Journal of Kerbala for Agricultural Sciences Issue (3), Volume (11), (2024)

Growth, forage yield and seed yield components responses of some bitter vetch (*Vicia ervilia*) varieties to different seeding rate in Sulamani Region

Jwan Gharib Rafaat [1], Ako Hussein Mahamood [2]* , Shaee Adeeb Ghareeb[1]

[1] **Biotechnology and Crop Science Department, College of Agricultural Engineering Sciences, University of Sulaimani, Sulaimani, Iraq.**

[2] **Department of Forestry, College of Agricultural Engineering Sciences, Salahaddin University- Erbil, Kurdistan Region, Iraq.**

***Corresponding author e-mail: ako.mahmood@su.edu.krd.**

https://doi.org/10.59658/jkas.v11i3.2350

Received: June 29, 2024

Accepted: Aug. 11, 2024

Published: Sept. 15, 2024

Abstract

A field trial investigated the impact of varying seeding rates; 60 kg ha^{-1}, 80 , 100 , and 120 Kg ha^{-1} on the growth, forage yield, and yield components of three bitter vetch (*Vicia ervilia*) varieties (Perper from Serbia, Larnaca, and Tarsan-2). The experiments were conducted during the winter season of 2022-2023 in the Sulaimani governorate at Qlyasan locations. A factorial design was employed, and the experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications. Mean comparisons were performed using the Duncan test. Results indicate that a seeding rate of 60 Kg ha^{-1} resulted in optimal plant height (96.644 cm). The parameters Days to 50% flowering and days to maturity reached maximum values of 121.831 and 157.614, respectively, with an 80 Kg ha^{-1}seeding rate. Dry leaf weight peaked at 1.129 g with the same seeding rate. Tarsan-2 exhibited the highest dry leaf weight (1.045 g), while variety number 2 showed the highest dry stem weight (3.746 g). Additionally, a seeding rate of 60 kg/ha combined with variety number 1 yielded the tallest plants (103.800 cm).Tarsan-2, in conjunction with a seeding rate of 120 , demonstrated the longest durations for Days to 50% flowering (127.300 days) and days to maturity (164.240 days), as well as the highest dry leaf weight (4.153 g). The maximum fresh yield was recorded at 24.699 ton/ha and 24.456 ton/ha with seeding rates of 100 Kg ha^{-1} and 120 Kg ha^{-1}, respectively. Variety number 2, seeded at 60 Kg ha^{-1}, exhibited the highest number of pods per plant (22.110). Conversely, variety number 1, when seeded at a rate of 100 Kg ha^{-1}, yielded the highest 100-seed weight (22.073 g), seed yield (5.801 Mg ha-1), and harvest index (0.326).

Keywords: *Vicia ervilia*, Seeding Rate, variety, growth, yield.

Introduction

Legume crops are widely acknowledged for their significant contribution to human and animal nutrition owing to their high protein content. Particularly prevalent in Asia and America, legumes have garnered increased attention in Europe due to observed protein deficiencies, prompting a surge in the cultivation of legumes rich in protein (25-40%) [1, 2]. Among these, *Vicia ervilia* L., commonly known as bitter vetch, holds historical importance as a high-protein forage crop in arid regions of Central West Asia and North Africa, where it not only serves as a crucial source of animal feed but also plays a role in maintaining soil fertility [3, 4].

Bitter vetch has a long history of cultivation for both grain and hay production across the Mediterranean region. Its distribution spans southern Europe, Western and Central Asia, and North Africa [5]. This ancient legume has been recognized for its potential as a grain legume crop [6, 7, 8], utilized for both forage and grain purposes , including its incorporation into ruminant feeds [9]. Amidst the growing interest in alternative crops rich in valuable nutrients for human consumption, bitter vetch (*Vicia ervilia* L.) emerges as a promising candidate [10]. However, the optimal seeding rate for bitter vetch cultivation is influenced by various factors such as soil type and fertility, climate, establishment methods, seed size, and crop growth patterns. Deviating from the appropriate seeding rate could adversely affect the dry matter and seed yield of forage crops, which are crucial sources of energy and protein for ruminants [11, 12, 13]. Therefore, this study aims to not only identify suitable bitter vetch varieties for the region but also determine the optimum seeding rate to enhance crop productivity. By comprehensively examining the interaction between seeding rate, bitter vetch varieties, and various growth parameters, this research seeks to provide valuable insights into optimizing bitter vetch cultivation practices for improved agricultural sustainability and enhanced nutritional outcomes.

