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Research Article/Araştırma Makalesi

The effects of different cutting times on morphological, agronomic and quality characteristics of wooly-pod vetch (*Vicia villosa* Roth ssp. *dasycarpa* (Ten) Cavi.)

Tüylü meyveli fiğde (Vicia villosa Roth ssp. dasycarpa (Ten) Cavi.) farklı biçim zamanlarının morfolojik, agronomik ve kalite özelliklerine etkileri

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ABSTRACT

In arid and semi-arid regions, vetch species are typically cultivated in row crop rotation or in the fallow year for the purpose of forage production. In order for vetch to be incorporated more effectively into this agricultural system, it is essential that it does not negatively impact the yield of the subsequent main crop. Therefore, vetches need to leave the field as soon as possible. For this reason, the morphological traits (main stem length, natural plant height), agronomic traits (forage yields) and quality traits (ADF and NDF ratio, digestible dry matter ratio, relative feed value) at four different growth periods were investigated in woolly pod vetch, Seğmen-2002 variety. This study was conducted at the Gölbaşı/İkizce research farm of the Central Research Institute of Field Crops between 2010 and 2013 in a randomised block design with four replications. The results indicated that the main stem length varied between 56.2 and 118.9 cm, while the natural plant height varied between 41.5 and 63.3 cm. The highest yields of fresh and dry forage were obtained at full flowering, with 2157.7 kg ha^{-1} and 354.1 kg ha^{-1}, respectively. While crude protein content was 19.7% at the beginning of flowering, it decreased gradually throughout the growth periods and decreased to 16.4% at the pod setting period. The highest crude protein yield was obtained at full flowering, with 67.0 kg ha^{-1}. The relative feed value was found to be the highest at the beginning of flowering (111.3) and to decrease to the lowest level (98.5) at full flowering. This research indicates that it is appropriate to cut wooly-pod vetch at full flowering in terms of yield, quality, and early completion of the harvesting process.

Keywords: Wooly-pod vetch, forage yield, crude protein yield, relative feed value

ÖZ

Kurak ve yarı–kurak bölgelerde fiğ türleri nadas yılında ya da ekim nöbeti içerisinde genellikle ot amaçlı olarak yetiştirilmektedir. Fiğlerin bu tarım sistemi içerisinde daha fazla yer bulması için, kendinden sonra gelen ana bitkinin verimini olumsuz etkilememesi önemlidir. Bu nedenle fiğlerin tarlayı mümkün olduğunca erken terk etmesi gereklidir. Bu çalışmada, tüylü meyveli fiğ 4 farklı dönemde biçilerek, morfolojik (ana sap uzunluğu, doğal bitki boyu), agronomik (yeşil ve kuru ot verimi) ve kalite özellikleri (ADF ve NDF oranı, sindirilebilir kuru madde oranı, nisbi yem değeri) incelenmiştir. Bu araştırmada, tüylü meyveli fiğin (*Vicia villosa Roth* ssp. *dasycarpa* (Ten) Cavi.) Seğmen çeşidi kullanılmış, 2010-2013 yılları arasında Tarla Bitkileri Merkez Araştırma Enstitüsünün Gölbaşı/İkizce araştırma çiftliğinde tesadüf blokları deneme deseninde dört tekerrürlü olarak yürütülmüştür. Araştırma sonucunda, ana sap uzunluğu 56.2-118.9 cm, doğal bitki boyu 41.5-63.3 cm arasında değişmiştir. En yüksek yeşil ot ve kuru ot verimi 2157.7 kg da^{-1}, 354.1 kg da^{-1} ile tam çiçeklenme döneminde elde edilmiştir. Ham protein oranı çiçeklenme başlangıcında %19.7 iken, biçim dönemlerinde azalarak, bakla bağlama döneminde % 16.4'e düşmüş, en yüksek HPV 67.0 kg da^{-1} ile tam çiçeklenme döneminde alınmıştır. Nisbi yem değeri çiçeklenme başlangıcında en yüksek (111.3) olmuş ve tam çiçeklenme döneminde de en düşük (98.5) seviyeye inmiştir. Bu araştırma sonucunda, verim, kalite ve tarlanın erken boşaltılması açısından tüylü meyveli fiğin tam çiçeklenme döneminde biçilmesinin uygun olduğu sonucuna varılmıştır.

Anahtar Kelimeler: Tüylü meyveli fiğ, ot verimi, ham protein verimi, nisbi yem değeri.

