very important for grain and herbage yield (Tan, 2018). This study, which aimed to determine the most suitable harvest time for herbage yield and quality in buckwheat, was conducted in 2021 under Kahramanmaras ecological conditions.

Material and Methods
In the summer season of 2021, the experiment was carried out in the experimental field of Kahramanmaras Sutcu Imam University, Faculty of Agriculture, Department of Field Crops. The experimental field located in Kahramanmaras Onikisubat district of the Mediterranean region is located between 37°35'40.86' north latitude and 36°48'47.51' east longitude degrees. The altitude is 487 m and the slope is 3-5%. The temperature, rainfall and relative humidity in 2021, when the experiment was established, are given in Table 1.

Table 1. Climate Data for 2021 and Long Years Measured at Kahramanmaras Meteorological Station

Months	Total Rainfall (mm)		Average Temperature (°C)		Relative Humidity (%)	
	2021	Long Years	2021	Long Years	2021	Long Years
April	16.2	73.0	16.3	15.6	45.3	57.59
May	12.0	38.8	23.2	20.6	47.8	54.95
June	0.0	8.6	26.0	25.7	48.1	49.67
Tot./Avr.	28.2	120.4	21.8	20.6	47.1	54.07

Based on Table 1, when the data of the research period are analysed, the long-term average of total rainfall is 120.4 mm (Anonymous, 2021a). Considering the dates of the experiment, this value was 28.2 mm and 92.2 mm less precipitation than the long-years average. In the season in which the research was conducted, the long-years average temperature was 20.6 °C. In the dates corresponding to the trial season, the average temperature was 21.8 °C. When this value is compared with the long-years average, it is seen that it is higher. When the relative humidity values are considered, the long-years average is 54.07% and 47.1% during the growing period. When the whole table is analysed, it can be said that the experimental year was hotter and drier.

Table 2. Physical and Chemical Properties of Soil from the Experimental Area

Parameters Analysed							
Depth (cm)	Water Saturation	pH	Lime (%)	Organic Matter (%)	Salinity (%)	P_2O_5 (kg/da)	K_2O (kg/da)
0-30	69.96	7.71	6.09	1.58	0.05	2.84	55.51

Before the experiment was established, samples were taken from 0-30 cm depth and analysed to determine the physical and chemical properties of the soil. The results of the analyses performed at USKIM are given in Table 2. According to the results of the analysis; water saturation was 69.96% (clay loam), pH value was 7.71 (slightly alkaline), lime content was 6.09% (medium calcareous), organic matter content was 1.58% (low), salinity was 0.05% (saline), phosphorus (P_2O_5) content was 2.84 kg/da (very low) and potassium (K2O) content was 55.51 kg/da (high) (Anonymous, 2021b).

Aktas and Gunes buckwheat varieties obtained from Bahri Dagdas International Agricultural Research Institute were used as the main material in this study. Aktas is a buckwheat variety with white flower colour, grain yield 80-160 kg/da, protein rate 11-14%, thousand grain weight 20-29 g, height range 80-95 cm and hectolitre weight 58-65 kg. It can be grown in every region of our country. Gunes is a variety with white flower colour, grain yield 100-180 kg/da, protein ratio between 11-14%, thousand grain weight 22-30 g, plant height 85-100 cm and hectolitre weight 60-68 kg. As in Aktas variety, it can be cultivated in every region of our country.

The research was established according to the split plots experimental design with 3 replicates. The experimental area was ploughed with plough. Then it was made suitable for sowing by using cultivator and tappet. Sowing was done manually in 6 rows in plots with 20 cm row spacing and 3 m length. The plot size was 1.2 m x 3 m = 3.6 m^2. For both varieties, 350 plants per m^2 was taken as a basis and 1260 plants per 3.6 m^2 were calculated. The thousand grain weight was found to be 25.52 g for Aktas buckwheat variety and 24.99 g for Gunes buckwheat variety. Based on the thousand grain weights, the amount of seeds per 3.6 m^2 was calculated as 32.16 g/parcel for Aktas variety and 31.48 g/parcel for Gunes variety. To determine the green herbage yield, the green herbage harvested from each plot was weighed. Then, based on the value determined for the plot, green herbage yield per decare was calculated. To calculate dry herbage yield, 700 g samples were taken from the mown green herbs and dried at 70 °C in the drying cabinet until the weight was constant. The dried samples were weighed and the dry herbage yield per plot was determined and converted to buckwheat dry herbage yield per decare. For crude ash content, samples of 3 grams each were taken from the plant samples dried at 105 °C and then cooled in a desiccator, placed in porcelain crucibles and burnt at 550 °C for 3 hours. Then crude ash content (%) was calculated by using the formula (Crude ash content (%) = (c-a)/(b-a) x 100 (a: Crucible tare b: Crucible tare + sample c: Crucible tare + ash)). In order to calculate the crude protein ratio, nitrogen analysis was performed on the dried samples by Kjeldahl method and the determined nitrogen values were multiplied by a coefficient of 6.25. In order to determine the crude protein yield, the crude protein ratios determined for each plot were multiplied by the dry herbage yield of each plot and crude protein yield was found. Then, crude protein yield per decare was calculated by making the necessary conversions. NDF and ADF ratios were determined by using Kutlu (2008). In order to determine the relative feed value, NDF and ADF values were calculated using the formulae described by Sheaffer et al. (1995).

Digestible Dry Matter (DDM) (%) = 88.9 - (0.779 x % ADF)

Dry Matter Intake (DMI) (%) = 120 / % NDF (in dry matter)

Relative Feed Value (RFV) = (DDM x DMI) / 1.29

The following formula was used to calculate the digestible dry matter yield (Tassever, 2019).

Digestible Dry Matter Yield (DDMY) (kg/da) = Dry Matter Yield (DMY) (kg/da) x Digestible Dry Matter (%) (DDM)

Based on the results of soil analysis, fertiliser application was made with 20.20.0 compound fertiliser as 6 kg/da N and 6 kg/da pure P. Weed control was carried out manually during the period from germination to harvest. During the vegetation period, drip irrigation was applied 9 times (22 April, 27 April, 5 May, 15 May, 23 May, 27 May, 4 June, 10 June and 14 June). In five different periods (beginning of flowering-22 May 2021, 50% flowering-27 May 2021, 75% flowering-1 June 2021, 100% flowering-7 June 2021, seed ripening-20 June 2021), mowing was done with the help of a sickle from the closest place to the soil.

Results and Discussion

Analysis of variance results of the analysed traits of buckwheat harvested at different times are given in Table 3.

Table 3. Analysis of Variance Results for the Analysed Traits of Buckwheat Harvested at Different Times

	GHY	DH Y	DMR	CPR	CPY	CAR	NDF	ADF	DDM	DMI	RFV	DDMY
	P Value*											
V	0.04	0.02	0.00	0.49	0.35	8.95	0.32	9.98	9.94	0.28	2.90	0.07
CT	0.62	5.53*	88.58*	43.48*	1.81	4.16*	78.26*	18.97*	18.88*	90.49*	71.57*	3.66*
V x CT	1.95	1.62	1.84	2.09	2.09	1.16	7.18*	7.59*	7.60*	6.76*	9.54*	1.89

*Significant at P≤0.05, V: Variety, CT: Cutting Time, GHY: Green Herbage Yield, DHY: Dry Herbage Yield, DMR: Dry Matter Ratio, CPR: Crude Protein Ratio, CPY: Crude Protein Yield, CAR: Crude Ash Ratio, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, DDM: Digestible Dry Matter, DMI: Dry Matter Intake, RFV: Relative Feed Value, DDMY: Digestible Dry Matter Yield.

Green Herbage Yield (kg/da)

Table 4. Average Green Herbage Yield (kg/da) of Buckwheat Varieties Harvested at Different Maturity Periods and Groups Formed

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	866.7	657.6	762.1
50% Flowering period	942.3	816.8	879.5
75% Flowering period	893.1	810.1	851.6
100% Flowering period	828.1	944.1	886.1
Seed ripening period	759.4	995.1	877.3
Average	857.9	844.7	851.3

Green herbage yield (kg/da) obtained from buckwheat varieties harvested at different maturity periods was not statistically significant. When Table 4 is analysed, the highest green herbage yield average was 857.9 kg/da for Aktas variety and the lowest green herbage yield average was 844.7 kg/da for Gunes variety. According to the mean values of green herbage yield for harvesting times, the highest green herbage yield was obtained as 886.1 kg/da in 100% flowering period. When Aktas cultivar was evaluated in terms of cultivar x harvest time interaction, it was determined that green herbage yield was between 759.4-942.3 kg/da. In Gunes variety, it was determined that the green herbage yield was between 657.6-995.1 kg/da in terms of variety x harvest time interaction. The highest green herbage yield was 995.1 kg/da in Gunes variety at seed ripening period and the lowest green herbage yield was 657.6 kg/da in Gunes variety at the beginning of flowering. When the results obtained were compared with the results of the researchers who previously studied on the same subject; our findings were higher than the findings obtained by Alkay (2019) in Bingol (269.75-410.00 kg/da), similar to the findings obtained by Polat and Kan (2021) in Konya (114.60- 1520.30 kg/da) and lower than the findings obtained by Acar et al. (2011) in Konya (1783.80 kg/da). It is thought that the difference between our data on green herbage and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Dry Herbage Yield (kg/da)

It was determined that the dry herbage yield (kg/da) obtained from buckwheat varieties harvested at different maturity periods was statistically significant in terms of harvest time.

Table 5. Averages and Groups of Dry Herbage Yield (kg/ha) of Buckwheat Varieties Harvested at Different Maturity Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	163.3	136.8	150.0 C[1]
50% Flowering period	219.6	183.9	201.7 BC
75% Flowering period	205.4	184.4	194.9 BC
100% Flowering period	214.4	235.6	225.0 AB
Seed ripening period	226.6	298.5	262.6 A
Average	205.9	207.8	206.9

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test.

When Table 5 is analysed, the highest average dry herbage yield was obtained in Gunes variety (207.8 kg/da) and the lowest average dry herbage yield was obtained in Aktas variety (205.9 kg/da. According to the mean values of dry herbage yield for harvest times, the highest dry herbage yield was determined as 262.6 kg/da at seed ripening period. In terms of cultivar x harvest time interaction, it was determined that the dry herbage yield of Aktas cultivar was in the range of 163.3-226.6 kg/da and the dry herbage yield of Gunes cultivar was in the range of 136.8-298.5 kg/da. The highest dry herbage yield of Gunes variety was 298.5 kg/da at the seed ripening period and the lowest yield of Gunes variety was 136.8 kg/da at the beginning of flowering. When the results obtained are compared with the results of the previous researchers on the same subject; our findings are higher than the results obtained by Omidbaigi and De Mastro (2004) in Tehran (10.7-25.2 kg/da) and Alkay (2019) in Bingöl (100. 2-142.3 kg/da), similar to the results obtained by Polat and Kan (2021) in Konya (29.5- 413.9 kg/da) and lower than the results obtained by Kara (2014) in Isparta (120.0-853.7 kg/da).

Dry Matter Ratio (%)

Table 6. Averages and Groups of Dry Matter Ratio (%) of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	19.0	20.8	19.9 D[1]
50% Flowering period	23.5	22.6	23.0 C
75% Flowering period	23.1	22.9	23.0 C
100% Flowering period	26.1	25.2	25.6 B
Seed ripening period	30.1	30.1	30.1 A
Average	24.3	24.3	24.3

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test.

It was determined that the dry matter ratio of buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time. Table 6 shows that the average dry matter ratio was 24.3% for Aktas and Gunes varieties. According to the mean values of dry matter ratio of cuttings, the highest dry matter ratio was obtained at the seed ripening period as 30.1% and the lowest dry matter ratio was obtained at the beginning of flowering as 19.9%. When evaluated in terms of cultivar x cutting time interactions, it was determined that the dry matter ratio of Aktas cultivar was between 19.0-30.1% and that of Gunes cultivar was between 20.8-30.1%. The highest dry matter ratio was observed in the seed ripening period (30.1%) for both varieties. The lowest dry matter ratio was reached at the beginning of flowering in Aktas variety with 19%. The findings obtained are higher than the findings of Yavuz and Kara (2018) in Isparta (11.1-21.25%).

Crude Protein Ratio (%)

It has been determined that the crude protein ratio obtained from buckwheat varieties harvested at different ripening periods is statistically significant in terms of mowing time.

Table 7. Crude Protein Ratio (%) Averages of Buckwheat Varieties Harvested at Different Ripening Periods and Groups Formed

	Varieties			Feed
Cutting Time	Aktas	Gunes	Average	Quality
Beginning of flowering	15.02	12.68	13.85 A[1]	2nd grade
50% Flowering period	13.24	12.61	12.93 A	3rd grade
75% Flowering period	11.48	10.98	11.23 B	3rd grade
100% Flowering period	8.50	9.18	8.84 C	4th grade
Seed ripening period	7.51	7.75	7.63 D	5th grade
Average	11.15	10.64	10.89	

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.05 error limits according to LSD test.

Rohweder et al. (1978) prepared a table to be used in classifying feed quality according to crude protein ratio. According to this table, if the crude protein ratio is higher than 19%, it is considered as "top quality feed", between 17-19% as "1st class feed", between 14-16% as "2nd class feed", between 11-13% as "3rd class feed", between 8-10% as "4th class feed" and less than 8% as "5th class feed". Feed quality classification is given in Table 7. When Table 7 is analysed, the highest crude protein ratio average was 11.15% in Aktas variety and the lowest crude protein ratio was 10.64% in Gunes variety. According to the average values of crude protein ratio for cutting times, the highest crude protein ratio was determined as 13.85% at the beginning of flowering. In the evaluation made in terms of variety x cutting time interaction, it was determined that the crude protein ratio was between 7.51-15.02% in Aktas variety and between 7.75-12.68% in Gunes variety. The highest crude protein ratio was 15.02% in Aktas variety at the beginning of flowering and the lowest crude protein ratio was 7.51% in Aktas variety at seed ripening period. The crude protein ratio of the plant in the vegetative development period is higher than the plants that have matured and completed their growth. As the plant matures, the ratio of leaves to stems decreases and crude protein ratio decreases with ripening (Buxton, 1996). The results are higher than those obtained by Alkay (2019) in Bingol (8.76-9.88%), similar to those obtained by Köksal (2017) in Yozgat (10.97-15.81%), and lower than those obtained by Arslan (2021) in Bursa (10.57-21.88%).

Crude Protein Yield (kg/da)

Table 8. Averages and Groups of Crude Protein Yield (kg/da) of Buckwheat Varieties Harvested at Different Maturation Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	24.59	17.27	20.94
50% Flowering period	29.72	23.02	26.37
75% Flowering period	23.31	19.91	21.61
100% Flowering period	18.00	21.37	19.68
Seed ripening period	17.14	22.66	19.90
Average	22.55	20.85	21.70

Crude protein yield obtained from buckwheat varieties harvested at different ripening periods was not statistically significant. When Table 8 is analyzed, it is seen that the highest crude protein yield average was 22.85 kg/da for Gunes variety and the lowest protein yield average was 20.55 kg/da for Aktas variety. According to the average values of crude protein yield for cutting times, the highest crude protein yield was found to be 26.37 kg/da at 50% flowering. According to the evaluation made in terms of variety x cutting time interaction, crude protein yield of Aktas variety was between 17.15-29.72 kg/da and crude protein yield of Gunes variety was between 17.27-23.02 kg/da. The highest crude protein yield of Aktas variety was 29.72 kg/da at 50% flowering period and the lowest crude protein yield of Aktas variety was 17.14 kg/da at seed ripening period. The results were higher than those obtained by Alkay (2019) in Bingol (8.9-12.7 kg/da) and lower than those obtained by Arslan (2021) in Bursa (27.26-62.49 kg/da). It is thought that the difference between our data and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Crude Ash Ratio (%)

It was determined that the crude ash content of buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time

Table 9. Crude Ash Ratio (%) Averages of Buckwheat Varieties Harvested at Different Ripening Periods and Groups Formed

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	12.97	11.39	12.18 A
50% Flowering period	11.10	10.61	10.86 B
75% Flowering period	11.68	10.66	11.17 AB
100% Flowering period	9.99	10.00	9.99 B
Seed ripening period	9.93	10.67	10.30 B
Average	11.13	10.67	10.90

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.05 error limits according to LSD test.

When Table 9 is examined, it is seen that the average crude ash content was 11.13% in Aktas variety and 10.67% in Güneş variety. According to the average values of the crude ash content of the cutting times, the highest crude ash content was 12.18% at the beginning of flowering and the lowest crude ash content was 9.99% at 100% flowering. According to the evaluation made in terms of variety and cutting time interactions, it was determined that the crude ash rate of Aktas variety was between 9.93-12.97% and the crude ash rate of Güneş variety was between 10.00-11.39%. The highest crude ash rate was obtained in Aktas variety (12.97%) at the beginning of flowering and the lowest crude ash rate was obtained in Aktas variety (9.93%) at seed ripening period. The findings were higher than the results obtained by Alkay (2019) in Bingol (2.29-2.60%) and close to the values obtained by Yavuz and Kara (2018) in Isparta (8.19-16.05%). It is thought that the difference between our data and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Neutral Detergent Fiber (NDF) (%)

It was determined that the NDF ratio (%) obtained from buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time and variety x cutting time interaction.