Materials and Methods

Plant Materials and Field Experiment

The study was conducted at the Qlyasan Agricultural Research Station, situated within Sulaimania province under the auspices of the College of Agricultural Sciences Engineering at the University of Sulaimani, during the winter season spanning 2022 to 2023. Three distinct varieties of bitter vetch (*Vicia ervilia*) were selected for examination, with four different seeding rates (60, 80 , 100 , and 120 Kg ha^{-1}) being employed to assess their impact on various growth parameters, forage yield, and yield components. Seeds for each variety utilized in the experiment were obtained from the International Center for Agricultural Research in the Dry Areas (ICARDA), ensuring consistency and reliability in the genetic material under investigation. Each experimental plot was meticulously prepared, consisting of four rows, each measuring 2 meters in length. The spacing between rows was maintained at 0.30 meters, with a distance of 30 centimeters between individual plants within rows. Throughout the experiment, standard agricultural practices were diligently applied to ensure optimal growth conditions and minimize external variables.

Plant Measurements

To accurately assess growth dynamics, forage yield components, and yield attributing parameters, five plants were randomly selected from each net plot and appropriately tagged for subsequent measurements. This sampling strategy allowed for representative data collection across the experimental plots, ensuring robust statistical analysis and inference.

Growth and Forage Yield Components

A comprehensive suite of parameters was measured to capture the intricate dynamics of plant growth and forage yield. These included plant height (measured in centimeters), days to 50% flowering, days to 50% maturity, the number of branches per plant, as well as leaf dry weight, stem dry weight, and the leaf-to-stem ratio. These metrics collectively provide insights into the developmental progression of the bitter vetch plants and their potential for forage production.

Seed Yield Components

Critical components pertaining to seed yield were meticulously recorded to gauge the productivity of the bitter vetch varieties under investigation. Data on seed yield, biological yield, and harvest index were obtained from the entirety of each plot, ensuring a comprehensive assessment of yield performance. Additionally, traits such as pod number per plant, seed number per pod, 100-seed weight, and biological yield (expressed as the average weight of entire plants per plot and converted to tons per hectare) were meticulously quantified. Harvest index (HI), a key indicator of resource allocation efficiency, was calculated as the ratio of seed yield to biological yield, following established methodologies [14].

Statistical Analysis

To rigorously evaluate the experimental results, a factorial design based on a randomized complete block design (RCBD) with three replications was implemented. This experimental design, widely recognized for its robustness and statistical power, allowed for the systematic investigation of the effects of seeding rate and variety on bitter vetch performance. Differences between treatments means were subsequently assessed using the Duncan test, a standard procedure for identifying significant differences in agricultural experiments. This statistical analysis facilitated the identification of meaningful trends and insights into the influence of seeding rate and variety on bitter vetch growth and yield characteristics.

Results and Discussion

Table (1) Presents the effects of different seeding rates on various growth and forage characteristics of bitter vetch, as a leguminous plant commonly used for forage. It is evident that varying seeding rates have significant effects on bitter vetch plant height. As the seeding rate increases from 60 Kg ha^{-1}to 120 Kg ha^{-1}, there is a corresponding decrease in plant height. This inverse relationship suggests that higher seeding rates result in shorter plant heights (82.261 cm). Additionally, the statistical significance denoted by the distinct letters emphasizes the validity and reliability of these observed differences. The number of branches per plant across all seeding rates suggests that there were no significant differences in the average number of branches observed on each bitter vetch plant at these seeding rates. Therefore, other factors or conditions might play a more dominant role in influencing the branching characteristics. The average number of days for 50% of flowering an important parameter in understanding the flowering behavior of the plants. Results indicate the observed differences in flowering times between seeding rates are statistically significant. For instance, at a seeding rate of 80 Kg ha^{-1}, the average time to reach 50% flowering (121.831 days) indicating that it is significantly different from the values associated with other seeding rates. Similarly, at a seeding rate of 120 Kg ha^{-1}, the average time to reach 50% flowering (123.811 days). conversely, seeding rates of 60 Kg ha^{-1}and 100 Kg ha^{-1}, with average flowering times of 98.511 days and 102.238 days respectively, are indicating that they share a similar flowering timeline. The impact of seeding rates on the maturity days of bitter vetch was varied. For example, at a seeding rate of 60 Kg ha^{-1}, the average time to reach maturity (143.934 days); suggesting the highest duration and it is significantly different from the values associated with other seeding rates. Conversely, seeding rates of 80 Kg ha^{-1}, 100 Kg ha^{-1}, and 120 Kg ha^{-1}, with average maturity times of 157.614 days, 162.671 days, and 160.016 days respectively, are indicating that they share a similar maturity days, and not statistically different from each other.