Introduction

Vetch species play a significant role in forage crops, providing valuable high-quality roughage for animal nutrition. Despite a decrease in cultivated area in recent years, farmers continue to cultivate the plant due to its high adaptability to various climatic and soil conditions, which range from arid to cool and humid. Although the area under vetch cultivation is currently estimated at 342 thousand hectares, there is potential for further expansion. The Central Anatolia Region, which is characterised by arid and semi-arid climatic conditions, is the region where fallow is the most prevalent practice, with an area of 2.96 million hectares (Anonymous, 2024). In the fallow year, when the field remains uncultivated and in a state of rotation, it is possible to sow vetch species as a winter intermediate crop, prior to the cultivation of summer crops for the production of forage. It is possible to cultivate hay without reducing the yield of cereals sown after it (Eser et al., 1997; Avcı et al., 2007). Vetch can be cultivated as a pre-crop prior to the cultivation of summer crops, including vegetables, sugar beet, cotton, sunflower, and maize. This practice allows for the production of forage and green manure. In irrigated agricultural areas where industrial products are grown, planting annual legume forage crops as winter intercrops can be carried out without reducing the yield of the main product (Kaplan and Gökkuş, 2018). They positively impact the soil structure, which is beneficial for summer crops (Eser et al., 1997; Kaya, 2009). The incorporation of annual legumes into the soil prior to planting maize has been demonstrated to positively influence the yield of the latter crop by facilitating the fixation of nitrogen in the soil (Kalkan, 2019). Among the different plants sown as a preplant, the highest nitrogen content was obtained from the application of hairy vetch (Liebmana et al., 2018).

Woolly pod vetch (*Vicia villosa* Roth ssp. *dasycarpa* (Ten) Cavi.), a subspecies of hairy vetch (*Vicia villosa* Roth), is also known as false hairy vetch (Açıkgöz 2021). Although it is a subspecies, it exhibits a number of distinctive characteristics that set it apart from hairy vetch. In contrast to the pubescence observed on the stems and leaves of other species, this variety exhibits a light and bright green colouration. Although it is less winter-hardy than hairy vetch (*V. villosa*), it emerges earlier than it. As it is approximately 10 days earlier than Hungarian vetch and grows earlier and more rapidly in the cool period of spring, it can be cultivated in fallow areas to a greater extent than Hungarian vetch (Mutlu, 2012). In a study on mixed sowing of vetches and cereals, it was observed that grazing sheep demonstrated a preference for common vetch, hairy vetch, and Hungarian vetch, followed by oats, barley, and rye (Munzur 1982). Since it is more preferred by animals and it has an early characteristic, it shows that wooly pod vetch has the potential to be grown more for forage purposes.

Vetches can be harvested for forage at various stages, beginning with flowering and ending with the full formation of pods (Açıkgöz, 2021). In the cereal-fallow system, earlier removal of vetch from the field before the main crop is planted allows vetch to be grown as a forage crop in more areas. The aim of this study was to determine the optimal cutting time for wooly pod vetch, focusing on forage yield and quality at different growth stages.

Material and Methods

The research was conducted between 2010 and 2013 at the Research and Application Farm of the Central Research Institute of Field Crops, located at the Gölbaşı/İkizce site. The soil structure of the test area was clayey-loamy textured, with an organic matter content of 0.92%. The phosphorus content was moderate, exhibiting a very calcareous character and a high potassium content. The pH was slightly alkaline (Table 1).

Table 1. Soil analysis results of the test area

Test area	Total Salt (%)	Organic matter (%)	Lime $CaCo_3$ (%)	Phosphorus P_2O_5 (kg da^{-1})	Potassium K_2O (kg da^{-1})	pH	Soil structure
Gölbaşı/İkizce	0.023	0.92	25.36	6.28	178.98	7.91	Clay-loamy

When the precipitation distribution in the years studied is examined, it is clear that there are significant differences in the distribution and amount of precipitation, particularly during the first two production seasons (Table 2). In the first production season, 343.6 mm of rain fell, which was close to the long-term average.

The precipitation was concentrated, particularly during the vetch development period. In the second production season, the rainfall total of 166 mm was considerably below the long-term average. The precipitation of 1.8 mm in March and April is considerably below the long-term average of 94.1 mm. The third-year rainfall is found to be very close to the long-term average.

Table 2. Precipitation (mm) and temperature data (°C) for the experimental area over the 2010-2013 period and for longer time periods

Months	Total Precipitation (mm)				Average temperature (°C)			
	2010-2011	2011-2012	2012-2013	1989-2010	2010-2011	2011-2012	2012-2013	1989-2010
September	0.0	1.6	3.6	19.4	17.0	17.1	19.0	16.9
October	81.6	34.0	46.3	23.7	11.3	12.3	14.5	12.4
November	10.0	2.2	34.7	34.4	11.8	6.4	6.9	5.4
December	13.2	19.8	60.4	50.0	4.3	1.0	1.3	0.4
January	28.0	56.4	27.0	29.1	0.2	-0.5	0.1	-1.5
February	5.0	3.6	26.8	32.9	-0.6	-0.3	3.8	-0.2
March	42.0	0.0	37.2	43.0	2.6	4.8	6.5	3.9
April	40.4	1.8	49.4	51.1	7.6	10.1	10.0	9.2
May	86.6	46.8	59.8	44.4	12.4	16.1	16.5	13.9
June	36.8	0.0	13.0	26.1	16.8	20.1	20.0	18.4
Total	343.6	166.2	358.2	354.1				
Average					8.3	8.7	7.9	7.9