Table 10. Averages and Groups of NDF Ratio (%) of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties			Feed
Cutting Time	Aktas	Gunes	Average	Quality
Beginning of flowering	53.95 e*	54.26 e	54.10 E[1]	3rd grade
50% Flowering period	55.49 de	56.95 cd	56.22 D	3rd grade
75% Flowering period	57.96 cd	57.90 cd	57.93 C	3rd grade
100% Flowering period	61.94 b	59.01 c	60.47 B	3rd grade
Seed ripening period	62.66 b	66.46 a	64.56 A	4th grade
Average	58.39	58.91	58.66	

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *Averages of cultivar-mowing time interactions indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

Rohweder et al. (1978) prepared a ruler to be used in classifying feed quality according to NDF values. According to this table, if the NDF value is less than 40%, it is considered as "best quality feed", 40-46% as "1st class feed", 47-53% as "2nd class feed", 54-60% as "3rd class feed", 61-65% as "4th class feed" and more than 65% as "5th class feed". Feed quality classification is given in Table 10. When Table 10 is analyzed, the highest NDF ratio mean value was found in Gunes variety with 58.91% and the lowest NDF ratio mean value was found in Aktas variety with 58.39%. According to the mean values of NDF ratio for cutting times, the highest NDF ratio was 64.56% at seed ripening and the lowest NDF ratio was 54.10% at the beginning of flowering. According to the evaluation made in terms of variety x cutting time interactions, it was determined that the NDF ratio of Aktas variety was between 53.95-62.66% and the NDF ratio of Gunes variety was between 54.26-66.46%. The highest NDF ratio of Gunes variety was 66.46% at the seed ripening period and the lowest NDF ratio of Aktas variety was 53.95% at the beginning of flowering. The results obtained were higher than the values determined by Surmen and Kara (2017) in Aydın (31.83-40.66%), Yavuz and Kara (2018) in Isparta (31.61 41.63%), and relatively close to the results determined by Köksal (2017) in Yozgat (42.20-52.03%).

Acid Detergent Fiber (ADF) Ratio (%)

It was determined that the ADF ratio (%) obtained from buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time and variety x cutting time interaction.

Table 11. Averages of ADF Rate (%) of Buckwheat Varieties Harvested at Different Maturation Periods and Formed Groups

	Varieties			Feed
Cutting Time	Aktas	Gunes	Average	Quality
Beginning of flowering	37.26*c	45.84 b	41.55 D[1]	3rd grade
50% Flowering period	46.28 b	47.52 ab	46.90 BC	5th grade
75% Flowering period	45.50 b	45.78 b	45.64 C	5th grade
100% Flowering period	50.52 a	48.56 ab	49.54 A	5th grade
Seed ripening period	47.81 ab	49.36 ab	48.58 AB	5th grade
Average	45.47	47.41	46.44	

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *Averages of cultivar-mowing time interactions indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

Rohweder et al. (1978) prepared a ruler to be used in classifying feed quality according to ADF values. According to this table, if the ADF value is less than 31%, it is considered as "best quality feed", between 31-35% as "1st class feed", between 36-40% as "2nd class feed", between 41-42% as "3rd class feed", between 43-45% as "4th class feed" and more than 45% as "5th class feed". Feed quality classification is given in Table 11. When Table 11 is analyzed, the highest average ADF rate was found in Gunes variety (47.41%) and the lowest in Aktas variety (45.47%). According to the mean values of ADF ratio for cutting times, the highest ADF ratio was found to be 49.54% at 100% flowering. When Table 11 was analyzed in terms of variety x cutting time, it was found that the ADF ratio of Aktaş variety was in the range of 37.26-50.52% and the ADF ratio of Gunes variety was in the range of 45.78-49.36%. The highest ADF content of Aktas variety was 50.52% at 100% flowering and the lowest ADF content of Aktas variety was 37.26% at the beginning of flowering. The findings were higher than the values obtained by Koksal (2017) in Yozgat (29.94-35.82%) and close to the results of Alkay (2019) in Bingöl (40.19-42.04%). It is thought that the difference between our data and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Digestible Dry Matter (%)

Table 12. Averages and Groups of Digestible Dry Matter Value of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	59.88*a	53.19 b	56.54 A[1]
50% Flowering period	52.85 b	51.89 bc	52.37 BC
75% Flowering period	53.46 b	53.24 b	53.35 B
100% Flowering period	49.55 c	51.08 bc	50.32 D
Seed ripening period	51.66 bc	50.45 bc	51.06 CD
Average	53.48	51.97	52.72

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *Averages of cultivar-mowing time interactions indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

It was determined that the digestible dry matter value obtained from buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time and variety x cutting time interaction. When Table 12 is examined, the highest average digestible dry matter value was obtained as 53.48% in Aktas variety and the lowest value was obtained as 51.97% in Gunes variety. When the mean values of digestible dry matter value of cutting times were analyzed, the highest value of 56.54% was obtained at the beginning of flowering. According to the evaluation made in terms of variety x cutting time interaction, it was determined that the digestible dry matter value of Aktas variety was between 49.55-59.88% and the digestible dry matter value of Gunes variety was between 50.45-53.24%. The highest digestible dry matter value was 59.88% in Aktaş variety at the beginning of flowering and the lowest value was 49.55% in Aktaş variety at 100% flowering. The values determined as a result of the research were similar to the values obtained by Alkay (2019) in Bingol (56.15-57.59%) and lower than the values obtained by Surmen and Kara (2017) in Aydin (60.99-67.05%).

Dry Matter Intake (%)

It was found that the digestible dry matter intake value obtained from buckwheat varieties harvested at different ripening periods was statistically significant in terms of harvest time and variety x harvest time interaction.

Table 13. Averages and Groups of Dry Matter Intake Value of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	2.22*a	2.21 a	2.22 A[1]
50% Flowering period	2.16 ab	2.11 bc	2.13 B
75% Flowering period	2.07 cd	2.07 cd	2.07 C
100% Flowering period	1.94 e	2.03 d	1.99 D
Seed ripening period	1.92 e	1.81 f	1.87 E
Average	2.06	2.05	2.06

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *Averages of cultivar-mowing time interactions indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

Table 13 shows that the average dry matter uptake value (%) was 2.06% for Aktas variety and 2.05% for Gunes variety. The highest value was 2.22% at the beginning of flowering and the lowest value was 1.87% at seed ripening. When the values in terms of variety x cutting time were analyzed, it was found that the dry matter uptake value of Aktas variety was in the range of 1.92-2.22% and Gunes variety was in the range of 1.81-2.21%. The highest dry matter uptake value was 2.22% for Aktas variety at the beginning of flowering and the lowest dry matter uptake value was 1.81% for Gunes variety at the seed ripening period. The values obtained were lower than the values obtained by Alkay (2019) in Bingol (2.61-2.92%).

Relative Feed Value

It was found the relative forage value obtained from buckwheat varieties harvested at different maturity periods was statistically significant in terms of harvest time and variety x harvest time interaction.

Table 14. Relative Feed Value Averages and Groups of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties			Feed
Cutting Time	Aktaş	Gunes	Average	Quality
Beginning of flowering	103.25*a	91.21 b	97.23 A[1]	3rd grade
%50 Flowering period	88.62 bc	84.80 cd	86.71 B	3rd grade
%75 Flowering period	85.86 bcd	85.56 bcd	85.71 B	4th grade
%100 Flowering period	74.68 ef	80.52 de	77.60 C	4th grade
Seed ripening period	76.75 e	70.60 f	73.68 D	5th grade
Average	85.83	82.54	84.19	

[1])Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *The Averages of variety-cropping time interaction indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

A table showing feed quality standards was prepared by Rivera and Parish to be used in classifying relative feed values. According to this table, if the relative feed value is greater than 151, it is considered as “the best quality feed”, 151-125 as “1st class feed”, 124-103 as “2nd class feed”, 102-87 as “3rd class feed”, 86-75 as “4th class feed” and less than 75 as “5th class feed”. Forage quality grades are given in Table 14. When Table 14 is analysed, the highest mean relative feed value was 85.83 in Aktas variety and the lowest mean relative feed value was 82.54 in Gunes variety. According to the mean values of the relative feed value of the harvesting times, the highest value was obtained as 97.23 at the beginning of flowering. The relative feed value of Aktas variety was found to be in the range of 74.68-103,25 and Gunes variety was found to be in the range of 70.60-91.21 in terms of variety x harvest time interaction. The highest relative feed value was found 103.25 in Aktas variety at the beginning of flowering an the lowest was found 70.60 in Gunes variety at seed ripening period. Our findings were lower than those obtained by Yavuz an Kara (2018) in Isparta (145.69-213.53), Sürmen and Kara (2017) in Aydin (139.75-196.22) and Alkay (2019) in Bingol (118.84-123.12). It is thought that the difference between our data and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Digestible Dry Matter Yield (kg/da)

İt was determined that the digestible dry matter yield values obtained from buckwheat varieties harvested at different ripening periods were statistically significant in terms of harvest time and variety x harvest time interaction.

Table 15. Averages and Groups of Digestible Dry Matter Yield of Buckwheat Varieties Harvested at Different Maturity Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	97.64	72.76	85.20 C[1]
%50 Flowering period	116.30	95.03	105.67 BC
%75 Flowering period	110.33	98.20	104.27 BC
%100 Flowering period	106.87	120.40	113.64 AB
Seed ripening period	116.92	150.17	133.54 A
Average	109.6	107.3	108.46

[1-]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test

When Table 15 is analysed, it is seen that the highest average digestible dry matter yield was 109.6 kg/da in Aktas variety and the lowest was 107.3 kg/da in Gunes variety. The highest digestible dry matter yield was 133.54 kg/da at seed ripening and the lowest was 85.20 kg/da at the beginning of flowering. The digestible dry matter yield of Aktas variety was 97.64-116.92 kg/da and that of Gunes variety was 72.76-150.17 kg/da. The highest digestible dry matter yield was 150.17 kg/da at seed ripening period in Gunes variety and the lowest digestible dry matter yield was 72.76 kg/da at the beginning of flowering in Gunes variety. The findings of the study were lower than the values determined by Arslan (2021) in Bursa (145.96-431.97 kg/da).

Conclusion

In this study, green herbage yield, dry herbage yield, dry matter rate, crude protein rate, crude ash rate, NFD, ADF, digestible dry matter value, dry matter intake value, relative feed value and digestible dry matter yield were investigated in buckwheat plant under the ecological conditions of Kahramanmaras. In general, it has been reported that feeds containing less than 8% crude protein enough ammonia for rumen microorganisms to maintain their normal activities (Norton, 2003). El-Shatnawi and Mohawesh (2000) reported the protein requirement of lactating ewes as 7-9% crude protein for survival and 10-12% crude protein for lactation period. Therefore, when the crude protein values of buckwheat hay to be used as an alternative feed source for feeding purposes are examined, it can be said that grasses containing less than 8% protein and mown during the seed ripening period will not be sufficient for the activity of rumen microorganisms in the animal. Therefore, when low protein buckwheat hay is used by animal breeders, a protein source must be added to the feed. In summary, buckwheat hay with a protein content above 8% is suitable for direct use in animal feeding, while buckwheat hay with a lower protein content is suitable for use as an additive in compound feeds. It can be said that the most suitable harvesting time in terms of dry herbage yield of buckwheat for animal feeding in Kahramanmaras conditions is 100% flowering or seed setting period, and the most suitable harvesting time in terms of forage quality (crude protein ratio, ash ratio, NDF, ADF and NYD) is the beginning of flowering.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author's Contributions

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before results.

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Comparative analysis of pesticide efficacy for controlling yellow stem borer (*Scirpophaga incertulas)* infestation in spring rice

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Abstract
Rice (*Oryza sativa* L.) is a crucial staple crop worldwide, essential for economic growth and food security. However, its cultivation is significantly threatened by pests like the yellow stem borer, especially in regions such as Nepal where rice is a primary crop. This study, conducted in Eastern Nepal, assessed the efficacy of six insecticides and a control group (water spray) using a randomized complete block design (RCBD) with three replications. The insecticides tested were Chlorantraniliprole 18.5 SC, Chlorpyriphos 20 EC, Emamectin Benzoate 5 SG, Metarhizium anisopliae-12%, Azadirachtin 0.03%, and Spinosad 45% SC. Results showed that Chlorantraniliprole 18.5 SC, applied at a concentration of 0.4 ml/l, resulted in the lowest occurrence of dead heart (5.24%) and white ear head (3.21%). Additionally, this treatment demonstrated superior yield and yield-contributing traits, suggesting its effectiveness in controlling yellow stem borer infestations and enhancing rice crop growth and productivity. Although these chemical insecticides proved effective, comprehensive studies are necessary to evaluate their performance across a broader range of ecological settings. Such studies are vital to validate and implement these findings in various agricultural environments.

Key words
Insecticides efficacy, Dead heart, White ear head, Spring Rice, *Scirpophaga incertulas*.

Introduction
Rice, scientifically known as *Oryza sativa*, stands as a prominent member of the Poaceae family, commanding a pivotal position among cereal crops worldwide (Ghimire et al., 2024), (Katel et al., 2023). With its roots tracing back to the fertile deltas of Asia, the cultivation of rice boasts a rich history spanning millennia, its cultivation practices traversing continents (Ghimire et al., 2023; Mehata et al., 2023). Delineated into diverse subspecies and varieties, the genetic tapestry of rice mirrors centuries of meticulous human selection and adaptation, showcasing its resilience to various environments (I. H. Mondal & Chakraborty, 2016), (Puppala et al., 2021; Sountharya & Prasad, 2022). In Nepal, rice assumes a paramount role, not merely as a dietary staple but also as a linchpin of the nation's economy, culture, and social ethos (Nirala et al., 2015; Thorat et al., 2023). Despite its importance, optimizing rice yield and quality faces persistent challenges such as pest incursions and suboptimal agricultural practices (Kakshapati et al., 2022; Yadav et al., 2024). In Eastern Nepal, rice is a key agricultural product, significantly influencing GDP and serving as a vital livelihood for many farmers (Mondal & Chakraborty, 2016; Puppala et al., 2021).

In 2023, a report published by MoALD revealed that rice cultivation spanned across 1.48 million hectares of Nepalese land (Ghimire et al., 2024; Yadav et al., 2023a). This expansive agricultural pursuit yielded a total rice output of 5.13 million tons, averaging 3.47 tons per hectare (Ghosh et al., 2020), (Gangopadhyay & Chatterjee, 2020). Despite its profound cultural and economic significance, Nepal's rice sector encounters a plethora of challenges endangering its sustainability and productivity (Rahman et al., 2020; Yadav et al., 2023b). Long-standing barriers, such as limited access to modern agricultural technologies, fragmented land tenure, and inadequate infrastructure, have hindered efforts to improve rice yields and quality (Patel et al., 2019; Yadav et al., 2023a). Furthermore, the looming specter of pests and diseases casts a alarming shadow over rice farming, posing a perpetual threat to both food security and livelihoods (Rath, 2012; Hussain et al., 2019). Among the array of pests plaguing rice cultivation, the Yellow Stem Borer (YSB), scientifically termed Scirpophaga incertulas, emerges as a formidable adversary, wreaking havoc by tunnelling into rice stems and disrupting vital nutrient pathways (Sharma et al., 2018; Girish et al., 2016). The deleterious impact of YSB infestation extends beyond mere quantity loss, profoundly compromising grain quality and inflicting substantial economic hardships on farmers (E. Mondal & Chakraborty, 2022; Yadav et al., 2023a). Moreover, pest outbreaks, particularly by the notorious YSB, significantly impede crop yields, intensifying anxieties surrounding food security (Nirmalkar et al., 2016; Roopwan et al., 2023). The urgency of addressing the Yellow Stem Borer threat looms large within Nepal's intricate agricultural landscape, necessitating holistic approaches that amalgamate traditional techniques with innovative solutions (Nag et al., 2018; Ghimire et al., 2024).

Recent studies have highlighted the significant damage caused by Yellow Stem Borer (YSB) in Nepalese rice fields, emphasizing the need for effective pest management (Kumari et al., 2019; Mishra & Singh, 2019). This has led to increased interest in evaluating various insecticides for managing YSB populations and reducing crop damage (Padmakumari et al., 2017). Pest management in rice farming includes synthetic chemicals and biopesticides (Sah & Sharma, 2023). The choice of insecticides must consider environmental sustainability, human health, and long-term efficacy, highlighting the importance of evidence-based research and holistic strategies (Ghimire et al., 2024; Mehata et al., 2023). Integrated Pest Management (IPM) is a comprehensive approach to controlling Yellow Stem Borer (YSB) with minimal environmental impact, integrating cultural, biological, and chemical measures to reduce pesticide reliance (Yadav et al., 2024; Katel et al., 2023). Educating farmers is crucial for effective IPM adoption (Yadav et al., 2024).

This research aims to conduct a comparative analysis of the efficacy of various insecticides in controlling yellow stem borer (YSB) infestations in spring rice cultivation in Eastern Nepal. By assessing the performance of different insecticides and their impact on pest populations and rice yield, the study seeks to generate actionable insights for policymakers, extension agents, and farmers. Ultimately, this research contributes to the resilience and sustainability of Nepal's rice sector by promoting informed pest management strategies.