The higher leaf-stem ratio an indicator for better forage quality, as leaves are generally richer in nutrients compared to stems. In this study, seeding rates of 120 Kg ha^{-1}resulted in higher leaf-stem ratios (3.294) compared to the lower seeding rate 60 Kg ha^{-1} was only (2.289), suggesting better forage quality at higher rate. The leaf and stem dry weights show how seeding rates impact biomass production. At a seeding rate of 80 Kg ha^{-1}, the average dry weight of leaves (1.129 g) indicating it is significantly different from the values associated with other seeding rates. At a seeding rate of 120 Kg ha^{-1}, the average dry weight of stems (4.191 g), significantly different from other values. Conversely, seeding rates of 60 Kg ha^{-1}and 100 Kg ha^{-1}have values of leaf dry weight and stem dry showing that they share similar characteristics in terms of dry weight. Our results regarding flowering performance in response to seeding rates are consistent with the findings of Kaplan et al, [15]. The significant differences in flowering times observed across different seeding rates underscore the intricate relationship between plant density and developmental milestones. Understanding these dynamics is essential for optimizing harvest timing and maximizing yield potential. Moreover, the higher leaf-stem ratio observed at higher seeding rates, indicative of better forage quality, echoes the findings of Sayar, [16]. This highlights the importance of seeding rate management in achieving desired nutritional outcomes in forage crops.

Table (1): Effect of seeding rate on some growth and forage characters of bitter vetch.

Seeding Rate (kg.ha^{-1})	plant height (cm)	No. of branch Plant^{-1}	Days to 50% flowering	Days to maturity	Leaf stem ratio	Stem dry weight (g)	leaf dry weight (g)
60	96.644	2.598 a	98.511 b	143.934 b	2.289 b	2.634 c	0.884 b

	a						
80	92.544 b	2.781 a	121.831 a	157.614 a	2.773 ab	2.551 c	1.129 a
100	85.933 c	2.772 a	102.238 b	162.671 a	2.394 b	3.307 b	0.658 c
120	82.261 d	2.962 a	123.811 a	160.016 a	3.294 a	4.191 a	0.944 b

Means that do not share a letter are significantly different.

Table (2) presents the effects of Varieties on some growth and forage characters for bitter vetch. In terms of leaf stem ratio, V2 exhibited the highest value (1.045), while V1 had the lowest (0.770). However, V3 had the highest stem dry weight (3.746 g), leaf dry weight (3.334 g),Regarding plant height, V1 was the tallest (91.958 cm), followed by V3 (89.071 cm) and V2 (87.008 cm).

These results suggest that different varieties of bitter vetch exhibit variations in growth and forage characteristics, which could be important considerations for farming practices and breeding programs. The current study's findings on bitter vetch varieties' growth and forage characteristics can be connected to previous research conducted on related legume species, such as hairy vetch. In previous studies, the variability in plant height of hairy vetch was observed within a range of 100 to 235 cm [17] and 82.20 to 87.60 cm [18]. These studies underscore the inherent variability in growth traits among different varieties or populations of vetch species.

Table (2): Effects of Varieties on some growth and forage characters for bitter vetch.