Woolly pod vetch, Seğmen-2002 (*Vicia villosa* Roth ssp. *dasycarpa* (Ten) Cavi.) cultivar, was used as the material in this trial. This study examined four various growth stages of vetch: the initial flowering stage (IFP), the mid-flowering stage (MFP), the full flowering stage (FFP), and the period when grains in the lower pods reach full maturity (PP). This latter period is typically recommended as the optimal cutting time for vetch, as outlined by Balabanlı (2009) and

Anlarsal (2009). The experiment was conducted in accordance with a randomised block design, with four replicates. Each plot comprised six rows of five metres in length, with a spacing of 26 centimetres between rows. The thousand grain weight of vetch was calculated, and 250 seeds per square metre (Munzur et al. 1995) were sown by hand at a depth of 3-4 cm. The remaining 4.16 m² area within the plots was harvested after the side rows had been mown, with a clearance of 50 cm from both sides of the row. The plot yield was determined by weighing the mown hay and fresh forage yield (FFY) was calculated for each cutting time according to the methodology proposed by Altınok and Hakyemez (2000). Prior to harvesting, the natural plant height (NPH) (Balabanlı, 1992) and main stem length (MSL) (Fırıncıoğlu et al., 2009; Bedir, 2010) were determined in five randomly selected plants. The growth habits were observed at five different growth stages (1:erect, 3:semi-erect, 5:non-erect) (Fırıncıoğlu et al., 2009).

A total of 500 g of fresh forage was randomly selected from each plot and subsequently dried. The dry forage yield (DFY) was determined according to the methodology described by Ünal (2011), while the crude protein ratio (CPR) was calculated using the approach outlined by Tekkanat and Soylu (2005). The crude protein yield (CPY) was obtained based on the method developed by Bedir (2010). Additionally, the acid detergent fibre (ADF) and neutral detergent fibre (NDF) analyses were conducted in accordance with the procedures outlined by Kutlu (2008). The digestible dry matter ratio (DDMR) and relative feed value (RFV) were determined using the techniques described by Starkey et al. (1993) and Demirbağ et al. (2015), respectively. The statistical analysis of the research results was performed using the statistical software package SAS. All averages were grouped according to the least significant difference (LSD) test.

Results and Discussion

Morphological traits

Growth habit

The growth habits observed at five different growth stages are presented in Table 3. Upon analysis of Table 3, it can be observed that woolly pod vetch exhibited a value of 2.7, indicating a medium level of development at the beginning of flowering. Subsequently, it demonstrated a semi-erect and non-erect development. The lowest value of main stem length was observed in the second and third years, coinciding with the onset of flowering. Accordingly, an evaluation of the main stem length and natural plant height (Table 4) reveals a tendency for lodging in wooly pod vetch from the time of the beginning of flowering.

Number of cutting days

Table 3 shows the number of days that should be cut in order to harvest fresh forage from woolly pod vetch at each growth stage. The mean numbers of day required cutting the four growth stages were 204.3, 210.7, 216.7 and 237.0 days, respectively. The prolongation of the PP in the first rainy year demonstrates that the vegetative growth period of woolly pod vetch is prolonged in accordance with rainfall and temperature. The results obtained in the present study were lower than those reported by Hakyemez et al. (1997), who found a duration of 194-240 days, and higher than those reported by Özpınar and Sabancı (2014), who found a duration of 97-118 days in the MFP period of hairy vetch. The difference may be attributed to the varying climatic conditions across the years.

Table 3. Growth habit and cutting day numbers of plants at different growth stages

	Growth habit				Cutting day numbers			
Developmental stages	2010-2011	2011-2012	2012-2013	Average	2010-2011	2011-2012	2012-2013	Average
IFP	4.0	2.0	2.0	2.7	204.0	208.0	201.0	204.3
MFP	5.0	3.0	3.0	3.7	212.0	216.0	204.0	210.7
FFP	5.0	3.0	4.0	4.0	220.0	223.0	207.0	216.7
PP	5.0	4.0	5.0	4.7	246.0	238.0	227.0	237.0
Average	4.8	3.0	3.5	3.8	220.5	221.3	209.8	217.2

IFP: initial flowering period, MFP: mid-flowering period, FFP: full flowering period, PP: the period when grains in the lower pods reach full maturity