Materials and Methodology:
Research Site:
The research undertaken at the G.P. Koirala College of Agriculture and Research Center in Sundarharaicha, Morang, Nepal, spanning from February to June 2023, was geared towards evaluating the efficacy of various pesticides in combatting yellow stem borer infestations within spring rice crops. Situated within a tropical climatic zone, characterized by an average annual temperature spectrum spanning from 19.83 to 34.46°C, and a yearly precipitation mean of 141.68mm, the locale provided an optimal setting for the investigation. Positioned at coordinates 26º 40’ 49.7” North latitude and 87º 21’ 16.3” East longitude, with an elevation measuring 149.9 m, this region presented an ideal location for the study's objectives. The selected Chaite-5 rice cultivar, renowned for its commendable grain yield yet notorious susceptibility to yellow stem borer incursions, served as the focal point of the experimental framework. Through meticulous scrutiny and methodological rigor, the research sought to elucidate the most efficacious strategies for curbing the detrimental impact of yellow stem borer infestations on this rice.

Experimental design and Field layout:
The study was meticulously executed employing a Randomized Complete Block Design (RCBD), incorporating six distinct insecticide groups alongside an untreated control group subjected solely to water spraying, as delineated in Table 1. Each treatment was replicated three times, thereby yielding a comprehensive total of 21 individual plots for analysis. To ensure precision and methodological rigor, a carefully planned layout was adopted. Each plot precisely measured 2×2 m^2, allowing for standardized evaluation across the experimental domain. To mitigate the risk of cross-contamination and facilitate unimpeded maintenance, a buffer zone spanning 0.5 meters was

clearly marked off between adjacent plots. Furthermore, the cultivation layout maintained a consistent spacing of 20 cm both between individual plants and rows, thereby facilitating optimal plant growth conditions. Each plot was then configured to accommodate precisely 100 rice plants, ensuring uniformity in experimental conditions and subsequent data analysis.

Table 1. Insecticides details along with trade name and dose.

S.N.	Insecticides	Trade name	Treatments	Dose
1	Chlorantraniliprole 18.5 SC	Cover	T1	0.4 ml/l
2	Chlorpyriphos 20 EC	Lethal	T2	2.0 ml/l
3	Emamectin Benzoate 5 SG	King Cobra	T3	0.25 g/l
4	*Metarhizium anisopliae-12*	Multiplex	T4	2 ml/l
5	Azadirachtin 0.03%	Multineem	T5	2 ml/l
6	Spinosad 45% SC	ONEUP	T6	0.3 ml/l
7	Water spray	N/A	T7	N/A

Cultural Practices:

The study aimed to assess the efficiency of insecticides in managing pest damage within the "Chaite Dhan-5" spring rice, a widely cultivated strain among local farmers. Initially, the transplantation of "Chaite Dhan-5" rice commenced following comprehensive soil preparation, in accordance with established regional farming customs. Insecticide application was initiated upon surpassing the Economic Threshold Level of 5% pest damage, facilitated using a battery-operated knapsack sprayer. Prior to seedling transplantation, essential nutrients such as nitrogen, phosphorus, and potash were administered according to established guidelines. Harvesting occurred manually upon reaching 80% maturity, followed by the traditional practices of sun-drying and manual threshing of the rice grains. Throughout the entirety of the process, Careful care was paid to guarantee that the grain weight was measured precisely. These procedures were meticulously executed to ascertain the effectiveness of insecticides while upholding precision in data collection and subsequent analysis.

Observation and data collection:

Plant height and tillers number: The height of the plants was documented once they attained full vegetative growth. Using a measuring tape, their height was gauged from the base to the apex of the plant, while the number of tillers sprouting from the main plants was counted.

Dead hearts and White ear head percentage:

From every plot, the cumulative count of afflicted (dead heart) and productive tillers was tallied, and subsequently, the dead heart percentage was computed utilizing the formula given by Islam et al. (2013) as per equations 1 provided below:

$$Dead\ heart\ (\%) = \frac{Number\ of\ dead\ heart\ (DH)}{Total\ tillers\ number} \times 100 \quad \text{(eq. 1)}$$

of white heads on both the plant and its tillers bearing panicles. The resultant percentage of white ear heads was then derived utilizing the formula given by Baskaran et al. (2019) & Katel et al. (2023), as outlined in equation 2.

$$White\ ear\ head = \frac{Total\ white\ head\ number\ (WH)}{Number\ of\ total\ tillers\ per\ panicle} \times 100 \quad \text{(eq. 2)}$$

Filled grains percentage:

Prior to rice harvesting, the plants underwent the process of cutting effective panicles containing fully matured grains, facilitating a precise enumeration of filled grains. Subsequently, the percentage of filled grains was computed using the formula outlined in the preceding investigation by Ghimire et al. (2024), as delineated in equation 3.

$$Filled\ Grains\ (\%) = \frac{Total\ filled\ grains}{Number\ of\ total\ grains} \times 100 \quad \text{(eq. 3)}$$

Yield and test weight:

For the determination of grain yield, ten plants were randomly chosen from each plot, subsequently harvested, and threshed. The moisture percentage of the grains was then assessed. Upon reaching a moisture level of 10%, the ultimate yield was computed employing the formula provided by Katel et al. (2023),

$$Grain\ Yield = \frac{Harvest\ yield \times (100 - Harest\ moisture)}{100 - Standard\ moisture} \times 100 \quad \text{(eq. 4)}$$

To assess the test weight, the sample yield was initially dried until reaching a moisture level of 10%. Subsequently, 1000 grains were randomly selected, and their weight was measured using an electric weighing machine.

$$Test\ weight = Weight\ of\ 1000\ grains$$

Statistical Analysis:

For analysis, the field experiment data were meticulously imported into MS Excel (2021). Statistical tools, such as R-Studio (Version 4.2.2), were utilized for data analysis. To ensure research accuracy, a square root transformation was applied to the data when normality assumptions were not met. R-Studio was then used to conduct Analysis of Variance (ANOVA) to compare various treatments. Post-hoc analyses, such as DMRT, were employed to identify treatment effects when significant differences were observed at a significance level of $p < 0.05$.

Results:

Infestation of dead heart and white head before treatment:

At the initial observation juncture, precisely 45 days post-commencement of the transplantation process, a statistically notable disparity was discerned concerning the prevalence of dead hearts within the rice crop. The incidence of dead hearts ranged from 5.88% to 10.99% per hill prior to any treatment, albeit registering an average rate of 8.43%. This trend was particularly pronounced preceding the application of pesticides. Concurrently, an average occurrence of 9.09% of cases characterized by white heads was recorded, spanning a spectrum from 6.21% to 11.98%. Evidently, these findings underscore the surpassing of the Economic Threshold Level.

Effects of treatments on dead heart caused by yellow stem borer in spring rice:

As shown in tables 2 the pesticides significantly reduced the invasion of stem borer. After the initial spray on the seventh day, when the efficacy of the different insecticidal treatments was evaluated, it became clear that Chlorantraniliprole 18.5 SC (0.4 ml/l) performed the best, significantly lowering the incidence of dead hearts to just 4.01%. Closely behind with dead heart rates of 4.18% and 4.49%, respectively, were Metarhizium anisopliae-12% (2 g/l) and Chlorpyriphos 20 EC (2 ml/l). Next, Spinosad 45% SC (0.3 ml/l) showed excellent performance with a 4.97% incidence of dead heart. With dead heart percentages of 5.03% and 5.80%, respectively, azadirachtin (2 ml/l) and Emamectin benzoate 5 SG (0.25 g/l) followed suit. Interestingly, Azadirachtin and Spinosad 45% SC showed comparable effectiveness. On the other hand, the untreated control group, which was merely exposed to water spray, had the greatest proportion of dead hearts (9.91%). After the first application, on the 14th day post-spray, a thorough analysis of several insecticidal treatments was conducted. The results showed that Chlorantraniliprole 18.5 SC was remarkably effective in reducing dead hearts compared to all other treatments. Following this, dead heart reductions of 6.02%, 6.91%, and 6.99% with Chlorpyriphos 20 EC, Metarhizium anisopliae-12%, and Spinosad 45% SC, respectively, showed efficacy. Interestingly, Chlorpyriphos 20 EC showed similar effectiveness to Spinosad 45% SC. On the other hand, Emamectin Benzoate 5 SG shown comparable efficacy to Azadiractin, whilst Azadiractin had the least efficacy and the largest proportion of dead hearts at 8.17%. At 13.48%, the control group that received water spray treatment had the greatest rate of dead hearts. When the effects of the different pesticides were examined 21 days after the spraying, the results showed that Chlorpyriphos 20 EC and Chlorantraniliprole 18.5 SC were the most successful in controlling the rice yellow stem borer, with the lowest percentages of dead hearts (6.96% and 6.89%, respectively). Following this, Spinosad 45% SC and Metarhizium anisopliae-12% showed noteworthy efficacy, with respective dead heart percentages of 8.95% and 8.98%. Emamectin Benzoate 5 SG and Azadirachtin came in close behind, with percentages of 9.05% and 9.99%, respectively. With a dead heart incidence of 17.17%, the untreated control group showed a considerably higher rate. At a significance level of 0.1%, a comparison of these pesticides showed significant variance in mean dead heart percentages. The lowest mean dead heart percentage was found in Chlorantraniliprole 18.5 SC (5.24%), followed by Chlorpyriphos 20 EC (5.71%) and Metarhizium anisopliae-12% (6.77%). Similar findings were obtained with percentages of 7.65%, 7.71%, and 7.00% for Emamectin Benzoate 5 SG, Azadirachtin, and Spinosad, respectively. With a mean dead heart percentage of 13.55%, the water spray group had the highest proportion. Furthermore, with a percentage reduction over control value of 61.33%, Chlorantraniliprole 18.5 SC showed the highest level of performance in suppressing the infestation of yellow stem borer, followed by Chlorpyriphos 20 EC at 57.86%.

Table 1: Effects of treatments on dead heart caused by yellow stem borer in spring rice.

Treatments	Dead hearts (Percent)				PROC of dead hearts
	7 DAS	14 DAS	21 DAS	Mean	
Chlorantraniliprole 18.5 SC	4.01^{a} (2.12)	5.01^{a} (2.35)	6.89^{a} (2.72)	5.24^{a} (2.40)	61.33
Chlorpyriphos 20 EC	4.18^{b} (2.16)	6.02^{b} (2.55)	6.96^{a} (2.73)	5.71^{b} (2.49)	57.86
Emamectin Benzoate 5 SG	5.80^{e} (2.51)	7.92^{d} (2.90)	9.05^{b} (3.09)	7.65^{e} (2.85)	43.54
Metarhizium anisopliae-12%	4.49^{c} (2.23)	6.91^{c} (2.72)	8.98^{b} (3.08)	6.77^{c} (2.70)	50.04
Azadirachtin	5.03^{d} (2.35)	8.17^{e} (2.94)	9.99^{c} (3.24)	7.71^{e} (2.87)	43.10
Spinosad	4.97^{d} (2.34)	6.99^{c} (2.74)	8.95^{b} (3.07)	7.00^{d} (2.74)	48.34
Water spray	9.91^{f} (3.23)	13.48^{f} (3.74)	17.17^{d} (4.20)	13.55^{f} (3.75)	-
Grand mean	5.48	7.78	9.71	7.66	
S.E.D.	7.5	8.4	7.3	7.7	
$LSD_{0.05}$	3.6	4.3	5.8	6.1	
CV%	11.8	12.3	9.5	8.2	
F test	***	***	***	***	

Note: DAS: Days after spray; PROC: Percentage reduction over control; Values are the mean of three replications at different day of observation; CV: Coefficient of variation; ***: Significant at 0.1% level of significance; *: Significant at 5% level of significance; S.E.D.: Standard error difference; LSD: Least Significant Difference; Values with the letters in a column are significantly different at 5% level significance by DMRT test; Parenthesized values are the result of square root transformation.

Effects of treatments on white head caused by yellow stem borer in spring rice:

The effectiveness of several insecticidal treatments against the infestation of rice yellow stem borer was closely examined during the observation period which is presented in table 3. After 7 days of spray, the most successful treatment was Chlorantraniliprole 18.5 SC, which produced a white head infestation of just 2.42%. Other treatments that were equally effective were Spinosad 45% SC, Emamectin Benzoate 5 SG, Azadirachtin, Metarhizium anisopliae-12%, and Chlorpyriphos 20 EC. On the other hand, with a white head infestation incidence of 10.55%, the untreated control group showed the highest rate. On the fourteenth day, Chlorantraniliprole 18.5 SC continued to be effective, showing a 3.34% infestation of white heads. Chlorpyriphos 20 EC and Metarhizium anisopliae-12% showed similar trends, with rates of 5.55% and 6.13%, respectively. Emamectin Benzoate 5 SG and Spinosad 45% SC both showed comparable levels of effectiveness, at 6.39% and 6.30%, respectively. With a notable 12.25% white ear percentage, the water spray therapy was shown to be the most effective. On the twenty-first day, Chlorpyriphos 20 EC showed similar efficiency at 6.37%, while Chlorantraniliprole 18.5 SC continued to be beneficial with a 4.29% white head infestation. At 8.29%, 7.17%, 9.16%, and 9.29%, respectively, Spinosad 45% SC, Emamectin Benzoate 5 SG, Metarhizium anisopliae-12%, and Azadirachtin showed rising infection rates. Overall, rice grown for white heads showed a considerable reduction in yellow stem borer infestation when treated with Chlorantraniliprole 18.5 SC. The other five insecticides had varying degrees of effectiveness, including Chlorpyriphos 20 EC, Spinosad 45% SC, Emamectin Benzoate 5 SG, Metarhizium anisopliae-12%, and Azadirachtin. Nevertheless, of the drugs utilised, azadirachtin had the greatest mean white ear head infestation percentage, indicating inferior efficiency. When compared to other pesticides employed in our study, Chlorantraniliprole 18.5 SC demonstrated the greatest percentage over control value (73.58%), indicating its efficiency in reducing yellow stem borer in spring rice. Azadirachtin, on the other hand, had the lowest percentage reduction over control, at just 41.89%.

Table 2: Effects of treatments on white head caused by yellow stem borer in spring rice.

Treatments	White heads (Percent)				PROC of ear heads
	7 DAS	14 DAS	21 DAS	Mean	
Chlorantraniliprole 18.5 SC	2.42[a] (1.71)	3.34[a] (1.96)	4.29[a] (2.19)	3.21[a] (1.93)	73.58
Chlorpyriphos 20 EC	4.62[d] (2.26)	5.55[b] (2.46)	6.37[b] (2.62)	5.48[b] (2.45)	54.90
Emamectin Benzoate 5 SG	5.32[f] (2.41)	6.30[cd] (2.61)	7.17[c] (2.77)	6.35[d] (2.62)	47.74
Metarhizium anisopliae-12%	4.32[c] (2.20)	6.13[c] (2.57)	9.16[e] (3.11)	6.51[e] (2.65)	46.42
Azadirachtin	4.89[e] (2.32)	6.99[e] (2.74)	9.29[e] (3.13)	7.06[f] (2.75)	41.89
Spinosad	4.02[b] (2.13)	6.39[d] (2.62)	8.29[d] (2.96)	6.21[c] (2.59)	48.89
Water spray	10.55[g] (3.32)	12.25[f] (3.57)	13.57[f] (3.75)	12.15[g] (3.56)	-
Grand mean	5.16	6.71	8.31	6.71	
S.E.D.	7.8	8.0	6.2	6.7	
$LSD_{0.05}$	9.7	6.7	7.5	4.8	
CV%	11.1	9.5	7.4	9.2	
F test	***	***	***	***	

Note: DAS: Days after spray; PROC: Percentage reduction over control; Values are the mean of three replications at different day of observation; CV: Coefficient of variation; ***: Significant at 0.1% level of significance; *: Significant at 5% level of significance; S.E.D.: Standard error difference; LSD: Least Significant Difference; Values with the letters in a column are significantly different at 5% level significance by DMRT test; Parenthesized values are the result of square root transformation.

Effects of treatments on yield and yield attributing characters of spring rice:

Plant height:

The findings pertaining to plant height are displayed in Table 4. Among the several pesticides used, our analysis showed that all these yield-related metrics showed exceptionally high significance at the 0.1% level. Numerous variables, including as genotypic features, varied fertilizer and organic matter doses, weather patterns, and pesticide impacts, might be responsible for the observed variance in plant height. Emamectin Benzoate 5 SG achieved a plant height of 122.30 cm, which is an impressive result. Plant heights of 100–103 cm, on the other hand, were noted in groups that received water spraying and other pesticide treatment.

Filled grains:

The findings pertaining to field grains are displayed in Table 4. Among the several pesticides used, our analysis showed that filled grain percentage per panicle showed very high significant at the 0.1% level of significance. The results showed that, Chlorantraniliprole 18.5 SC (82.06 %) recorded the highest percentage of filled grains per panicle, closely followed by Emamectin Benzoate 5 SG (81.28 %), and Chlorpyriphos 20 EC (77.43 %) respectively. The lowest filled grains were observed in water sprayed group i.e. 58.57 %.