Varieties	plant height (cm)	No. of branch Plant^{-1}	Days to 50% Flowering	Days to maturity	Leaf dry weight (g)	Stem dry weight (g)	Leaf stem ratio
V1	91.958 a	2.583 a	111.837 a	157.499 a	2.058 a	2.927 b	0.770 b
V2	87.008 ab	2.835 a	111.392 a	154.992 a	2.671 b	2.840 b	1.045 a
V3	89.071 b	2.918 a	111.564 a	155.686 a	3.334 c	3.746 a	0.897 ab

Means that do not share a letter are significantly different.

Table (3) shows the effect of seeding rate on the forage yield of bitter vetch, as indicated by fresh yield (tons per hectare), dry yield (tons per hectare) and dry matter percentage.

The dry matter percentage remained relatively consistent across different seeding rates. However, there were variations in dry and fresh yields with different seeding rates. Both

dry and fresh yields increased as the seeding rate increased from 60 kg ha^{-1} to 100 kg ha^{-1}, with the highest yields observed at the seeding rate of 100 kg ha^{-1}.
These results indicate that the seeding rate significantly influences the forage yield of bitter vetch, with an optimal seeding rate of 100 kg/ha leading to the highest yields. However, further investigation may be needed to understand the reasons for the decrease in yield observed at the higher seeding rate of 120 kg ha^{-1}.

Table (3): Effect of seeding rate on forage yield of bitter vetch

seeding rate (kg ha^{-1})	Fresh yield (ton $.ha^{-1}$)	Dry yield (ton $.ha^{-1}$)	DM %
60	20.308 b	2.714 a	13.886a
80	20.479 b	2.889 a	14.042 a
100	24.699 a	3.162 a	13.981 a
120	24.456 a	3.259 a	13.632 a

Means that do not share a letter are significantly different

Table (4) Presents the effect of different varieties on forage yield characteristics of bitter vetch. The data include fresh yield (tons per hectare), dry yield (tons per hectare), and dry matter percentage (DM %) for each variety.

Variety one (V1) exhibited the highest fresh and dry yields among the three varieties, with fresh yield of 24.344 ton $.ha^{-1}$and dry yield of 3.113 ton $.ha^{-1}$. Variety 3 also showed competitive performance with a fresh yield of 22.385 ton $.ha^{-1}$and dry yield of 3.131 ton $.ha^{-1}$. However, variety 2 had the lowest yields, with a fresh yield of 20.728 ton $.ha^{-1}$and dry yield of 2.775 ton $.ha^{-1}$.

In terms of dry matter percentage, V3 had the highest value (14.924%), indicating a higher proportion of dry matter in the harvested forage compared to the other varieties. Varieties V1 and V2 had similar dry matter percentages, around 13.4% to 13.3%. These results suggest that variety one (V1) generally performs better in terms of forage yield compared to varieties V2 and V3. However, variety V3 exhibits a higher dry matter percentage, which could be advantageous in certain cultivated contexts.

Table (4): Effect of Varieties on forage yield characters for bitter vetch.

Varsities	Fresh yield ton $.ha^{-1}$	Dry yield ton $.ha^{-1}$	DM %
V1	24.344 $_a$	3.113 a	13.435 b
V2	20.728 b	2.775$_a$	13.296 b
V3	22.385 ab	3.131 a	14.924 a

Means that do not share a letter are significantly different.

Table (5) Illustrates the interaction between seeding rate kg ha^{-1} and different varieties on various growth and forage characteristics of bitter vetch. This data indicates that both seeding rate and variety have significant effects on the growth and forage characteristics of bitter vetch. For instance, higher seeding rates generally lead to increased plant height, number of branches per plant, and dry matter production. However, the specific response varies depending on the variety. Additionally, different varieties exhibit distinct traits, such as leaf dry weight, stem dry weight, and leaf stem ratio, which contribute to overall forage quality and productivity. Further analysis and experimentation may be necessary to fully understand the complex interactions between seeding rate and variety in influencing bitter vetch growth and forage yield.

Table (5): Effect of interaction between seeding rate and varieties on some growth and forage characters for bitter vetch.