Table 4. Main stem length (cm) and natural plant height (cm) of plants at different growth stages

	Main stem length				Natural plant height			
Developmental stages	2010-2011	2011-2012	2012-2013	Average	2010-2011	2011-2012	2012-2013	Average
IFP	88.0 d	37.6 c	42.9 b	56.2 d	58.3	26.2 d	40.1 b	41.5 c
MFP	121.6 c	47.0 b	41.9 b	70.1 c	56.9	33.2 c	39.1 b	43.0 bc
FFP	145.4 b	54.0 b	48.5 b	82.6 b	59.1	38.3 b	44.3 b	47.2 b
PP	202.9 a	77.6 a	76.3 a	118.9 a	61.2	67.9 a	61.0 a	63.3 a
Average	139.5 a	54.0 b	52.4 b	82.0	58.9 a	41.4 c	46.1 b	48.8
$F_{(cutting)}$	77.5**	51.2**	31.5**	143.0**	1.0	144.9**	8.4**	47.9**
$F_{(years)}$				652.8**				52.3**
$F_{(cutting\ x\ years)}$				23.8**				11.5**
$LSD_{(cutting)\ (0.05)}$	17.6	7.6	9.2	6.5	5.6	4.9	11.3	4.2
CV (%)	7.9	8.8	11.0	9.5	6.0	7.4	15.3	10.3

*IFP: initial flowering period, MFP: mid-flowering period, FFP: full flowering period, PP: the period when grains in the lower pods reach full maturity, **: Significant difference at 1% level, CV: Coefficient of variation (%)*

Main stem length

The results of the variance analysis of main stem length (cm), as presented in Table 4, indicate that the factors of years (P < 0.01), cutting periods (P < 0.01) and cutting x years interaction (P < 0.01) were found to be statistically significant. The mean main stem length (MSL) was found to be greatest during the PP, at 118.9 cm, followed by the FFP, MFP and IFP, which exhibited mean lengths of 82.6, 70.1 and 56.2 cm, respectively. The highest MSL value was recorded during the PP in all three years. While the mean MSL values measured in the second and third years were similar, the MSL value measured in the first year was notably high at 139.5 cm, due to the occurrence of heavy rainfall. The MSL values obtained in the first year were higher than those reported by Doğan (2014), who found 62.3 cm in the PP, and were also close to those reported by Özdemir et al. (2021), who found 102.8-194.3 cm. They were, however, higher than those reported by Hakyemez et al. (1997) found 31-80 cm in the MFP, and which is consistent with the findings of Altınok and Hakyemez (2000), who observed 82 cm in the FFP period. Additionally, the results align with those of Mihailovic et al. (2007), who recorded 98 cm, and Şahar (2006), who noted 89.3 cm. The high MSL values observed in the first year can be attributed to the climate conditions prevailing during that period.

Natural plant height (NPH)

The analysis of variance revealed statistical significance for NPH, years (P<0.01), cutting periods (P<0.01), and the interaction between cutting and years (Table 4). The mean NPH values were highest during the PP (63.3 cm), followed by the FFP, MFP, and IFP (47.2, 43.0, and 41.5 cm, respectively). The highest NPH was observed in the first year, with a value of 58.9 cm, while the second and third years exhibited similar values, at 41.4 and 46.1 cm, respectively. The mean NPH values obtained in this study were similar to those reported by Tenikecier et al. (2020), who found 43.3, 53.6, and 39.3 cm for Hungarian vetch in the IFP, MFP, and FFP, respectively.

Agronomic traits

Fresh forage yield

The analysis of variance found statistically significant for fresh forage yield (FFY) at cutting stages, year, and cutting x year interaction (P<0.01). The mean results indicated that the highest FFY was observed during the FFP, with a yield of 2157.7 kg da^{-1}. This was followed by the MFP, IFP, and PP, with yields of 1758.6, 1686.8, and 1161.9 kg da^{-1}, respectively. The highest FFY was obtained in the first rainy year, with an annual average of 3793.1 kg da^{-1}, followed by the third and second years, with annual averages of 872.9 and 407.7 kg da^{-1}, respectively. The highest FFY was obtained in the FFP in the first year, in accordance with the established cutting periods. In contrast, the highest FFY was obtained in the PP in the subsequent years. The difference observed in the initial year can be attributed to the rotting of the lower branches, which was caused by the lodging of the overgrown plants due to the excessive rainfall. The differentiation between the harvesting periods according to the years resulted in the form-by-year interaction being statistically significant. The high FFY values observed in the PP during the second and third years led to the conclusion that wooly pod vetch effectively utilised the rainfall in May, resulting in an increased FFY in both years. The highest FFY was obtained in the FFP in our study, as evidenced by the average values. Our findings were higher than those reported by Desalegn and Hassen (2015), who observed a mean of 1534.1 kg da^{-1} during the MFP, and Coşkun and Çaçan (2019), who noted a range of 449-1901 kg da^{-1} during the PP. The differing climatic conditions may be the reason for this discrepancy. The results obtained in this study were lower than those reported by Özdemir et al. (2021), who found 1841-2591 kg da^{-1} in the PP, and Hakyemez et al. (2005), who found 2157-2310, 2160-2002, 1448-1467 kg da^{-1} in the IFP, FFP, and PP, respectively. Additionally, the findings were lower than those reported by Mihailovic et al. (2007), who found 3120 kg da^{-1} in the PP. The discrepancy in FFY values may be attributed to the different vetch species involved.