Test weight:

A comparison of the test weight of rice with various insecticides used in the current study revealed statistically significant differences at 0.1% level of significance (Table 4). The data indicates that, overall, Chlorantraniliprole 18.5 SC had the greatest weight of 1000 grains, weighing 20.75 g. This was closely followed by Spinosad 45% SC, Emamectin Benzoate 5 SG (19.50 g), Chlorpyriphos 20 EC (19.26 g), and Metarhizium anisopliae-12% (19.14 g), all of which had comparable grain weights. In comparison, rice that had been sprayed with water had the lowest test weight just 15.98 g.

Yield (t/ha):

Table 4 shows a significant statistical difference in the amount of rice produced per hectare because of using various chemical pesticides throughout the current experiment. The results showed a substantial influence on the rice production per hectare, with a significance level of 0.1%. The average rice yield across treatments treated with water and different pesticides was 5.57 t/ha. Variations in climate, pesticide use, nutritional availability, and genetics might all be contributing contributors to this yield fluctuation. Significantly, the maximum grain yield was obtained by Chlorantraniliprole 18.5 SC (6.89 t/ha), closely followed by Emamectin Benzoate 5 SG (6.40 t/ha) and Chlorpyriphos 20 EC (6.25 t/ha), in that order. On the other hand, farms that were merely given water had the lowest yield just 3.85 t/ha.

Table 4: Effects of treatments on yield and yield attributing characters of spring rice.

Treatments	Plant height (cm)	Filled grain (%)	Test weight (g)	Yield (t/ha)
Chlorantraniliprole 18.5 SC	101.18[b]	82.06[g]	20.75[e]	6.89[f]
Chlorpyriphos 20 EC	102.63[e]	77.43[e]	19.26[c]	6.25[d]
Emamectin Benzoate 5 SG	122.30[f]	81.28[f]	19.50[d]	6.40[e]
Metarhizium anisopliae-12%	100.30[a]	66.66[c]	19.14[c]	5.16[c]
Azadirachtin	101.74[d]	65.13[b]	17.24[b]	4.28[b]
Spinosad	101.28[bc]	71.91[d]	19.51[d]	6.17[d]
Water spray	101.41[c]	58.57[a]	15.98[a]	3.85[a]
Grand mean	104.41	71.86	18.77	5.57
S.E.D.	2.07	3.69	3.17	4.66
$LSD_{0.05}$	3.16	15.1	6.15	14.4
CV%	8.1	12.1	9.4	10.4
F test	***	***	***	***

Note: Values are the mean of three replications at different day of observation; CV: Coefficient of variation; ***: Significant at 0.1% level of significance; S.E.D.: Standard error difference; LSD: Least Significant Difference; Values with the letters in a column are significantly different at 5% level significance by DMRT test.

Discussions

The research explored the effectiveness of various insecticides in controlling damage caused by the yellow stem borer (YSB) in rice fields. Our results reveal a notable decrease in damage and yield loss with the application of insecticides. Notably, Chlorantraniliprole 18.5 SC demonstrated superior efficacy in reducing dead heart (DH%) and white heads. It notably reduced DH% from 8.43% to 5.24% and white heads from 9.09% to 3.21% compared to the untreated control group. This finding aligns with previous studies by Ghimire et al. (2024), Katel et al. (2023), and Thorat et al. (2023), which also found Chlorantraniliprole 18.5 SC to be effective in controlling YSB infestation in rice. The exceptional performance of Chlorantraniliprole 18.5 SC in reducing dead heart and white head percentages can be attributed to several factors, including its comprehensive pest eradication, systemic qualities, extended residual activity, compatibility with environmental conditions, and targeted pest control (Patel et al., 2019). Similarly, Patel et al. (2019) found Chlorantraniliprole 18.5 SC to be the most effective insecticide in their field experiments. Furthermore, Sharma et al. (2025) reported that Chlorantraniliprole 18.5 SC (60 ml/acre) applied at the booting stage was highly effective in minimizing YSB infestations. Additionally, Chlorpyriphos 20 EC and Metarhizium anisopliae-12% were identified as the second most effective insecticides, consistent with the findings of Katel et al. (2023), Ghimire et al. (2024), Sah and Sharma (2023), and Nirmalkar et al. (2016). The variations in effectiveness among the tested insecticides may be attributed to their unique active ingredients and ecological factors influencing pest behavior. Differences in chemical compositions and interactions with environmental conditions contribute to varied efficacy levels, highlighting the complex interplay between insecticide properties and ecological dynamics. Moreover, our study recorded the highest grain yield with Chlorantraniliprole 18.5 SC, consistent with previous studies by Nirmalkar et al. (2016) and Patel et al. (2019). However, the insecticides exerted diverse effects on the growth and maturation of rice plants, influenced by their respective modes of action and other contextual factors. Further investigation is warranted to explore this phenomenon. It's worth noting that the fields treated solely with water exhibited the highest percentage of dead heart and white head, along with lower yields and yield-contributing parameters. This outcome is consistent with previous studies by Ghimire et al. (2024), Katel et al. (2023), and Nirmalkar et al. (2016), which found minimal yields and increased YSB infestations in control groups. Inadequate pest control and insufficient management practices likely contribute to heightened infestation levels and decreased productivity in fields treated solely with water.

Conclusions

In conclusion, our research identifies Chlorantraniliprole 18.5 SC as the most effective insecticide for controlling Yellow Stem Borer (YSB) infestation in rice fields. This insecticide notably reduced dead heart and white head percentages, showcasing its potential as a primary tool in YSB management. Additionally, Chlorpyriphos 20 EC and Metarhizium anisopliae-12% exhibited significant efficacy, warranting further investigation. Future studies should explore optimized application techniques and integrated pest management approaches to enhance sustainability and minimize environmental impact. By prioritizing the use of these effective insecticides and integrating them into holistic pest management strategies, farmers can mitigate YSB damage more effectively, safeguarding rice production and ensuring food security in Nepal's agricultural sector.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author's Contributions

The authors contributed equally to this manuscript.

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The Utilization of Olive Oil Mills Wates (OMW) in Wheat (*Triticum aestivum L.*) Breeding

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Abstract

In parallel with the increase in the world's population, agricultural industry wastes increase from year to year. The olive oil mills come to the forefront among the industrial wastes based on the agriculture. In particular, these wastes are rich in nutrients and can be used as a source of organic matter. In the present study, we tried to determine the usability of olive oil mills including olive pomace, olive pomace oil and olive mill wastewater (OMW) in wheat breeding. In the study, germination rate (%), plant height (cm), root length (cm), fresh and dry weight of plant were investigated. The highest germination rate was 84% for olive pomace oil and 30.67% for olive pomace. All parameters in olive pomace application showed low values, and the highest plant height (22.07 cm) was obtained in OMW application. The results of the study showed that olive pomace oil and olive mill wastewater can be used effectively in wheat farming.
Increasing global population leads to a rise in agricultural industry waste, with olive oil mills being a prominent contributor. This study explores the potential use of olive pomace, olive pomace oil, and olive mill wastewater in wheat breeding.

Key words
Wheat, Olive mill wastewater (OMW), Olive pomace, Olive oil, Plant breeding.

Introduction

Cereal and cereal products constitute the basic food sources of humanity from past to present. For this reason, cereals constitute a group of plants that are cultivated and produced in large areas around the world. In addition to human and animal nutrition, the use of cereals in the industry has led people who are engaged in agriculture to seek new opportunities. The importance of wheat, which maintains its strategic importance among cereals is increasing day by day. In the world, wheat cultivation areas cover 1/7 of the cultivated land in each succeeding year. Wheat is planted in the world in 22 million ha area in 2021 and, 770 tons production has been realized. The wheat cultivation area in Türkiye in 2020 was 6 million ha and 20 million tons were produced (FAO, 2023).

Along with the rapidly growing population, adequate and balanced nutrition is becoming more difficult every day. For this reason, growing wheat with high value in terms of yield and quality is of great importance in supplying the growing nutritional needs. In this context, more plant feeding methods need to be determined to obtain efficient wheat cultivation. For this purpose, various fertilizer and fertilizer doses on wheat are tried to determine the most suitable conditions. Research to determine the sources of fertilizer is important for increasing wheat yield in the unit area. The importance of organic fertilizers has increased as a result of the soil pollution based on irregular chemical fertilizers use for years, the formation of harmful substances for human health in food products, and a decrease of quality and durability.

In the world, olive production was made in 10 million hectares and total production became 23 million tons in 2021. According to 2020 data, olive area in Türkiye is 8 million decares and production is 1.3 million tons. Türkiye ranks 5th in olive oil production with 217 bin tons after Spain, Italy, Greece and Tunisia (FAO, 2023). In Türkiye, the share of agricultural land allocated to cultivated crops, including olive trees, in total agricultural land increased over the years, reaching 8.8% in 2017, while the share of the total area covered by olive trees reached 2.2% (Anonymous, 2024). In the Türkiye, olive production was made in 889 bin ha and total production 1,7 million tons in 2021 (FAO, 2023)

The amount and properties of the wastes revealed during olive oil production vary depending on the olive oil manufacturing stages, the type of olives to be processed, the pesticide and fertilizer types used during olive cultivation, and the climate of the cultivated region (Andreozzi et al., 1998).

Olive pomace, olive pomace oil and olive mill wastewater (OMW) are the by-product of olive oil production. After the olive oil is extracted from olives in factories, the remaining residue is called as olive pomace. Also, olive pomace oil is oil that has not undergone the reesterification process, obtained by extractions with organic solvents, being mixed with other oils and mixtures. Olive pomace oil cannot be called olive oil under any circumstances and is used in soap, paint and similar industries. OMW is the material of the fine structure in the sedimented or suspended form in the pools where the wastewater is stored after the oil is obtained.

The wastewater from olive oil factories is currently being used as irrigation water in agricultural areas. Olive mill wastewater emerges as a waste during the process of squeezing the olive in factories. If given directly to the soil without participating in irrigation water, it negatively affects the development of plants.

The application of olive mill wastewater (OMW) in agriculture has been limited because it contains toxic phenolics that negatively affect biological activity. However, polyphenols are important in agri-food as they reduce oxidative stress by neutralizing free radicals. (El Moudden et al., 2022).

OMW adversely affects photosynthesis by preventing plants from taking advantage of sunlight. Again, because of the oil it contains, it creates a film layer on the surface of the water and prevents oxygen transport from the air to the water. Olive oil processing units, however, play an important role in the agricultural industry in all Mediterranean countries. Olive oil, which contains organic acids and phenolic substances, show a weak acid reaction and is also rich in dispersible or colloidal substances. Organic compounds in the structure of olive mill wastewater include sugar, nitrogen compounds, volatile acids, polyalcohol, pectin, oil, polyphenols, tannins that give the colour to olive mill wastewater (Cassano et al., 2013; Sygouni et al., 2019). The main crop of agricultural areas irrigated with oil wastewater is wheat and soybeans (Aybeke et al., 2000).

Olive cultivation is widespread in the world, so the wastes obtained after olive oil production have the potential to be used as organic fertilizer in plant farming. Cabrera et al. (1996) stated that, by directly irrigating the soil with olive oil mills, the water will be preserved making the fertilization possible and that it is useful for areas less than 800 m^3/ha. Altındal and Altındal (2016) investigated the effect of OMW on the germination of sainfoin seed showing the natural spread widely in Türkiye and having great importance in agriculture and animal husbandry. In the study, olive mill wastewater was applied in 6 doses [control, direct (pure olive oil wastewater), 1/1, 1/2, 1/3, 1/4 (olive oil wastewater/water)]. In general, increased wastewater concentration reduced the rate of germination. The highest germination rate was obtained from the concentration of 1/1 (30.01%) (Olive oil wastewater/water). Olive mill wastewater was applied to seeds in studies on different plant species, direct and 1/10.000 applications and increased the germination rate in wheat seeds, whereas, at different concentrations (1/10, 1/100 and 1/1000), germination was either lower or not present (Aybeke et al., 2000).

In this research, the effect of olive mill wastewater at different concentrations (control, 1/1, 1/2, 1/3, 1/4 [OMW/distilled water] and undiluted OMW) on the seed germination of sainfoin (Onobrychis vicifolia Scop.) was studied. According to treatments, germination in the shortest time occurred in 1/4 (OWM/distilled water) treatment. As a result, olive oil wastewater (OMW) mixed to irrigation water in certain doses may increase seed germination and can be used as fertilizer in agriculture (Altındal and Altındal 2018).

Dakhli et al. (2021), OMW produced in Tunisia contains phototoxic, acid and salinity content in its content and therefore toxic in the soil. In order to determine the availability of OMW in faba bean cultivation and to develop ways to utilize it in agriculture, researches applied different 0-15-30-45 m3/ha OWV in a three-year study on sandy soil. The study reported that 15 m3/ha OWV application increased bean growth and yield and soil microorganism activity

Khalil et al. (2021), in the study investigating the effect of olive factory wastewater doses on durum wheat (*Triticum aestivum* var. Douma1) yield and soil organism activity under Syrian conditions, OMW was applied to potted vertisol soil at a dose of 0-5-10-15 L/m. Germination rate (%), plant height (cm), spike length (cm), number of grains and grain yield (g/m^2) increased compared to the control. In addition, microbial activity increased in parallel with the wastewater dose. Researchers reported that studies on pre-application and bacterial activities in vertisol soils and Syrian climate should be carried out.

In the study investigating the effect of olive mill wastewater (OMW) on the yield parameters and essential oil composition of *Mentha aquatica* var. citrata, 9 ml/100 g, 22.5 ml/ dose of OMW did not affect the amount of leaves, stems, roots and chlorophyll of bergamot-mint cultivated for 110 days in pot soil, but phenol content in leaves increased. It was also reported that OMW affected secondary metabolite production and essential oil content (El Hassani et al. 2022). Organic matter obtained by drying waste sludge (OMWS) from olive oil with solar energy (SDy) was grown in greenhouse to evaluate the agronomic yield of *Zea mays* (Youness et al., 2022). In this study, SDy increased soil fertility, decreased soil pH and delayed germination and plant growth in the early stages of OMWS application. In the present study olive pomace, olive pomace oil and OMW were applied to the soil to determine their usefulness.

Materials and Methods

To determine the effect of olive oil mills on wheat, this research was carried out in pots in 4 repetitions as 1/3 olive pomace/soil, 1/3 olive pomace oil/soil, 99 ml olive oil wastewater/650 kg soil and only soil according to the random plots trial design in greenhouse conditions. Organic wastes (olive mill wastewater (OMW), olive pomace, and olive pomace oil) used in the study were obtained from local olive oil factories located in Muğla region. The data from the plants in each pot was obtained separately and the averages were taken and examined as one repetition in each pot.

Germination rate (%): Germination rates were calculated according to this formula; (number of germinated seeds/ number of seeds placed in germination environment) x 100.

Plant height and root length (cm): the roots and bodies of seedlings germinated in accordance with ISTA rules were cut with a razor from the joints, and the average root and plant height of each plant were determined as cm with the help of a millimeter ruler.

The fresh and dry weight of plants (g): Plant fresh weight was determined as gram by taking the total weights of the body and roots of the plants that represent the repetition for each application. The plants and roots were then dried at 105°C for 48 hours. After this process, dry weights were calculated as gram.

Statistical analysis was performed by taking the mean values and standard errors of the data obtained from all the applications (mean±SE). The data obtained from morphological observations were analyzed using the SAS package program to determine the effects of olive pomace, olive pomace oil, OMW, and control applications. Significant differences were determined using the LSD and Duncan multiple comparison tests in the MSTAT program to ensure control.

Results and Discussion

The highest germination rate in the study was obtained from olive pomace oil with 84.00% and the lowest rate from olive pomace with 30.67%. All the parameters examined in the application of olive pomace showed low values and the highest plant height (22,07 cm) was obtained from olive mill wastewater (Table 1).

Table 1: Effect of olive oil mills on germination rate, plant height, root length, fresh and dry weight of wheat

Treatment	Germination rate (%)	Plant height (cm)	Root length (cm)	Plant fresh weight (g)	Plant dry weight (g)
Olive pomace	30,67 ± 2,31	7,14 ± 1,23	6,53 ± 0,55	0,78 ± 0,00	0,16 ± 0,02
Olive pomace oil	84,00 ± 4,00	16,43 ± 0,78	9,23 ± 0,73	2,98 ± 0,14	0,39 ± 0,21
OMW	81,33 ± 2,31	22,07 ± 1,08	14,25 ± 0,65	4,19 ± 1,16	0,46 ± 0,02
Control	77,33 ± 2,31	18,70 ± 1,01	19,37 ± 0,63	4,38 ± 1,34	0,48 ± 0,15

Germination rate (%):

The negative effect of the application of olive pomace on the germination rate was determined through the study. It reduced the germination rate (30,67%). According to obtained results, the germination rate obtained by olive pomace oil and OMW application was higher than the control (Table 1; Figure 1).