Seeding rate ($kg.ha^{-1}$)	Varieties	Plant height (cm)	No. of branches $plant^{-1}$	Days to 50% flowering	Days to maturity	leaf dry weight (g)	Stem dry weight (g)	Leaf stem ratio
60	V1	103.800 a	2.543 ab	102.362 b	148.653 bc	1.283 e	1.580 f	0.811 cd
	V2	90.633 cd	2.330 b	96.561 b	141.483 c	0.330 bcd	3.780 c	0.699 de
	V3	95.500 bc	2.920 ab	96.609 b	141.667 c	2.953 bc	2.543 d	1.142 bc
80	V1	100.567 ab	2.720 ab	121.437 a	157.493 ab	3.397 abc	2.700 d	1.265 ab
	V2	88.700 de	2.627 ab	123.363 a	159.167 ab	2.153 bcd	1.687 ef	1.281 ab
	V3	88.367 de	2.997 ab	120.693 a	156.183 ab	2.770 bcd	3.267 c	0.841 cd
100	V1	75.433 f	2.433 ab	102.703 b	165.673 a	1.220 e	1.687 ef	0.595 de
	V2	83.667 e	2.850 ab	102.357 b	161.687 a	2.503 bcd	3.647 c	0.686 de
	V3	87.683 de	3.033 ab	101.653 b	160.653 ab	3.460 ab	4.587 b	0.694 de
120	V1	88.033 de	2.633 ab	120.847 a	158.177 ab	2.333 cd	5.740 a	0.407 e
	V2	85.033 de	3.533 a	123.287 a	157.630 ab	3.397 abc	2.247 de	1.515 a
	V3	84.733 de	2.720 ab	127.300 a	164.240 a	4.153 a	4.587 b	0.911 cd

Means that do not share a letter are significantly different.

Table 6.Presents the effect of the interaction between seeding rate (kg ha^{-1}) and varieties on forage yield characteristics of bitter vetch. It shows how different combinations of seeding rates and varieties influence the dry leaf weight, dry stem weight, and leaf stem ratio, which are important indicators of forage productivity and quality. These insights can be valuable for optimizing seeding rates and selecting suitable varieties to maximize forage yield in bitter vetch cultivation.

The best combination for maximizing dry leaf weight (g) is seeding Rate 120 kg ha^{-1} with Variety V3, which yielded 4.153 g of dry leaf weight. This combination represents the highest dry leaf weight observed across all seeding rates and varieties listed in the table. It suggests that for this specific characteristic (dry leaf weight), utilizing a seeding rate of 120 kg ha^{-1} with Variety V3 would be the most effective approach. Consequently, for maximizing dry stem weight, Seeding Rate 120 kg ha^{-1} with Variety V1 is optimal, while for maximizing leaf stem ratio, Seeding Rate 120 kg ha^{-1} with Variety V2 is the most effective.

Table (6): Effect of interaction between seeding rate and varieties on forage yield for bitter vetch.

seeding rate (kg.ha-1)	Varieties	Dry leaf weight (g)	Dry stem weight (g)	Leaf stem ratio
60	V1	1.283 e	1.580 f	0.811 cd
	V2	2.630 bcd	3.780 c	0.699 d
	V3	2.953 bcd	2.543 d	1.142 bc
80	V1	3.397 abc	2.700 d	1.265 ab
	V2	2.153 de	1.687 ef	1.281 ab
	V3	2.770 bcd	3.267 c	0.841 bc
100	V1	1.220 e	1.687 ef	0.595 de
	V2	2.503 bcd	3.647 c	0.686 de
	V3	3.460 ab	4.587 b	0.694 de
120	V1	2.333 cd	5.740 a	0.407 e
	V2	3.397 abc	2.247 de	1.515 a
	V3	4.153 a	4.587 b	0.911 cd

Means that do not share a letter are significantly different.

Table (7) presents the effect of seeding rate on seed yield and its components of bitter vetch. The seeding rate were significantly influenced some various components of seed yield. Additionally, the 100-seed weight reached its peak at the same seeding rate of 100 kg ha^{-1}, with an average weight of 20.681 grams. Notably, the highest seed yield was achieved at the seeding rate of 100 kg ha^{-1}, reaching 5.009 kg ha^{-1}, indicating the optimal seeding rate for maximizing seed production. This increase in seed yield corresponded with the highest biological yield recorded at the same seeding rate, totaling 18.928 kg ha^{-1}. Moreover, the harvest index, which represents the efficiency of biomass allocation towards seed production, peaked at 0.269, also observed at the seeding rate of 100 kg ha^{-1}. Overall, these findings underscore the importance of selecting an appropriate seeding rate, with the 100 kg ha^{-1}rate demonstrating superior performance in terms of seed yield and related components in bitter vetch cultivation.