Dry forage yield

Dry forage yields (DFY) were statistically significant years (P < 0.01), cutting stages (P < 0.01), and the cutting x year interaction (P < 0.01) (Table 5). The highest FFY was obtained in the FFP, with an average of 354.1 kg da^{-1}. This was followed by the PP, MFP, IFP and IFP, which had average DFYs of 319.9, 285.6, 271.1 and 271.1 kg da^{-1}, respectively. The highest average DFY was observed in the first rainy year, with a value of 482.0 kg da^{-1}. In the second and third years, the highest DFY value was obtained from cutting conducted during the PP period, whereas in the first year, it was obtained from cutting conducted during the FFP period. This discrepancy resulted in a statistically significant cutting x years interaction. The results demonstrate that the rotting of the lower branches and leaves during the PP, caused by the lodging of the overgrown plants in the first year, was an effective phenomenon. The results obtained in this study were higher than those reported by Coşkun and Çaçan (2019), who found a mean yield of 225 kg ha^{-1} during the PP. This discrepancy can be attributed to variations in climatic conditions. Among researchers working on hairy vetch, Ova and Uslu (2021) harvested in the same periods (593.4, 887.4, 803.9, 852.8 kg da^{-1}), Özdemir et al. (2021) harvested 280-559 kg da^{-1}in the PP, Hakyemez et al. (2005) harvested in the IFP, MFP, and PP (461.9-526.5, 510-554.7, 583-549.4 kg da^{-1}), and Mihailovic et al. (2007) harvested 570 kg da^{-1} in the PP period. The discrepancy in values may be attributed to the different species of vetch involved.

Table 5. Fresh forage (kg da^{-1}) and dry forage yield (kg da^{-1}) values at different growth stages

	Fresh forage yield				Dry forage yield			
Developmental stages	2010-2011	2011-2012	2012-2013	Average	2010-2011	2011-2012	2012-2013	Average
IFP	4225.5 b	208.5 d	626.2 c	1686.8 b	665.3 b	38.9 bc	109.1 bc	271.1 c
MFP	4281.1 b	308.3 c	686.3 bc	1758.6 b	683.5 b	51.4 c	121.8 c	285.6 bc
FFP	5232.9 a	415.6 b	824.6 b	2157.7 a	843.3 a	67.7 b	151.3 b	354.1 a
PP	1432.9 c	698.1 a	1354.7 a	1161.9 c	482.0 c	171.1 a	306.4 a	319.9 ab
Average	3793.1 a	407.7 c	872.9 b	1691.2	668.5 a	82.3 c	172.2 b	307.6
$F_{(cutting)}$	98.4**	73.7**	31.2**	54.5**	15.2**	73.0**	62.6**	5.6**
$F_{(years)}$				1466.5**				547.9**
$F_{(cutting\ x\ years)}$				127.6**				20.5**
$LSD_{(cutting)\ (0.05)}$	529.0	78.7	189.9	159.2	121.5	22.6	36.9	**44.8**
CV (%)	8.7	12.1	13.6	11.3	11.4	17.2	13.4	**17.5**

*IFP: initial flowering period, MFP: mid-flowering period, FFP: full flowering period, PP: the period when grains in the lower pods reach full maturity, **: Significant difference at 1% level, CV: Coefficient of variation (%)*

Quality traits

Crude protein ratio (CPR)

The analysis of variance (Table 6) of crude protein ratios (%) determined at harvesting periods revealed statistically significant findings for the factors of harvesting periods (P < 0.01), harvesting x year interactions (P < 0.01), and years (P < 0.01). The highest crude protein ratio was observed during the MFP period, with an average of 19.9%. This was followed by the IFP, FFP and PP periods, which exhibited crude protein ratios of 19.7%, 18.9% and 16.4% HP, respectively. The highest crude protein ratio was recorded during the MFP period, which was influenced by the second year's rainfall, which led to vegetative growth in the plants and consequently increased the crude protein ratio (CPR) during the MFP and PP periods. This resulted in the highest mean crude protein ratio of the year, with a value of 19.5%. This is due to the significant interaction between cutting and year. The three-year average of our study revealed that the crude protein ratio (CPR) was higher than that reported by Desalegn and Hassen (2015), who found 18.9% in the MFP period, and higher than that reported by Coşkun and Çaçan (2019), who found 21.8% in the PP period. However, it was lower than that reported by Doğan (2014), who found 20%. The percentage was 26% in the PP period, which is lower than the findings of Özdemir et al. (2021), who reported a range of 17.1-18.7% for the same period. It is also close to the results of Ova and Uslu (2021), who observed values of 20.0%, 18.0%, 18.0%, 18.0%, and 18.0% for the same periods of hairy vetch. The difference in the results can be explained by the differences in the climatic conditions of the year and the type of vetch.