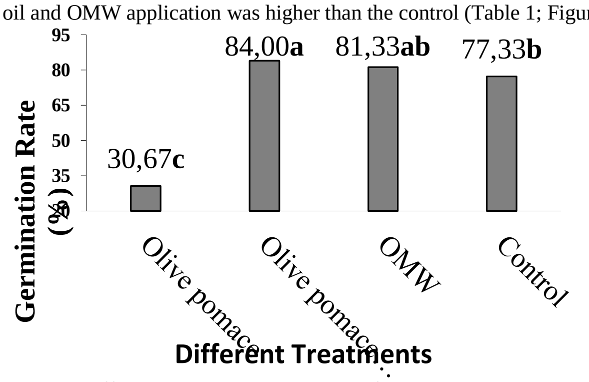

Figure 1. Effect on germination rate (%) of olive pomace, olive pomace oil, OMW and control on wheat. Data are mean ±SD of four replicates The same letters are not significantly different by Duncan's test (p> 0.05)

We believe that the adverse effect of olive pomace on seed germination is due to the acidic nature of the olive pomace and the phenolic compounds it contains.

Plant Height (cm)

While olive mill wastewater application significantly increased plant height in wheat, olive pomace application reduced plant height (7,14 cm). This value was followed by the olive pomace oil application with 16.43 cm (Table 1; Figure 2).

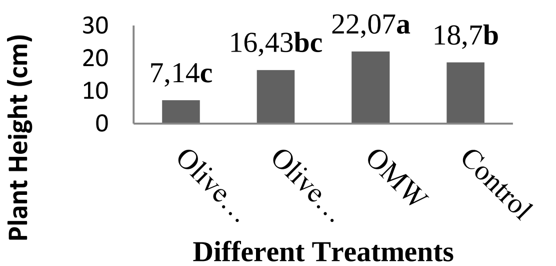

Figure 2. Effect on plant height (cm) of Olive pomace, Olive pomace oil, OMW and Control on wheat. Data are mean ±SD of four replicates The same letters are not significantly different by Duncan's test (p> 0.05)

Root Length (cm)

While the shortest root length (6.53 cm) was obtained from the olive pomace application, the longest root length was obtained from the control group with 19,37 cm (Table 1; Figure 3). In the study, in general, root length increased parallel to the plant height. Some of the carbohydrate requirements of plants are obtained from the seed's reserves and from photosynthesis, immediately after germination. As a result of this, photosynthesis increases with increasing plant height, thus root development is positively affected.

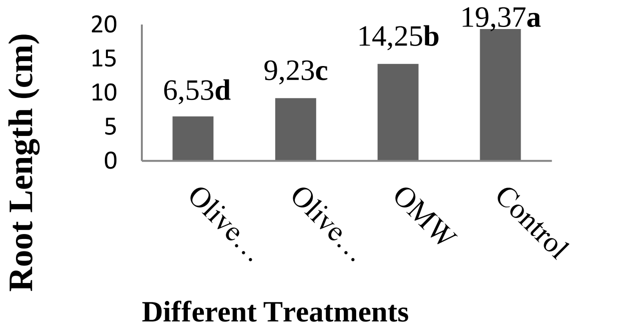

Figure 3. Effect on root length (cm) of Olive pomace, Olive pomace oil, OMW and Control on wheat. Data are mean ±SD of four replicates The same letters are not significantly different by Duncan's test (p > 0.05)

Plant Fresh Weight (g)

The plant fresh weight (4.38 g) was high in the control pots without olive oil wastes, followed by OMW application (4.19 g). The lowest fresh weight (0.78 g) was also detected in the application of olive pomace (Table 1; Figure 4).

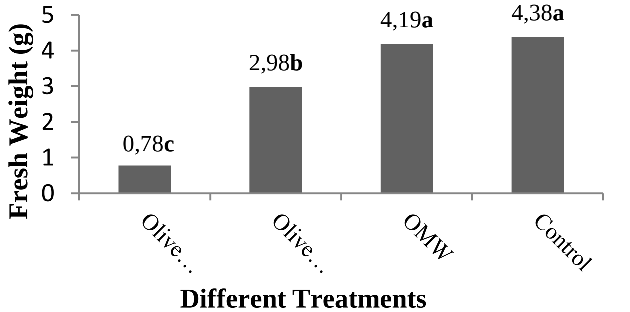

Figure 4. Effect of on fresh weight (g) of olive pomace, olive pomace oil, OMW and control on wheat. Data are mean ±SD of four replicates The same letters are not significantly different by Duncan's test (p> 0.05)

Plant Dry Weight (g)

In the study, plant dry weight increased parallel to plant fresh weight. According to the results obtained, the lowest dry weight was obtained from olive pomace administration (0.16 g) and the highest was obtained from the control group (0.48 g) (Table 1; Figure 5). Again, dry weight was determined as low for all olive oil waste applications.

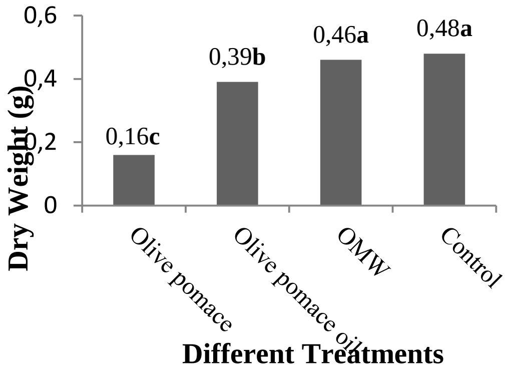

Figure 5. Effect on dry weight (g) of olive pomace, olive pomace oil, OMW and control on wheat. Data are mean ±SD of four replicates The same letters are not significantly different by Duncan's test (p> 0.05)

The present study, we determined that all the parameters were affected variously by the application of olive pomace, olive pomace oil and OMW. As can be seen from the results, the germination rate was high in olive pomace oil application, and the plant-height was high in olive pomace wastewater application. The reason for this is thought to be plant nutrients, which are present in a high proportion in olive pomace oil and OMW. They were not effective in the germination rate of olive pomace, plant and root lenght, plant wet and dry weight. The negative effect of olive pomace on seed germination and plant growth can be attributed to the acidic structure of olive pomace, the antimicrobial properties caused by phenolic compounds it contains and the unbalanced C/N ratio. Because the C source given to the environment with olive pomace increases, there may be a large amount of N immobilization, which can have a negative effect on the N intake of plants (Chapman, 1997). Olive pomace and olive pomace oil have negative effects on plants due to its high ratio of crude cellulose, tannins and phenolic compounds. Therefore, it should be made useful for agriculture by using physical, chemical, biological and natural refinement methods. In addition, OMW contains high amounts of organic (polyphenol etc.) and inorganic matter, and its acid properties and salt ratio is high (Hocaoğlu et al., 2017). For this reason, when diluted with water and used as a controlled and suitable volume, it can be evaluated as a liquid fertilizer because of the plant nutrient elements, minerals and organic matter it contains.

To increase the use of olive oil mills in agriculture, further research is needed to determine the effects of these wastes on plant development and also on the physical and chemical properties of soils, as well as the use of them as fertilizers and soil improving the organic matter.

Statement of Conflict of Interest

The author(s) declare no conflict of interest for this study.

Author's Contributions

The contribution of the authors is equal

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A Study on Herbage Yield and Quality of Different Ratios of Vetch (*Vicia* sp.) and Wheat (*Triticum* sp.) Mixtures

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Abstract
The aim of this study was to determine the appropriate mixture ratios by experimenting the mixed sowing of vetch and wheat, which is a valuable forage crop in Kahramanmaras province located in the east of the Mediterranean Region, and to examine the hay yield and quality. The research according to the randomized complete block design (RCBD) with three replications. One mixture form (Wheat + Vetch) and five mixture ratios (100:0, 75:25, 50:50, 25:75, 0:100) were used. According to the results, it was observed that the mixture ratio had statistically significant effects on plant height, green herbage yield, vetch ratio in green and dry herbage, total proportional yield, crude protein ratio and yield, NDF ratio and relative feed value. As the proportion of wheat among the seeds in the mixture increased, the green herbage yield increased in general, while the crude protein ratio decreased. The contribution rates of vetch mixtures to green and dry herbage yield were lower than those of seed mixtures. The results obtained showed that vetch + wheat mixed sowing practices yielded higher amounts of green and dry herbage the plain sowing practices in terms of herbage yield and quality in Kahramanmaras province and in the conditions dominated by the typical Mediterranean climate. It was also observed that common vetch had superior characteristics than hungarian vetch in terms of proportional yield. As a result of the research, it was concluded that 75% wheat + 25% common vetch mixture is the most suitable mixture in terms of both herbage yield and quality and more functional use of ecological resources under the conditions of Kahramanmaras province.

Key words
ADF and NDF ratio, wheat, vetch, mixture ratio, protein ratio, herbage yield and quality.

Introduction
Forage crops like vetch, fodder peas, and damson, among annual legumes, often suffer from lodging due to their creeping and weak stem structure. This makes harvesting challenging, leading to decreased grass quality and yield due to leaf loss and decay (Anlarsal et al., 1996; Tan and Serin, 1996). In our country, many forage plant species can be easily grown, especially annual ones, but their cultivation faces challenges such as farmers' limited knowledge, small-scale farms, and lack of crop rotation planning. Vetch is one of the most cultivated forage crops after alfalfa in Turkey (Anonymous, 2013). However, vetch plants with weak stems face lodging issues and reduced hay and seed yields when grown without support plants (Açıkgöz, 2001). Mixing vetch with grasses addresses this problem by reducing rotting, lodging, and leaf loss due to grasses' upright growth habit, easing harvesting (Bakoğlu and Memiş, 2002). This mixed planting is recommended to enhance hay yield, given that grasses have lower crude protein but higher crude cellulose content compared to vetch (Avcıoğlu and Avcıoğlu, 1982; Korkmaz et al., 1993). Mixed cropping, where two or more plant varieties are grown together, requires careful consideration of suitable species and proportions to create a competitive yet beneficial environment (Pekşen and Gülümser, 1995; Arslan, 2012). Adjusting planting rates is crucial for maximizing the benefits of mixed planting (Serin et al., 1999). Research has shown varied outcomes: in Bursa, a 50% common vetch + 50% oat mixture resulted in the highest protein yield, while in Tokat 33% barley + 67% Hungarian vetch mixture produced the highest crude protein yield and dry matter (Bayram and Çelik, 1999; İptaş and Yılmaz, 1998). The aim of this study was to investigate the effects of mixed sowing of vetch and wheat, which is a valuable forage crop, at different rates on morphological development, herbage yield and quality in Kahramanmaraş province located in the east of the Mediterranean Region.

Materials and Methods
Material
This study was conducted in the experimental field of Kahramanmaraş Sütçü İmam University, Faculty of Agriculture, Department of Field Crops during the 2017-2018 winter cropping season. The experimental field is located in the Mediterranean region between 37°35'40.86" north latitude and 36°48'47.51" east longitude and has a slope of 3-5%. It is 487 m above sea level. Two vetch and one wheat species were used as plant material. Ayaz-08 (common vetch) (*Vicia sativa* L.) and Tarım Beyazı-98 (Hungarian vetch) (*Vicia pannonica* Crantz.) varieties were preferred as vetch species and Ceyhan-99 (*Triticum aestivum* L.) variety was preferred as wheat species. As a result of the analysis of the soil sample taken from 0-30 cm depth, it was determined as heavy textured (85.8% clayey), neutral (pH 7.28), slightly saline (0.30%), very slightly calcareous (1%), medium in terms of organic matter (2.08%), high in potassium (266.8 mg/kg) and low in phosphorus (10.46 mg/kg) (Anonymous, 2018a). Kahramanmaraş is located in the East-Mediterranean region of Turkey. Under the influence of the Mediterranean climate, the city has hot and dry summers and mild and rainy winters. Total precipitation in Kahramanmaraş during the research season was 523.5 mm, the average temperature was 14.7 °C and the average relative humidity was 59.97%, while the long-term average precipitation in the same period was 650.8 mm, the average temperature was 12.6 °C and the average relative humidity was 63.04% (Anonymous, 2018b).

Method
The research was carried out with 3 replications according to the randomized complete block design on the area which was deep ploughed with a plow for field preparation and then cultivated and tapped. Sowing was done manually in 6 rows of 3 m length with a row spacing of 20 cm. The number of seed calculated for each plot was distributed equally to 6 rows and vetch and wheat were sown in the same row as a mixture. The plot size was 1.2 m x 3 m = 3.6 m^2. Hungarian vetch was sown at 12 kg/ha, wheat at 25 kg/ha (Çaçan and Yılmaz, 2015) and common vetch at 200 seeds/m^2 (Yücel et al., 2012). After sowing, fertilization was applied with 20.20.0 compound base fertilizer containing 5 kg/da pure N and P, taking into account the soil analysis results. One mixture form (Vetch + Wheat) and five mixture ratios (100:0, 75:25, 50:50, 25:75, 0:100) were considered in the study. Harvesting was done after one row from the sides of the plot and 50 cm from the top and bottom of the plot. The harvested plot area was 1.6 m^2. Sowing was done on November 27, 2017, and harvesting was done on April 27, 2018, when the lower pods appeared in vetch and wheat reached the milk maturity stage. The experiment was not irrigated. Weed control was done manually. The characteristics examined were analysed according to the methods described by De Wit and Van den Bergh (1965), Kaçar (1972), Anlarsal (1987), Yağbasanlar (1987), Şılbır et al. (1991), Van Soest et al. (1991), Sheaffer et al. (1995), Van Dyke and Anderson (2002) and Kutlu (2008). The natural plant height of vetch was measured by measuring the height of 10 randomly selected vetch plants in the field and the height at which they were wrapped with wheat. In 10 wheat plants, wheat plant height was measured by measuring the distance between the soil surface and the last spikelet in cm. In addition, vetch stem length was determined by measuring the distance between the soil surface and the last bud in cm in 10 randomly selected common vetch and hungarian vetch plants in each plot. These measurements were then averaged. After subtracting the edge effect, the grass obtained in the form was weighed and the plot wet weight was found. The values were converted into kg/ha units and green herbage yield was calculated. From each plot, 500 g of vetch and 500 g of wheat herbage samples were dried in an oven at 70°C for 48 hours. Then, the dry herbage samples were weighed and their weights were determined. Based on this, vetch and wheat dry herbage yields of the plots were calculated. Vetch and wheat dry herbage yields determined for each plot were summed and total dry herbage yield was found separately for each plot. This value was converted into decare herbage yield. The herbage harvested from each plot was separated

into its components as vetch and wheat, their green and dry weights were determined, these weights were proportioned to the total green and dry herbage yield of the plot, and the ratio of vetch in green and dry herbage was determined. Dried plant samples were ground and sieved through a 1 mm sieve and prepared for analysis. The ground hay samples were analysed for nitrogen determination by Kjeldahl method. The measured nitrogen percentage values were then multiplied by a coefficient of 6.25 and the crude protein content of each sample was determined. Using the crude protein content value calculated in each plot, the following equation was used and the crude protein content of the plot hay was found.

The crude protein rate of the plot was multiplied by the dry herbage yield of the plot and the crude protein yield was determined, then the necessary conversions were made and the crude protein yield was calculated in kg/decare. In the determination of crude ash content, 3-gram samples obtained from plant samples dried at 105 °C and cooled in a desiccator were placed in a porcelain crucible and burned at 550 °C for 3 hours. Crude ash content was calculated by proportioning the ash obtained to the burned sample.

The total proportional yield is considered as a measure of the efficiency with which ecological resources are utilized when crops sown in mixtures are sown alone. It was calculated with the following formula using the dry herbage yields in the mixtures.

RYT = VHY(M) / VHY(P) + WHY(M) / WHY(P)

RYT = Relative Yield Total

VHY(M) = Vetch dry herbage yield (in mixture)

VHY(P) = Vetch dry herbage yield (pure sowing)

WHY(M) = Wheat dry herbage yield (in mixture)

WHY(P) = Wheat dry herbage yield (pure sowing)

Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined by ANKOM A220 fiber analyser (ANKOM Technology, Fairport, NY) using ANKOM filter bag technique.

Digestible dry matter (DDM) value, dry matter intake (DMI) value and relative feed value (RFV) were calculated by using the following formulas by evaluating NDF and ADF analysis results.

DDM% = 88.9 - (0.779 x ADF%)

DMI% = 120 / NDF%

RFV = (DDM x DMI) / 1.29

The data obtained as a result of the research were subjected to analysis of variance in SAS (Anonymous, 2014) statistical package program based on the randomized complete block design. According to the results of analysis of variance, the differences between the mean values of the statistically significant traits were compared using LSD test.

Results and Discussion

The averages of the characteristics examined in the study are given in Tables 1, 2 and 3. As seen in Table 1, the effect of mixture ratios on vetch natural plant height, wheat natural plant height, vetch stem length and green herbage yield were found statistically significant.