Table 6. Crude protein ratio (%) and crude protein yield (kg da^{-1}) at different growth stages

	Crude protein ratio				Crude protein yield			
Developmental stages	2010-2011	2011-2012	2012-2013	Average	2010-2011	2011-2012	2012-2013	Average
IFP	20.3 a	19.3 b	19.4 a	19.7 a	135.1 a	7.5 c	21.2 b	54.6 b
MFP	19.7 ab	21.2 a	18.7 a	19.9 a	134.6 a	10.9 bc	22.8 b	56.1 b
FFP	19.2 b	21.3 a	16.3 b	18.9 a	161.9 a	14.4 b	24.47b	67.0 a
PP	16.5 c	16.2 c	16.5 b	16.4 b	79.5 b	27.7 a	50.6 a	52.6 b
Average	18.9 a	19.5 a	17.7 b	18.7	127.8 a	15.1 c	29.8 b	57.6
$F_{(cutting)}$	5.8*	47.5**	5.5*	20.1**	12.9**	39.3**	55.1**	3.8*
$F_{(years)}$				8.5**				498.4**
$F_{(cutting\ x\ years)}$				4.4**				22.3**
$LSD_{(cutting)\ (0.05)}$	2.3	1.1	2.2	1.0	30.0	4.6	6.0	9.0
CV (%)	7.5	3.5	7.6	6.6	14.9	18.7	12.7	19.0

*IFP: initial flowering period, MFP: mid-flowering period, FFP: full flowering period, PP: the period when grains in the lower pods reach full maturity, **: Significant difference at 1% level, *: Significant difference at 5% level, CV: Coefficient of variation (%)*

Crude protein yield (CPY)

The analysis of variance (Table 7) of crude protein yield (CPY) values (kg da-1) determined for years (P<0.01), cutting periods (P<0.05) and cutting x year interactions (P<0.01) revealed statistically significant results. The mean CPY was highest at the FFP stage, at 67.0 kg da^{-1}, while the CPYs obtained at the MFP, IFP and PP growth stages were 56.1, 54.6 and 52.6 kg da^{-1}, respectively. The highest CPY was obtained in the first rainy year, as compared to subsequent years. The highest CPY was obtained during the FFP period in the initial year and during the PP period in the second and third years. The difference in outcomes observed between the two years led to the conclusion that the interaction between the cutting factor and the year factor was statistically significant. The highest CPY was observed in the first year, with an average of 127.8 kg da^{-1}, followed by the third and second years, with average CPY values of 29.8 and 15.1 kg da^{-1}, respectively. The CPY findings obtained from our research were found to be lower than those reported by Coşkun and Çaçan (2019) and Doğan (2014). The former reported 63.4 kg da^{-1}, while the latter reported 61.89 kg da^{-1} in the PP period. Similarly, among researchers engaged in studies on hairy vetch, the findings were observed to be lower than those reported by Ova and Uslu (2021), who conducted harvesting during the same periods (120.8, 162.3, 147.3, 157.0 kg da^{-1}), and Özdemir et al. (2021), who undertook harvesting during the PP period (47. 8-103.8 kg da^{-1}), Altınok and Hakyemez (2000) in FFP period (87.0 kg da^{-1}), Hakyemez et al. (2005) in IFP, FFP periods (75.8-88.7, 67.8-79.4 kg da^{-1}). The low CPY results can be attributed to the reduced rainfall levels experienced during the second and third years of the growth period for the plants in question.

Acid detergent fibre (ADF)

The analysis of variance (Table 7) revealed that the ADF ratios of woolly pod vetch exhibited statistically significant differences (P<0.01) across years and cutting periods. However, the cutting x year interaction was found to be insignificant. The highest ADF rate was observed in the FFP period, with an average of 41.5%, followed by the MFP, PP and IFP periods, which exhibited average rates of 39.9, 38.3 and 38.1%, respectively. In general, the ADF rate increased with the progression of the development period. In the first year and the third year, the ADF rate increased until the FFP period and then decreased in the PP period. In contrast, in the second year, the highest ADF rate was determined in the IFP period and then showed a slight decrease with the progression of the development period. The highest ADF rate was identified in the initial year, with a value of 43.0%. This was followed by rates of 40.4% and 34.6% in the third and second years, respectively. It was determined that the lowest ADF rate in the second year and the decline in ADF rate with the progression of the development period, in contrast to the other years, was attributable to the vegetative development of the plants, which was influenced by rainfall in May. The difference between the ADF ratios determined for the development periods was found to be statistically significant in the third year, while the other years were found to be insignificant. The ADF ratio values obtained in this study were higher than those reported by Desalegn and Hassen (2015) for the MFP period (37.3%) and by Coşkun and Çaçan (2019) for the PP period (37.6%). The results were higher than those reported by Ova and Uslu (2021) for the same periods (34.0%, 39.0%, 35.0%, 37.0%), with the exception of the MFP period. Furthermore, they were higher than those reported by Özdemir et al. (2021) for the PP period (35.4-39.5%). The discrepancy may be attributed to variations in climatic conditions and species-specific differences.

Neutral detergent fibre (NDF)

The analysis of variance (Table 7) revealed that the NDF ratios of woolly pod vetch were statistically significant (P < 0.01) for both the years and cutting periods. However, the cutting x year interaction was found to be insignificant. The mean NDF ratio was highest during the FFP period

(55.5%), followed by PP (54.7%), MFP (51.7%), and IFP (50.5%) periods. The difference between the NDF ratios determined for cutting periods was statistically significant (P < 0.01) in the third year, but not in the first or second years. The lowest NDF ratio was observed in the second year, with a value of 46.6%. In the initial and third years, the NDF ratio demonstrated an increase throughout the growth period, reaching its peak during the FFP period, and subsequently declined during the PP period. In contrast, in the second year, the NDF ratio exhibited a different trend, displaying a decline from the IFP to the FFP period and attaining its highest level during the PP period. It was thus concluded that this result was due to the vegetative development of the plants, which was once again stimulated by the rainfall in May. The NDF ratios obtained in the present study exhibited higher values than those reported by Desalegn and Hassen (2015) for the MFP period (47.1%) and Coşkun and Çaçan (2019) for the PP period (47.2%). In hairy vetch, the values were higher than those reported by Ova and Uslu (2021) for the same periods (42.0%, 54.0%, 46.0%, 50.0%) and Özdemir et al. (2021) for the PP period (47.5-49.8%). The elevated NDF ratios observed may be attributed to climatic conditions and species-specific factors.

Table 7. Acid detergent fibre (%) and neutral detergent fibre ratios (%) of plants at different growth stages

	Acid detergent fibre				Neutral detergent fibre			
Developmental stages	2010-2011	2011-2012	2012-2013	Average	2010-2011	2011-2012	2012-2013	Average
IFP	41.2	35.2	37.9 c	38.1 b	58.0	46.2	47.2 c	50.5 c
MFP	43.1	34.9	39.9 b	39.3 b	59.3	45.5	50.4 bc	51.7 bc
FFP	46.0	34.0	44.6 a	41.5 a	64.3	44.9	57.4 a	55.5 a
PP	41.5	34.1	39.3 bc	38.3 b	62.9	49.9	51.4 b	54.7 ab
Average	43.0 a	34.6	40.4 b	39.3	61.1 a	46.6 c	51.6 b	53.1
$F_{(cutting)}$	2.0	0.5	25.5**	4.6**	1.2	2.9	13.0**	3.6*
$F_{(years)}$				46.4**				44.5**
$F_{(cutting\ x\ years)}$				1.9				1.5
$LSD_{(cutting)\ (0.05)}$	5.0	2.7	1.8	2.1	8.6	4.2	3.8	3.7
CV (%)	7.2	4.9	2.8	6.4	8.8	5.6	4.6	8.3

*IFP: initial flowering period, MFP: mid-flowering period, FFP: full flowering period, PP: the period when grains in the lower pods reach full maturity, **: Significant difference at 1% level, *: Significant difference at 5% level, CV: Coefficient of variation (%)*

Digestible dry matter ratio (DDMR)

The analysis of variance (Table 8) revealed that the digestible dry matter ratios (DDMR) of woolly pod vetch exhibited statistically significant differences (P < 0.01) between years and cutting periods. However, the cutting x year interaction was found to be insignificant. The highest DDMR was identified during the IFP period, with a value of 59.2%. This was followed by the PP, MFP and FFP periods, which exhibited DDMRs of 59.1%, 58.3% and 56.5%, respectively. The difference between the DDMRs determined for the cutting periods was statistically significant in the third year (P < 0.01), but not in the first and second years. The highest DDMR was obtained in the second year, with a value of 62.0%. In the first and third years, DDMR decreased from IFP to FFP, reflecting the progression of the development period. In contrast, it increased in the PP period. In the second year, however, it exhibited a slight increase from IFP to FFP and a decrease in the PP period. This discrepancy in DDMR between years can be attributed to the rainfall in May and the vegetative growth of the plants. The DDMRs obtained according to the three-year averages of our study were similar to those reported by Coşkun and Çaçan (2019) for the PP period (59.6%), comparable to the MFP period of Ova and Uslu (2021) who mowed hairy vetch in the same periods (62.3, 58.6, 61.6, 60.0%), and lower than the other periods. These findings are consistent with those reported by Özdemir et al. (2021) in the PP period of hairy vetch (58.1-61.3%). The discrepancy in results between cropping periods may be attributed to species-specific differences.