Table 1. The averages of vetch natural plant height (VNPH), wheat natural plant height (WNPH), vetch stem length (VSL) and green herbage yield (GHY) determined in vetch + wheat mixtures and the groups

Mixtures	VNPH (cm)	WNPH (cm)	VSL (cm)	GHY (kg/da)
Pure Wheat	-	81.61 a	-	2159.6 ab
Pure Common Vetch	39.20 c	-	72.57 b	2232.3 ab
Pure Hungarian Vetch	40.13 c	-	63.57 b	1861.1 b
25% Wheat + 75% Common Vetch	62.20 b	76.17 b	72.73 b	2124.0 ab
50% Wheat + 50% Common Vetch	72.20 a	78.62 b	77.70 b	2126.7 ab
75% Wheat + 25% Common Vetch	63.13 b	83.32 a	94.87 a	2706.0 a
25% Wheat + 75% Hungarian Vetch	68.67 b	79.20 b	70.97 b	2186.5 ab
50% Wheat + 50% Hungarian Vetch	64.50 b	81.27 a	69.23 b	2164.6 ab
75% Wheat + 25% Hungarian Vetch	63.67 b	79.40 b	68.25 b	2067.9 ab
Mean	61.70	70.99	65.54	2180.9
F Value	14.69**	55.73**	25.38**	0.97*
LSD	15.54	7.17	10.85	679.64
CV (%)	10.16	5.84	13.70	18.00

*Significant according to p<0.05, **Significant according to p<0.01, LSD: Minimum significant difference, CV: Coefficient of variation

Table 1 shows that the highest natural plant height of vetch was obtained in 50% Wheat + 50% Common Vetch mixture (72.20 cm) and the lowest natural plant height of vetch was obtained in Pure Common Vetch (39.20 cm). The highest wheat natural plant height was obtained in 75% Wheat + 25% Common Vetch mixture (83.32 cm) and the lowest wheat natural plant height was obtained in 25% Wheat + 75% Common Vetch (76.17 cm). The highest vetch stem length was obtained in 75% Wheat + 25% Common Vetch mixture (94.87 cm) and the lowest vetch stem length was obtained in Pure Hungarian Vetch (63.57 cm). Avcıoğlu et al. (2000) and Yolcu et al. (2009) observed that legume plant height increased in parallel with the increase in legume ratio in the mixture. It can be said that mixed planting increases plant height due to light competition. It was determined that wheat height was longer in mixtures with high grasses ratio. We can say that mixed planting increases plant height due to light competition. When the pure plantings were compared with the other mixtures, it can be said that the higher plant height in the mixtures was due to the competition between vetch and wheat. This situation proves that interspecific competition is effective rather than intraspecific competition (Geren et al., 2007).

The highest green herbage yield was 2706.0 kg/ha in 75% Wheat + 25% Common Vetch mixture and the lowest was 1861.1 kg/ha in Pure Common Vetch planting (Table 1). It was observed that the herbage yield was higher in mixed plantings compared to pure plantings. In previous studies, it was stated that green herbage yields were different from each other depending on genotypes.

As can be seen from Table 2, the effects of different mixture ratios on the averages of vetch rate in green herbage, relative yield total, crude ash rate, crude protein rate and crude protein yield were statistically significant. The highest values of vetch rate in green herbage from pure common vetch and pure hungarian vetch plots were 25 % Wheat + 75 % Common Vetch (29.71 %) and 25 % Wheat + 75 % Hungarian Vetch (27.75 %). The lowest ratio of vetch in green herbage was obtained in 50% Wheat + 50% Hungarian Vetch mixture (13.80%) (Table 2). The highest average relative yield total was obtained in the mixture of 75% Wheat + 25% Common Vetch (1.32) and the lowest average relative yield total was obtained in the mixture of 50% Wheat + 50% Hungarian Vetch (0.84) (Table 2). Relative yield total (RYT), which is an indicator of the efficiency of using ecological resources when grown as a mixture compared to pure cultivation of the species that make up the mixture; When it is less than 1, it means that growing the mixture components separately in the same area has a yield advantage over growing the mixture, when this value is equal to 1, it means that there is no difference in yield between growing the mixture components separately and growing them as a mixture, and when it is greater than 1, it means that growing the mixture has a yield advantage over growing the mixture components separately (De Wit and Van den Bergh, 1965). According to this situation, it can be said that common vetch and wheat mixtures utilize ecological resources more efficiently than pure plantings with hungarian vetch and wheat mixtures.

Table 2. The averages of vetch ratio in green herbage (VRGH), relative yield total (RYT), crude ash ratio (CAR), crude protein ratio (CPR) and crude protein yield (CPY) determined in vetch + wheat mixtures and the groups

Mixtures	VRGH (%)	RYT	CAR (%)	CPR (%)	CPY (kg/da)
Pure Wheat	-	1.00 b	7.88 cd	4.65 d	71.87 d
Pure Common Vetch	100.00 a	1.00 b	10.09 a	20.93 a	151.38 ab
Pure Hungarian Vetch	100.00 a	1.00 b	10.10 a	22.52 a	165.16 a
25% Wheat + 75% Common Vetch	29.71 b	1.11 ab	8.69 bc	8.67 b	109.92 bcd
50% Wheat + 50% Common Vetch	21.57 bc	1.05 ab	10.27 a	7.66 bc	101.78 cd
75% Wheat + 25% Common Vetch	15.84 cd	1.32 a	8.43 c	7.14 bc	128.97 abc
25% Wheat + 75% Hungarian Vetch	27.75 b	1.00 b	7.48 d	8.91 b	109.10 bcd
50% Wheat + 50% Hungarian Vetch	12.98 d	0.84 b	7.54 d	6.12 cd	75.85 d
75% Wheat + 25% Hungarian Vetch	13.80 cd	0.94 b	9.49 ab	5.93 cd	84.80 cd
Mean	35.74	1.02	8.89	10.28	110.98
F Value	173.99**	1.80*	16.75**	82.89**	4.69**
LSD	8.51	0.29	0.82	2.18	44.92
CV (%)	13.76	16.55	5.38	12.28	23.38

*Significant according to p<0.05, **Significant according to p<0.01, LSD: Minimum significant difference, CV: Coefficient of variation

The highest crude ash content was found in 50% Wheat + 50% Common Vetch (10.27%) mixture, followed by Pure Common Vetch (10.10%) and Pure Wheat (10.9%) treatments in the same statistical group. The lowest crude ash content was obtained from the mixture of 25% Wheat + 75% Hungarian vetch (7.48%). Crude ash content is also an indicator of macro and micronutrient content of plants. Mineral substances are vital for plants. It was determined that ash content of legume forage crops was higher than that of grasses forage crops.

The highest crude protein content and yield were obtained from Pure Hungarian Vetch (22.52% and 165.16 kg/ha) and the lowest crude protein content and yield were obtained from Pure Wheat (4.65% and 71.87 kg/ha) (Table 2). This difference is an expected result. It is known that legume forage crops have higher protein ratios than grasses forage crops. As the vetch rate in the mixture decreased, the crude protein rate also decreased. It is understood that there is a positive correlation between vetch ratio and crude protein ratio. One of the main purposes of mixed sowing of legumes with grasses is to increase the quality of the grasses and to ensure that the free nitrogen of the air is used by the grasses by binding it to the soil thanks to the Rhizobium bacteria in the roots of the legumes and to reduce the consumption of chemical fertilizers. In our study, the decrease in the proportion of legumes in the mixture resulted in a decrease in the crude protein ratio.

Table 3. The averages of neutral detergent fiber (NDF), acid detergent fiber (ADF), digestible dry matter (DDM), dry matter intake (DMI) and relative feed value (RFV) determined in vetch + wheat mixtures and the groups

Mixtures	NDF (%)	ADF (%)	DDM %)	DMI (%)	RFV
Pure Wheat	48.20 bc	28.09	67.02	2.54 bc	132.33 ab
Pure Common Vetch	40.25 d	33.66	62.68	2.98 a	145.00 a
Pure Hungarian Vetch	47.00 c	32.37	63.68	2.60 b	128.67 abc
25% Wheat + 75% Common Vetch	53.69 abc	31.59	64.29	2.25 bcd	112.33 bcd
50% Wheat + 50% Common Vetch	54.11 abc	31.76	64.16	2.22 cd	110.67 bcd
75% Wheat + 25% Common Vetch	58.36 a	33.45	62.84	2.05 d	100.00 d
25% Wheat + 75% Hungarian Vetch	60.74 a	34.97	61.65	1.99 d	95.33 d
50% Wheat + 50% Hungarian Vetch	56.25 a	29.70	65.76	2.14 d	109.67 cd
75% Wheat + 25% Hungarian Vetch	54.32 ab	32.20	63.81	2.21 cd	109.00 cd
Mean	52.55	31.98	63.99	2.33	115.89
F Value	7.15**	1.95^{ns}	1.95^{ns}	6.37**	4.62**
LSD	7.11	4.46	3.47	0.37	22.49
CV (%)	7.82	8.06	3.13	9.32	11.21

*Significant according to p<0.05, **Significant according to p<0.01, ns: not statistically significant, LSD: Minimum significant difference, CV: Coefficient of variation

The highest NDF ratio was obtained from 25% Wheat + 75% Hungarian Vetch mixture (60.74%). This was followed by 75% Wheat + 25% Common Vetch (58.36%) and 50% Wheat + 50% Hungarian Vetch (56.25%) mixtures in the same statistical group. The lowest NDF content was obtained in Pure Common Vetch (40.25%). Lower rates of NDF were obtained in pure legume plantings compared to mixed plantings. NDF is composed of cellulose, hemicellulose and lignin, which are cell wall materials in plants. Legumes have less cell wall than grasses and therefore have higher digestibility (Wilson, 1993). This is clearly seen in bare sowing. It was found that the total NDF ratio decreased in mixed plantings with vetch, which was suppressed by wheat even if its ratio in the mixture was high at the time of sowing.

The amount of ADF in plants represents the total amount of cellulose and lignin. The highest ADF rate was obtained from 25% Wheat + 75% Hungarian Vetch mixture (34.97%). This was followed by Pure Common Vetch (33.66%) and 75% Wheat + 25% Common Vetch (33.45%). The lowest ADF rate was obtained from Pure Wheat (28.09%).

In the study, the difference between the averages of digestible dry matter was statistically insignificant, while the difference between the averages of dry matter intake and relative feed value was significant. Digestible dry matter values were found between 61.65-67.02%.

The highest dry matter intake value was obtained in Pure Common Vetch (2.98%), followed by Pure Wheat (2.60%). The lowest dry matter intake value was obtained in the mixture of 25% Wheat + 75% Hungarian Vetch (1.99). Dry matter intake values are calculated using the NDF ratios of the hay in the mixture. There is an inverse relationship between dry matter consumption and NDF value. Dry matter consumption increases with a decrease in the total ratio of NDF, i.e. hemicellulose, cellulose and lignin.

Relative feed value is an index used to describe the overall value of roughages (Henning et al., 2000). Relative feed value used to determine forage quality consists of a single number. Relative feed value measure does not give information about the physical properties and protein value of the hay, but it is a good measure when used together with protein and physical properties (Ball et al, 1996). This calculated figure gives the best information about the value of the forage and is an accurate and effective way of relating the quality of the hay (Tremblay, 1998). Table 3 shows that there were statistically significant differences between the mixture ratios in terms of relative feed value. The highest relative feed value was obtained in Pure Common Vetch (145.00) and the lowest relative feed value was obtained in 25% Wheat + 75% Hungarian Vetch (95.33) mixture. Since RFV is a quality characteristic calculated using NDF and ADF values, there is an inverse relationship between them in terms of feed quality. Low ADF and NDF values resulted in high RFV values.

Conclusion

This study was conducted to determine the appropriate mixture ratios of vetch and wheat mixtures in order to meet the forage deficit of livestock producers in Kahramanmaraş province with typical Mediterranean climate characteristics. In the study in which herbage yield and quality characteristics were also examined, it was understood that mixed sowing practices were more advantageous and had superior characteristics compared to lean sowing. When the results of the study were evaluated, it was concluded that 75% Wheat + 25% Common Vetch Mixture ratio is the most suitable mixture ratio in terms of herbage yield and quality as well as more efficient use of existing ecological resources both in Kahramanmaraş and in regions with typical Mediterranean climate.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author's Contributions

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before results.

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Effect of Different Nitrogen Doses on Quality Characteristics of Sater (*Satureja hortensis* L.) Plant

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Abstract
Satureja hortensis is an important species among the medicinal and aromatic plants used as thyme. This study was carried out in Kahramanmaras central conditions in order to determine the yield and quality characteristics of *Satureja hortensis* (0, 5, 10, 15, 20, 25, 30, 35, 40, 45 kg da^{-1}) at increasing nitrogen doses. The experiment was set up in the research area of Sutcu Imam University, Faculty of Agriculture, Department of Field Crops according to the Factorial experimental design in randomized blocks with 3 replications. According to the results of essential oil analysis and macro-micro nutrients; essential oil yield was determined as 5.19-20.79 L da^{-1}, protein ratio was determined as 11.12-22.70%. Twenty-three different components were determined in the essential oil and the main components are; carvacrol was determined as 31.64-39.03%, ɣ-terpinene as 32.38-38.27%, p-cymene as 6.34-10.71%, carene as 2.90-5.60% and myrcene as 3.06-3.91%. Plant nutrients in dry herba; phosphorus was determined in the range of 2361.00-4552.00 mg kg^{-1}, iron 107.45-222.85 mg kg^{-1}, zinc 25.18-47.82 mg kg^{-1}, manganese 22.16-46.92 mg kg^{-1}, potassium 12790.00-22615.00 mg kg^{-1}, calcium 10225.00-21235.00 mg kg^{-1}, copper 9.15-17.73 mg kg^{-1}, sodium 33.41-75.55 mg kg^{-1} and nitrogen was determined in the range of 2.21-4.50%.

Key words
Sater, Satureja hortensis, Essential oil, Nitrogen doses.

Introduction
The use of medicinal and aromatic plants has a very long history in the world. According to the World Health Organization (WHO), there are 20,000 plant species for medicinal purposes, 4,000 of which are widely used, while 10% have commercial value (Satıl et al. 2008). Turkey is among the leading countries in the production and export of thyme, both cultivated and collected from natural growth areas. Thyme, which has an important place among medicinal and aromatic plants, is a very important plant in terms of its contribution to both the local people who produce it and the country's economy (Anonymous, 2020). Many plant species containing "carvacrol" and "thymol" in their essential oils are considered "thyme" (Tasar et al. 2023). Thyme is the first plant that comes to mind when it comes to spice trade in Turkey. Plant species belonging to different genera (*Origanum, Thymus, Thymbra, Satureja*) are evaluated as thyme in Turkey, and the brand value of "Turkish thyme" has been accepted internationally (Anonymous, 2020). While some thyme species are collected from nature, some are cultivated. Some of the thyme species exported as thyme are *Satureja species* (Satıl et al. 2004). While there are 50 species of the *Satureja* genus in the world (Davis, 1982), it is represented by 16 species in Turkey (Dirmenci et al., 2019). *Satureja hortensis*; mediterranean origin, annual, herbaceous, varying between 10 cm and 30 cm in height, with white-pink-purple flowers, is cultivated by seed in Mediterranean climates and temperate climates. In addition to its many uses, the leaves of the plant are used as a spice. The leaves are 1-3 cm long, spear-oval shaped, stemless, hairy, gray green-brown. Its scent is thyme-like, spicy, herbaceous, and its taste is bitter, spicy, sharp and astringent. In 100 g of spice; It contains 272 kcal energy, 9 g water, 6.7 g protein, 5.9 g fat, 68.7 g carbohydrate, 15.3 g fiber, 9.6 g ash, 22132 mg Ca, 38 mg Fe, 377 mg Mn, 140 g P, 1051 mg K, 24 mg Na, 4 mg Zn (Akgül, 1993). The oil is close to yellow-brown in color with a yield of 0.5-1.5 % by steam distillation from the whole flowering plant of *Satureja hortensis*. Although the main component in the volatile oil is generally carvacrol, thymol, p-cymene, ɣ-terpinen, borneol or linalool can also be the main components in some chemotypes (Akgül, 1993). The essential oil of the sater plant has an important place among medicinal plants because it is used in cosmetics, medicine, food and many other industrial areas (Makkizadeh et al. 2012). It has been reported that *Satureja hortensis* essential oil has strong antibacterial activity against *Proteus vulgaris*, *Bacillus subtilis*, *Klebsiella pneumoniae* and *Escherichia coli* (Ilic et al. 2023). This study was carried out to determine how increasing nitrogen applications affect the essential oil yield, protein content, plant nutrient element content and essential oil components in sater plant.

Material and Method
The seed material of the *S. hortensis* species used in the study was obtained from people who grow it in the Nurhak district of Kahramanmaras province. The seeds were planted in the greenhouse on 25 March 2022, and the seedlings that reached 5 cm in length were transplanted into the viols prepared with a mixture of peat and sand, and the thyme seedlings were kept in a semi-shaded environment until the appropriate planting time so that they could get used to the external environmental conditions. After the soil preparation of the trial area was done, the trial was set up with a seedling planting machine on 12 May 2022, taking into account a distance of 40 x 25 cm in 5 rows. After the seedlings were transplanted to the trial area, a drip irrigation system was established and the plants were watered regularly. Weeds were physically weeding, and no disease agents were encountered until the cutting time of the plant. In the trial area, TSP (triple super phosphate) (42%) was used as phosphorus and ammonium nitrate fertilizers (33%) were used in the application of nitrogen doses along with planting. Nine different nitrogen doses were applied in the experiment: 0 (control), 5, 10, 15, 20, 25, 30, 35, 40 and 45 kg da^{-1}. As a base fertilizer, all phosphorus (6 kg da^{-1}) and half of the nitrogen doses were given at planting, while the remaining half of the nitrogen was given when the plants reached 10-15 cm in height.

Climate and soil characteristics of the trial area:
The climate data for the March-October 2022 growing season, when the study was carried out, are given in Table 1.

Table 1. Kahramanmaras province 2022 climate data (Anonymous, 2024)

Months	Precipitation (mm)		Average Temperature (°C)	
	2022	Long years (1980-2022)	2022	Long years (1980-2022)
March	157.8	95.10	7.14	10.40
April	12.7	73.00	18.24	15.10
May	40.4	38.80	20.38	20.10
June	3.7	8.60	26.16	24.90
July	0.5	2.70	29.61	28.30
August	0	2.20	29.37	28.40
September	10.7	11.00	26.09	25.00
October	12.3	45.40	20.60	18.90
Total or Average	238.1	276.8	22.20	21.39

The total rainfall amount of 2022 (238.1 mm) is below the total rainfall amount of long years (276.8 mm). While the average temperature between March and October of 2022, when the study was carried out, was 22.20 ºC, the long-term average temperature of Kahramanmaras was 21.39 ºC. In Kahramanmaras conditions, 2022 had a temperature value above the long-term average temperature (Table 1). When the soil properties taken from the 0-30 cm depth from the experimental area were examined, it was determined that it was clayey loamy (water saturation 60%), slightly alkaline (pH 7.58), low in organic matter (1.16%), low in lime (0.93%), salt-free in terms of salinity (0.01%) and low in phosphorus (4.73 kg da^{-1}).

Examined Features: Essential oil yield (L da-1): Calculated by dividing the essential oil ratios obtained from the study by the herb yield per decare and stated as L da-1.

Essential Oil Components (%): The components and percentages of the essential oils obtained by steam distillation from dry herb were determined by analyzing them on the GS-MS device. Component analysis was carried out by receiving service from Cukurova University Central Research Laboratory (CUMERLAB).

GS-MS Analysis Conditions: Volatile component analysis was determined with Agilent Brand 7890B GC, 7010B MS system. In the analysis, 1 uL of sample was injected into DB-Wax (60 m x 0.25mm i.dx 0.25 µm, J&W Scientific-Folsom, USA) capillary column through a 0.45 um filter. Injection temperature was 250 °C, column temperature was increased by 3 °C per minute to 90 °C after waiting for 4 minutes at 40 °C, then by increasing it by 4 °C per minute to 130 °C, and after waiting for 4 minutes at this temperature, the temperature was adjusted to 240 °C by increasing it by 5 °C per minute and kept at this temperature for 8 minutes. He was used as the carrier gas. Electron energy was 70 eV and mass range was 30-600 m/z. Split was 1:20. NIST14L was used as the library.

Macro-Micro Nutrient Elements: The ratios of N, P, K, Ca, Fe, Mn, Cu, Zn and Na nutrients in the material obtained from the dry herbs of the Sater plant and ground were determined. The determination of plant nutrients was carried out by receiving service from KSU USKIM Laboratory.

Crude protein ratio (%): Nitrogen ratios of dry herb samples were calculated with the Micro Kjeldahl method and crude protein ratios were obtained by multiplying with the coefficient of 6.25.

Evaluation of data: The analysis results of the quality-related characteristics obtained from the conducted study were performed using the SAS 9.1 package program for analysis of variance according to the factorial experimental design in randomized blocks. Significant differences were subjected to the LSD multiple comparison test (P<0.05 according to the significant probability limit).

Result and Discussion

Essential oil yield and Crude protein ratio

In terms of the effect of increasing nitrogen doses on essential oil yield in sater plants, cutting, dose and cutting x dose interaction were found to be statistically significant at 1% (Table 2).

Table 2**.** Data on the effect of increasing nitrogen doses on the essential oil yield and crude protein content of sater plant.

Doses (kg da^{-1} N)	Essential oil yield (L da^{-1})			Protein content (%)		
	Cutting 1	Cutting 2	Total	Cutting 1	Cutting 2	Mean
0	9.24 d	8.47 d	17.72 E	16.37 l	13.83 q	15.10 H
5	6.69 f	6.57 fg	13.25 F	16.12 m	15.47 n	15.80 G
10	13.41 c	5.19 g	18.60 E	18.35 j	15.54 n	16.95 F
15	15.64 b	8.39 ed	24.03 CD	24.78 c	14.28 p	19.53 C
20	16.19 b	6.37 fg	22.57 D	20.14 g	16.43 l	18.29 E
25	16.99 b	6.66 f	23.66 CD	22.08 f	17.38 k	19.73 C
30	19.94 a	9.49 d	29.43A	25.13 b	18.68 ı	21.90 B
35	19.44a	6.15 fg	25.59 BC	22.85 e	15.12 o	18.98 D
40	20.44a	7.08 ef	27.53 AB	23.63 d	15.61 n	19.62 C
45	20.79 a	8.53 d	29.32 A	28.12 a	19.10 h	23.61 A
Mean	15.80 A	7.29 B		21.76 A	16.14 B	
LSD (C)	0.44**			0.12**		
LSD (D)	2.99**			0.27**		
LSD (CxD)	1.39 **			0.21**		

When the effect of applied nitrogen doses on the essential oil yield of sater plant was examined, the average essential oil yield in the first cutting was determined as 15.80 L da^{-1}, and the average essential oil yield in the second cutting was determined as 7.29 L da^{-1}. When the effect of applied doses on essential oil yield was examined, the highest value was statistically obtained from 30 kg da^{-1} (29.43 L da^{-1}) and 45 kg da^{-1} N (29.32 L da^{-1}) applications in the same group, while the lowest essential oil yield was obtained from 5 kg da^{-1} N (13.25 L da^{-1}) application. When the cutting x dose interaction was examined, the highest essential oil yield value was statistically obtained from the first cutting of 30, 35, 40 and 45 kg da^{-1} N doses in the same group, while the lowest value was obtained from 10 kg da^{-1} N application (Table 2). When similar studies were examined; Danalou (2018) obtained the essential oil yield as 2.9-7.11 L da^{-1}, Katar (2015) as 6.27-8.73 L da^{-1}, Katar and Katar (2016) as 5.2-9.4 L da^{-1}, Kaçar et al. (2017) as 2.56-2.87 L da^{-1} and these values are lower than the essential oil values in the study. Katar and Aytac (2019) determined the essential oil yield as 6.54-20.65 L da^{-1} and it is similar to the values obtained in the study. Coban (2019) determined the total essential oil yield in the study conducted in two different locations as 32.93 L da^{-1}-57.04 L da^{-1}, which is higher than the total essential oil yield in this study. In terms of its effect on protein content, cutting, dose and cutting x dose interaction were found to be statistically significant at 1% level. When Table 2 is examined, the average protein content of the first cutting of the application of increasing nitrogen doses (21.76%) is higher than the average protein content of the second cutting (16.14%). When the nitrogen dose averages are examined, the highest protein content was obtained from the 45 kg da^{-1} N application with 23.61%, while the lowest content was obtained from the control application with 15.10%. When the cutting x dose interaction is examined, the highest protein content was obtained from the 45 kg da^{-1} N application (28.12%) of the first cutting, and the lowest protein content was obtained from the control application (13.83%) of the second cutting.

Table 3. Data on β-Myrcene and Carene essential oil components in sater plant with increasing nitrogen doses

Doses (kg da^{-1} N)	β-Myrcene (%)			Carene (%)		
	Cutting 1	Cutting 2	Mean	Cutting 1	Cutting 2	Mean
0	3.80 bcd	3.73 def	3.76 A	5.50 b	5.28 d	5.39 A
5	3.06 n	3.75 cde	3.40 F	2.90 j	5.41 c	4.15 H
10	3.86 ab	3.57 ıjk	3.71 AB	5.04 fg	5.08 ef	5.06 D
15	3.27 l	3.66 fgh	3.46 E	4.51 ı	5.38 c	4.94 E
20	3.53 jk	3.62 ghı	3.57 D	4.56 ı	5.15 e	4.85 F
25	3.91 a	3.60 hıj	3.75 A	5.60 a	5.00 g	5.30 B
30	3.52 k	3.81 bc	3.66 BC	5.00 g	5.39 c	5.19 C
35	3.18 m	3.32 l	3.25 G	4.58 ı	4.83 h	4.70 G
40	3.61 ghı	3.70 ef	3.65 C	4.76 h	5.28 d	5.02 D
45	3.68 efg	3.33 l	3.50 E	5.11 ef	4.80 h	4.95 E
Mean	3.54 B	3.60 A		4.75 B	5.16 A	
LSD (C)	0.02**			0.02**		
LSD (D)	0.05**			0.05**		
LSD (CxD)	0.07**			0.07**		

As indicated in Table 3, in terms of the effect of increasing nitrogen doses on β-myrcene and carene, which are essential oil components in sater plant, cutting, dose and cutting x dose interaction were found to be statistically significant at 1% level. When the mean values of β-myrcene component were examined, β-myrcene rate in the second cutting (3.60%) was higher than that in the first cutting (3.54%). When β-myrcene rates were examined in terms of applied nitrogen doses, the highest β-myrcene rate was statistically obtained from control (3.76%) application and 25 kg da^{-1} N (3.75%) application in the same group, while the lowest β-myrcene rate was obtained from 35 kg da^{-1} N (3.25%) application. When the cutting x dose interaction was examined, the highest β-myrcene value was obtained from the 25 kg da^{-1} N application of the first cutting with 3.91%, while the lowest β-myrcene value was obtained from the 5 kg da^{-1} N application of the first cutting with 3.06%. When the mean values of the main component of carene were examined, it was seen that the mean carene value of the second cutting (5.16%) was higher than the first cutting carene value (4.75%). When the nitrogen dose means were examined, the highest value was obtained from the control application with 5.39%, and the lowest carene value was obtained from the application of 5 kg da^{-1} N (4.15%). When the cutting x dose interaction was examined, the highest carene value was obtained from the application of 25 kg da^{-1} N (5.60%) of the first cutting, and the lowest value was obtained from the application of 5 kg da^{-1} N (2.90%) of the first cutting (Table 3). In terms of the effect of increasing nitrogen doses on ɣ-terpinene and p-cymene, which are volatile oil components in the sater plant, the cutting, dose and cutting x dose interaction were found to be statistically significant at the level of 1% (Table 4).

Table 4. Data on essential oil components of ɣ-terpinene and p-cymene in sater plant with increasing nitrogen doses

Doses	ɣ-terpinene (%)			p-cymene (%)		
(kg da^{-1} N)	Cutting 1	Cutting 2	Mean	Cutting 1	Cutting 2	Mean
0	37.15 b	35.90 g	36.52 D	9.21 b	8.76 d	8.98 B
5	32.72 k	35.98 f	34.35 I	10.71 a	8.44 ef	9.57 A
10	36.64 e	37.15 b	36.89 C	8.99 c	7.96 ı	8.47 D
15	35.55 ı	37.17 b	36.36 F	7.66 j	7.45 l	7.55 H
20	36.88 c	35.62 ı	36.25 G	8.80 d	8.32 g	8.56 C
25	38.22 a	36.60 e	37.41 A	8.24 h	8.36 g	8.30 E
30	33.93 ı	35.71 h	34.82 H	7.65 j	8.51 e	8.08 F
35	32.38 l	35.88 g	34.13 J	6.34 m	7.93 ı	7.13 I
40	36.83 c	36.75 d	36.79 D	8.79 d	8.39 fg	8.59 C
45	38.27 a	35.89 g	37.08 B	7.54 k	7.91 ı	7.72 G
Mean	35.85 B	36.26 A		8.39 A	8.20 B	
LSD (C)	0.01**			0.02**		
LSD (D)	0.05**			0.05**		
LSD (CxD)	0.07**			0.07**		

When the two cutting periods were examined, it was seen that the ɣ-terpinene rate obtained in the second cutting (%36.26) was higher than the first cutting (%35.85). In terms of doses, the highest ɣ-terpinene value was obtained from 25 kg da^{-1} N application with 37.41%, and the lowest value was obtained from 35 kg da^{-1} N application with 34.13%. When the cutting x dose interaction was examined, the highest ɣ-terpinene value was obtained from 25 kg da^{-1} (38.22%) and 45 kg da^{-1} N (38.27%) applications which are statistically in the same group in the first cutting, while the lowest value was obtained from 35 kg da^{-1} N (%32.38) application of the first cutting (Table 4). When the literature studies were examined; Ceri (2022) found the ɣ-terpinene ratio as 9.47-16.21%, Katar and Aytaç (2019) found the ɣ-terpinene ratio as 28.25-34.88% and Alizadeh et al. (2010) found the ɣ-terpinene ratio as 30.7-40.2%. The ɣ-terpinene ratio in this study is higher than the value of Ceri (2022) and in a similar range to the ɣ-terpinene ratios of Katar and Aytac (2019), and Alizadeh et al. (2010). With increasing nitrogen doses, the p-cymene ratio was determined as 8.39% in the first cutting, while it was determined as 8.20% in the second cutting. When the p-cymene ratios were examined in terms of applied nitrogen doses, it was seen that the highest p-cymene ratio was obtained from 5 kg da^{-1} N (9.57%) application, and the lowest value was obtained from 35 kg da^{-1} N (7.13%) application. When the cutting x dose interaction was examined, the highest p-cymene ratio in sater plant was determined from 5 kg da^{-1} N (10.71%) application of the first cutting, and the lowest value was determined from 35 kg da^{-1} N (6.34%) application of the first cutting (Table 4). Ceri (2022) reported the p-cymene ratio as 9.47-16.21% and gave higher results than the p-cymene ratios in this study, while Alizadeh et al. (2010) reported the p-cymene ratio as 1.8-2.2% in their study, which is lower than the p-cymene ratio of this study.

According to Table 5, in terms of the effect of increasing nitrogen doses on carvacrol, cutting, dose and cutting x dose interaction were found to be significant at the 1% level. When carvacrol rates, one of the important components of Sater essential oil, were examined; carvacrol rate obtained from the second cutting (35.94%) was higher than the carvacrol rate of the first cutting (34.70%). When the average carvacrol rates were examined in terms of doses, the highest was obtained from 15 kg da^{-1} N (37.73%) application, and the lowest carvacrol value was obtained from 30 kg da^{-1} (32.88%) N application.

able 5. Data on carvacrol, one of the essential oil components, in sater plant with increasing nitrogen doses

Doses	Carvacrol (%)		
(kg da^{-1} N)	Cutting 1	Cutting 2	Mean
0	33.41 n	34.27 j	33.84 H
5	34.80 ı	34.02 l	34.41 G
10	33.01 p	36.61 d	34.81 F
15	39.03 a	36.44 e	37.73 A
20	36.06 g	35.74 h	35.90 C
25	33.91 m	36.05 g	34.98 E
30	31.65 q	34.12 k	32.88 I
35	33.17 o	38.54 b	35.85 C
40	35.68 h	35.70 h	35.69 D
45	36.35 f	37.93 c	37.14 B
Mean	34.70 B	35.94 A	
LSD (C)	0.02**		
LSD (D)	0.05**		
LSD (CxD)	0.07**		

When we looked at the cutting x dose interaction, the highest carvacrol value was obtained from 15 kg da^{-1} N (39.03%) application of the first cutting, and the lowest value was obtained from 30 kg da^{-1} N (31.65%) application of the first cutting. Batıray (2009) reported the carvacrol ratio as 46.6-65.2%, Dinç (2014) reported the carvacrol ratio as 39.90-62.36%, Katar and Aytac (2019) reported the carvacrol ratio as 49.65-57.64%, Katar et al. (2011) reported the carvacrol ratio as 55.02-59.94% and Alizadeh et al. (2010) reported the carvacrol ratio as 43.9-59.2% and they obtained higher values than the carvacrol ratio obtained in this study. Ceri (2022) found that the carvacrol ratio varied between 21.67-27.00%. The carvacrol ratio obtained in this study is higher than Ceri (2022). Skubij and Dzida (2019) reported in their study that the oil obtained from the lowest nitrogen dose application and the full bloom phase of the plants had the highest carvacrol content. The plant can uptake the nutrient (N) up to a certain optimum level and then reduce its use intensity. Accordingly, they reported that it can be explained by Voisin's maximum law, which is expressed as "the excess of a mineral in the soil limits the effectiveness of the others and reduces the yield".