Relative feed value (RFV)

The analysis of variance (Table 8) revealed that the relative feed value (RFV) of woolly pod vetch was statistically significant for both years ($P < 0.01$) and cutting periods ($P < 0.05$). However, the cutting x year interaction was found to be insignificant. The mean results indicated that the highest RFV was observed in the IFP period, with a value of 111.3, followed by the MFP, PP, and FFP periods, which exhibited mean values of 107.1, 102.4, and 98.5, respectively. The discrepancy between the RFVs determined for the cutting periods was statistically significant in the third year, but not in the other years. The highest RFV was observed in the second year, which was characterised by a lack of precipitation, with a value of 124.2. This result can be attributed to the impact of precipitation in May on vegetative development in plants. The RFV values obtained in this study were found to be lower than reported by Coşkun and Çaçan (2019) during PP period (118.6). It was found to be higher than the YY period and lower than other periods of Ova and Uslu (2021), who harvested hairy vetch in the same periods (138.3, 100.78, 124.60, 111.82). It was found to be lower than (112-120) Özdemir et al.(2021) In the BB period for hairy vetch. The RFV that we obtained may be due to the change in climatic conditions. The difference in the RFV can be explained by the differences in the climatic conditions of the year and the type of vetch.

Table 8. Digestible dry matter ratio (%) and relative feed value of plants at different growth stages

	Digestible dry matter ratio				Relative feed value			
Developmental stages	2010-2011	2011-2012	2012-2013	Average	2010-2011	2011-2012	2012-2013	Average
IFP	56.8	61.5	59.3 a	59.2 a	91.8	124.3	117.7 a	111.3 a
MFP	55.3	61.7	57.9 b	58.3 a	87.4	126.4	107.3 ab	107.1 ab
FFP	53.0	62.4	54.2 c	56.5 b	78.1	129.5	87.9 c	98.5 b
PP	56.6	62.3	58.3 ab	59.1 a	84.6	116.7	106.1 b	102.4 ab
Average	55.4 c	62.0 a	57.4 b	58.3	85.5 c	124.2 a	104.7 b	104.8
$F_{(cutting)}$	2.0	0.5	25.5**	4.6**	1.2	2.9	13.0**	3.6*
$F_{(years)}$				46.4**				52.6**
$F_{(cutting\ x\ years)}$				1.9				1.5
$LSD_{(cutting)\ (0.05)}$	5.0	2.7	1.8	2.1	8.6	4.2	3.8	3.7
CV (%)	7.2	4.9	2.8	6.4	8.8	5.6	4.6	8.3

*IFP: initial flowering period, MFP: mid-flowering period, FFP: full flowering period, PP: the period when grains in the lower pods reach full maturity, **: Significant difference at 1% level, *: Significant difference at 5% level, CV: Coefficient of variation (%)*

Conclusion

The main purpose of vetch cultivation is to obtain more economic income and provide feed production without losing yield in the main product. Different climatic conditions emerged each year in this study, which covered three years. Woolly pod vetch produced a significant yield in the study's first year under ideal rainfall and temperature conditions. This clearly shows that he has high potential. Considering the variable climate conditions, the most suitable time for cutting may vary according to the producer's preferences. In later years, when plant development slows down due to decreased rainfall during the growing season, the most suitable harvesting time is when the grains in the lower pods reach full maturity. The three-year average results show that harvesting woolly pod vetch at full flowering, when grown for hay, is a good practice. However, it is possible to delay cutting by 15 days in the second year and 20 days in the third year, i.e. to leave the field for a longer period. In this instance, the producer must decide between the potential gain from forage and the possibility of yield loss in the main crop resulting from delayed vetch cutting. Additionally, it is crucial to note that woolly pod vetch, which exhibits horizontal growth characteristics, should be sown in conjunction with cereals in regions experiencing a rainy spring season.

Conflict of Interest: The authors declare that they have no conflict of interest.

Authors' Contribution: : ZM designed the study and set up the experiments, ZM, SÜ and BE conducted the study, ZM and SÜ analyzed the data, and ZM, SÜ and BE wrote the article.

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