Table 6. Data on nitrogen and phosphorus nutrients in sater with increasing nitrogen doses (mg kg^{-1})

Doses	Nitrogen (N)			Phosphorus (P)		
(kg da^{-1} N)	Cutting 1	Cutting 2	Mean	Cutting 1	Cutting 2	Mean
0	2.62 l	2.21 q	2.41 H	3734.50 c	3551.00 e	3642.75 B
5	2.58 m	2.47 n	2.52 G	2539.50 m	3623.50 d	3081.50 F
10	2.93 j	2.48 n	2.71 F	2670.50 l	3566.50 e	3118.50 E
15	3.96 c	2.28 p	3.12 C	2882.50 j	3845.50 b	3364.00 C
20	3.22 g	2.62 l	2.92 E	2705.50 k	3724.00 c	3214.75 D
25	3.53 f	2.78 k	3.15 C	2947.50 ı	4552.00 a	3749.75 A
30	4.02 b	2.99 ı	3.50 B	2485.00 n	3477.00 fg	2981.00 G
35	3.65 e	2.42 o	3.03 D	2361.00 p	3466.00 g	2913.50 I
40	3.78 d	2.49 n	3.14 C	2434.50 o	3310.50 h	2872.50 J
45	4.50 a	3.06 h	3.78 A	2419.50 o	3494.50 f	2957.00 H
Mean	3.48 A	2.58 B		2718.0 B	3661.05 A	
LSD (C)	0.01**			8.56**		
LSD (D)	0.05**			19.15**		
LSD (CxD)	0.03**			27.09**		

In terms of the effects of increasing nitrogen doses on nitrogen and phosphorus elements in sater plants, cutting, dose and cutting x dose interaction were found to be statistically significant at the 1% level. When Table 6 is examined; the nitrogen value obtained from the first cutting (3.48%) is higher than the value obtained from the second cutting (2.58%). When the nitrogen element values are examined in terms of applied nitrogen doses, the highest value was obtained from 45 kg da^{-1} N (3.78%) application, and the lowest value was obtained from control (2.41%) application. When the cutting x dose interaction values are examined, the highest nitrogen element value was obtained from 45 kg da^{-1} N (4.50%) application in the first cutting, and the lowest value was obtained from control (2.21%) application of the second cutting. When the nutrient element values obtained from previous studies are examined; Seidler-lozykowska et al. (2009) reported that the nitrogen value varied between 2.52-3.02% in their study, and between 0.36-1.46% in the study conducted by Bayram (2018). The nitrogen values obtained from this study were parallel to the nitrogen rate of Seidler-lozykowska et al. (2009) and higher than the nitrogen rate reported by Bayram (2018). When the mean cutting values were examined, it was seen that the phosphorus value obtained from the second cutting (3661.05 mg kg^{-1}) was higher than the phosphorus value obtained from the first cutting (2718.0 mg kg^{-1}). When the phosphorus content values were examined in terms of doses, the highest phosphorus value was obtained from 25 kg da^{-1} N (3749.75 mg kg^{-1}) application, while the lowest value was obtained from 40 kg da-1 (2872.50 mg kg^{-1}) N application. When the cut x dose interaction was examined, the highest phosphorus content was obtained from 25 kg da^{-1} N (4552.00 mg kg^{-1}) application of the second cutting, while the lowest value was obtained from 35 kg da^{-1} (2361.00 mg kg^{-1}) N application of the first cutting (Table 5). Gedik et al. (2022) reported that the phosphorus value varied between 2136.0-1253.0 mg kg^{-1} in their study on sater genotypes. It is seen that it is lower than the phosphorus value obtained from this study. Dizida et al. (2015) reported in their study that many factors such as fertilization dose and type, soil type, planting place, cultivated species and developmental stage affect macro and micro element contents.

Table 7. Data on potassium and calcium nutrients in sater with increasing nitrogen doses (mg kg^{-1})

Doses	Potassium (K) (mg kg^{-1})			Calcium (Ca)		
(kg da^{-1} N)	**Cutting 1**	**Cutting 2**	**Mean**	**Cutting 1**	**Cutting 2**	**Mean**
0	17635 f	17805 f	17720.00 D	13770 ı	18710 e	16240.00 D
5	1279 l	16850 g	14820.00 G	10225 m	18825 e	14525.00 H
10	14585 j	18830 e	16707.50 F	10395 lm	21040 a	15717.50 E
15	14585 j	19540 d	17062.50 E	10605 l	19535 cd	15070.00 F
20	14445 jk	18840 e	16642.50 F	11405 k	19675 bc	15540.00 E
25	15335 ı	22615 a	18975.00 A	11395 k	19755 bc	15575.00 E
30	15475 ı	19740 c	17607.50 D	11805 j	17675 f	14740.00 G
35	15495 ı	21450 b	18472.50 B	16480 g	19855 b	18167.50 B
40	14325 k	19670 cd	16997.50 E	15050 h	18710 e	16880.00 C
45	15925 h	19820 c	17872.50 C	19375 d	21235 a	20305.00 A
Mean	15059.50 B	19516.00 A		13050.50 B	19501.50A	
LSD (C)	53.82**			84.75**		
LSD (D)	120.35**			189.51**		
LSD (CxD)	170.20**			268.01**		

In terms of potassium and calcium elements in the Sater plant, the cutting, dose and cutting x dose interaction were found to be significant at the level of 1%. When the cutting periods were examined in terms of potassium values, which is a macronutrient element; the potassium value obtained from the second cutting was determined as 19516.00 mg kg^{-1}, while the potassium value obtained from the first cutting was determined as 15059.50 mg kg^{-1} (Table 7). When the average potassium values were examined in terms of doses, the highest potassium value was obtained from the 25 kg da^{-1} N (18975.00 mg kg^{-1}) application, and the lowest value was obtained from the 5 kg da^{-1} N (14820.00 mg kg^{-1}) application. When the cutting x dose interaction was examined, the highest potassium value was observed from the 25 kg da^{-1} N (22615 mg kg^{-1}) application of the second cutting, and the lowest value was observed from the 5 kg da^{-1} N (12790 mg kg^{-1}) application of the first cutting (Table 7). In the study conducted by Gedik et al. (2022), they reported that the potassium value was in the range of 13575.0-14680.0 mg kg^{-1}. The potassium value obtained from this study was found to be higher. When the values given in Table 8 are examined in terms of calcium nutrient element; it was seen that the calcium value obtained in the second cutting, 19501.50 mg kg^{-1}, was higher than the value obtained from the first cutting (13050.50 mg kg^{-1}). When the effect of applied nitrogen doses on calcium nutrient element was examined; the highest calcium value was obtained from 45 kg da^{-1} N (20305.00 mg kg^{-1}) application, and the lowest value was obtained from 5 kg da^{-1} N (14525.00 mg kg^{-1}) application. When the cutting x dose interaction was examined, the highest calcium value was statistically obtained from 10 kg da^{-1} (21040 mg kg^{-1}) and 45 kg da^{-1} N (21235 mg kg^{-1}) applications of the second form in the same group, and the lowest value was obtained from 5 kg da^{-1} N (10225.00 mg kg^{-1}) application of the first cutting (Table 7). In the study conducted by Gedik et al. (2022), they reported that calcium values ranged between 7510.0-36944.7 mg kg^{-1} and it was found to be higher than the calcium values obtained in this study.

Table 8. Data on iron and manganese nutrient elements in sater with increasing nitrogen doses (mg kg^{-1})

Doses	Iron (Fe)			Manganese (Mn)		
(kg da^{-1} N)	**Cutting 1**	**Cutting 2**	**Mean**	**Cutting 1**	**Cutting 2**	**Mean**
0	143.50 j	219.80 b	181.65 B	28.23 l	30.97 j	29.60 F
5	121.00 l	169.70 gh	145.35 H	22.16 n	28.99 l	25.57 H
10	107.45 o	140.45 k	123.95 I	26.02 m	31.92 ı	28.97 G
15	108.25 o	220.70 ab	164.47 E	28.75 l	43.14 c	35.94 D
20	112.85 n	176.90 f	144.87 H	30.14 k	36.94 g	33.54 E
25	122.65 l	194.10 d	158.37 F	30.09 k	46.09 b	38.09 C
30	144.00 j	202.65 c	173.32 C	34.00 h	38.90 e	36.45 D
35	151.90 ı	222.85 a	187.37 A	41.67 d	37.93 f	39.80 B
40	118.25 m	190.60 e	154.42 G	36.76 g	36.19 g	36.47 D
45	168.50 h	172.25 g	170.37 D	46.92 a	41.97 d	44.44 A
Mean	129.83 B	191.0 A		32.47 B	37.30 A	
LSD (C)	0.81**			0.25**		
LSD (D)	1.82**			0.56**		
LSD (CxD)	2.58**			0.79**		

When the variance analysis table of iron nutrient element in Sater plant is examined, dose and cutting x dose statistical interaction is significant at 1% level. When the cutting periods are examined in terms of iron values which are micronutrients; the iron value obtained from the second cutting (191.0 mg kg^{-1}) is higher than the iron value obtained from the first cutting (129.83 mg kg^{-1}). When the average iron content values are examined in terms of doses, it is seen that the highest iron content is obtained from 35 kg da^{-1} N (187.37 mg kg^{-1}) application and the lowest value is obtained from 10 kg da^{-1} N (123.95 mg kg^{-1}) application. When the cutting x dose interaction was examined, the highest iron content was determined from the 35 kg da^{-1} N (222.85 mg kg^{-1}) application of the second cutting, and the lowest value was determined from the 10 kg da^{-1} (107.45 mg kg^{-1}) and 15 kg da^{-1} N (108.25 mg kg^{-1}) applications of the first cutting, which were statistically in the same group (Table 8). In the study conducted by Gedik et al. (2022), iron nutrient element values were reported to vary between 252.45-462.95 mg kg^{-1}, and in the study conducted by Seidler-lozykowska et al. (2009), it was reported that the iron value varied between 330-634 mg kg^{-1}, and they obtained higher iron values than this study. When Table 8 is examined, in terms of the effect of increasing nitrogen doses on the micro nutrient element manganese in sater plants, cutting, dose and cutting x dose interaction were found to be statistically significant at 1%. When the averages belonging to the manganese nutrient element content were evaluated; while the manganese value obtained from the second cutting was 37.30 mg kg^{-1}, it was seen that the value in the first cutting was 32.47 mg kg^{-1}. When the manganese average values of nitrogen dose applications were examined, the highest manganese value was seen in the 45 kg da^{-1} N (44.44 mg kg^{-1}) application and the lowest value was seen in the 5 kg da^{-1} N (25.57 mg kg^{-1}) application. When the cutting x dose interaction was examined, the highest manganese value was obtained in the 45 kg da^{-1} N (46.92 mg kg^{-1}) application of the first cutting, while the lowest value was obtained in the 5 kg da^{-1} N (22.16 mg kg^{-1}) application of the first cutting. When the literature studies on nutrient elements were examined; Gedik et al. (2022) reported that it varied between 36.20-78.42 mg kg^{-1}, Seidler-lozykowska et al. (2009) between 28-164 mg kg^{-1}, and Bayram (2018) between 59-85 mg kg^{-1}. The manganese value obtained from this study was found to be lower than the values determined by Gedik et al. (2022), Seidler-lozykowska et al. (2009) and Bayram (2018).

Table 9. Data on copper and zinc nutrient elements in sater with increasing nitrogen doses (mg kg^{-1})

Doses	Copper (Cu)			Zinc (Zn)		
(kg da^{-1} N)	Cutting 1	Cutting 2	Mean	Cutting 1	Cutting 2	Mean
0	17.73 a	10.67 hıj	14.20 A	47.82 a	25.18 j	36.50 A
5	11.38 fgh	11.06 ghı	11.22 CD	31.71 c	28.18 gh	29.94 C
10	11.68 d-h	11.79 d-h	11.74 C	28.42 fgh	27.67 h	28.04 E
15	12.35 d-g	11.50 fgh	11.92 BC	28.14 gh	28.88 fg	28.51 E
20	9.63 ıj	11.52 fgh	10.58 D	29.75 de	28.81 fg	29.28 D
25	15.13 b	14.32 bc	14.72 A	30.16 d	35.00 b	32.58 B
30	12.72 def	10.86 ghı	11.79 C	28.20 gh	25.96 ıj	27.08 F
35	11.01 ghı	11.60 e-h	11.30 CD	27.73 h	28.33 fgh	28.03 E
40	9.15 j	13.16 cd	11.15 CD	26.05 ı	29.94 d	27.99 E
45	12.77 def	13.06 cde	12.91 B	30.97 c	29.02 ef	29.99 C
Mean	12.35	11.95		30.89 A	28.70 B	
LSD (C)	0.48			0.25**		
LSD (D)	1.07**			0.55**		
LSD (CxD)	1.52**			0.79**		

While no difference was observed between the cutting times for the micronutrient copper, dose and cutting x dose interaction were found to be significant at the 1% level. When the variance analysis table for the effect on zinc was examined, cutting, dose and cutting x dose interaction were found to be significant at the 1% level.

When the averages of copper nutrient element content of increasing nitrogen doses were examined; no difference was observed between the cutting times. When the average values of copper nutrient element were examined in terms of applied nitrogen doses, the highest values were statistically obtained from the control (14.20 mg kg^{-1}) and 25 kg da^{-1} N (14.72 mg kg^{-1}) applications in the same group, while the lowest value was obtained from the 20 kg da^{-1} N (10.58 mg kg^{-1}) nitrogen application. When the cutting x dose interaction values were examined, it was seen that the highest copper value was from the control (17.73 mg kg^{-1}) application of the first cutting, while the lowest value was from the 40 kg da^{-1} N (9.15 mg kg^{-1}) application of the first cutting (Table 9). In the study conducted by Gedik et al. (2022), copper values were reported to vary between 11.26-26.81 mg kg^{-1}, and Bayram (2018) copper values were reported to vary between 13-38 mg kg^{-1}, and these values are lower than the copper values obtained from the study. Seidler-lozykowska et al. (2009) reported that the copper value varied between 12.2-14 mg kg^{-1}, and they are similar to the copper values obtained from this study. When the average values of the zinc nutrient element content of the sater plant with increasing nitrogen doses are examined in Table 9; the average zinc value of the first cutting was determined as 30.89 mg kg^{-1}, while the average zinc value of the second cutting was determined as 28.70 mg kg^{-1}. When the zinc values were examined in terms of doses, the highest zinc value was obtained from the control (36.50 mg kg^{-1}) application, and the lowest zinc value was obtained from the 30 kg da^{-1} N (27.08 mg kg^{-1}) application. When the cutting x dose interaction was examined, the highest zinc content was obtained from the control (47.82 mg kg^{-1}) application of the first cut and the lowest value was obtained from the control (25.18 mg kg^{-1}) application of the second cutting (Table 9). When previous studies were examined; Gedik et al. (2022) reported that it varied between 16.63-57.96 mg kg^{-1}, Seidler-lozykowska et al. (2009) 35.7-130.1 mg kg^{-1}, and Bayram (2018) 14-45 mg kg^{-1}. When Table 10 is examined, in terms of the effect of increasing nitrogen doses on sodium element in sater plant, cutting, dose and cutting x dose interaction were found to be statistically significant at the level of 1%. When the values found in terms of sodium nutrient element were examined; the sodium value obtained from the second cutting (64.18 mg kg^{-1}) was higher than the value obtained from the first cutting (38.59 mg kg^{-1}). In terms of nitrogen doses, the highest value of sodium element was statistically obtained from the control (57.35 mg kg^{-1}) and 25 kg da^{-1} N (56.18 mg kg^{-1}) applications in the same group, while the lowest value was obtained from the 15 kg da^{-1} N (46.95 mg kg^{-1}) application.

Table 10. Data on sodium nutrient element in sater with increasing nitrogen doses (mg kg^{-1})

Doses	Sodium (Na)		
(kg da^{-1} N)	Cutting 1	Cutting 2	Mean
0	46.21 g	68.50 c	57.35 A
5	39.53 hı	53.88 f	46.70 F
10	33.41 k	75.55 a	54.48 B
15	35.47 j	58.43 e	46.95 F
20	38.78 ı	61.24 d	50.01 D
25	40.27 hı	72.09 b	56.18 A
30	39.89 hı	67.20 c	53.55 BC
35	36.41 j	68.70 c	52.55 C
40	34.59 jk	62.44 d	48.52 E
45	41.33 h	53.78 f	47.55 EF
Mean	38.59 B	64.18 A	
LSD (C)	0.59**		
LSD (D)	1.32**		
LSD (CxD)	1.88**		

When the cutting x dose interaction was examined, the highest sodium value was obtained from the application of 10 kg da^{-1} N (75.55 mg kg^{-1}) of the second form, and the lowest value was obtained from the application of 10 kg da^{-1} N (33.41 mg kg^{-1}) of the first cutting (Table 10). In the study conducted by Gedik et al. (2022), sodium values were reported to vary between 92.83-210.85 mg kg^{-1}, and it was observed that these values were higher than the sodium values obtained in this study.

Conclusion

In this study, it was investigated how the quality characteristics of *Satureja hortensis*, which is used as thyme and has an important place among medicinal and aromatic plants, changed with increasing nitrogen applications. Accordingly, plant nutrients were affected at different rates by the applied nitrogen doses. Sodium, potassium, copper and phosphorus had the highest values at 25 kg da^{-1} application, iron at 35 kg da^{-1} application, and manganese, calcium and nitrogen elements at 45 kg da^{-1} application. When the main essential oil components were examined, it was seen that nitrogen applications positively affected some components up to 25 kg da^{-1} dose, but essential oil components were not affected by applications above this dose. Crude protein ratio and essential oil yield increased parallel to increasing nitrogen doses. This increase in essential oil yield was due to the increase in herb yield caused by the applied nitrogen doses. This study is the first study on the agricultural characteristics of the sater plant in Kahramanmaras conditions and will both form the basis for future studies and shed light on the studies.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author's Contributions

N.G.K. Responsible for the setup and all stages of the trial, O.G. Responsible for the setup and all stages of the experiment and preparation of the article

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