Table (7): Effect of seeding rate on seed yield and its components of bitter Vetch

Seeding rate($kg.ha^{-1}$)	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	100 Seed weight (g)	Seed yield (ton. ha^{-1})	Biological yield ($ton.ha^{-1}$)	Harvest index
60	20.241a	3.071 a	19.193 b	2.638 c	14.498 b	0.184 b
80	19.397 a	3.216 a	20.464 a	3.679 b	14.549 b	0.256 a
100	19.167 a	3.674 a	20.681 a	5.009 a	18.928 a	0.269 a
129	20.996 a	3.659 a	19.869 ab	4.180 b	17.601 a	0.239 a

Means that do not share a letter are significantly different.

Table 8 illustrates the effect of different bitter vetch varieties on seed yield and its components, including the number of pods per plant, the number of seeds per pod, 100-seed weight (g), seed yield ($ton.ha^{-1}$), biological yield ($ton.ha^{-1}$), and harvest index. Here's a written paragraph summarizing the results, highlighting the highest significantly results. Furthermore, Variety V1 displayed the highest seed yield among the varieties, reaching 4.286 $ton.ha^{-1}$. This was accompanied by the highest biological yield for Variety V1, totaling 16.668 $ton.ha^{-1}$. These results suggest that Variety V1 not only produced a higher quantity of seeds but also generated more biomass overall, indicating its potential for greater productivity.

Regarding the harvest index, which represents the efficiency of biomass allocation towards seed production, Variety V1 also outperformed the other varieties, with a harvest index of 0.255. This indicates that Variety V1 allocated a higher proportion of its biomass towards seed production compared to Varieties V2 and V3.

Table (8) : Effect of bitter vetch varieties on seed yield its components

Varieties	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 Seed weight (g)	Seed yield (ton. ha-1)	Biological yield (ton. ha^{-1})	Harvest index
V1	20.118 a	3.374 a	20.085 a	4.286 a	16.668 a	0.255 a
V2	20.575 a	3.498 a	20.192 a	3.449 b	16.668 a	0.242 b
V3	19.157 a	3.343 a	19.879 a	3.894 a	15.898 a	0.214 ab

Means that do not share a letter are significantly different.

Table 9 illustrates the effect of interactions between bitter vetch varieties and seeding rates on seed yield and its components. Across the different seeding rates, Variety V2 consistently exhibited the highest number of pods per plant, with the peak value of 22.110 pods/plant observed at a seeding rate of 60 kg ha^{-1}. Additionally, Variety 3 consistently displayed the highest number of seeds per pod, reaching its maximum of 4.103 seeds/pod at a seeding rate of 100 kg ha^{-1}.

Additionally, Variety V2 consistently produced the highest biological yield, with a peak value of 19.981 tons/ha observed at the same seeding rate.

The harvest index, reflecting the efficiency of biomass allocation towards seed production, was highest for Variety V1 across various seeding rates. The peak harvest index of 0.326 was achieved by Variety V1 at a seeding rate of 100 kg ha^{-1}, indicating its superior ability to allocate biomass towards seed production compared to the other varieties. The variations in bitter vetch growth characteristics, such as pod production and biological yield, reflect similar results observed in previous studies on common vetch and narbonne vetch. This suggests consistent genotype-environment interactions across vetch species, underscoring the importance of considering both genetic traits and environmental factors in vetch cultivation and breeding programs, as highlighted by Orak et al. [19], Cil and Yücel [20], and Sayar et al. [21].

Table (9): Effect of interactions of bitter vetch varieties and seeding rate on seed yield its components

Seeding rate kg.ha^{-1}	Varieties	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 Seed Weight (g)	weight of seed (gm)	Seed yield (ton.ha^{-1})	Biological yield (ton.ha^{-1})	Harvest index
60	V1	20.210 abc	2.847 ab	18.470 e	0.947 a	3.203 cd	14.390 de	0.223 cde
	V2	22.110	3.767	19.290	0.830	2.280 d	15.198 de	0.151

		a	ab	cde	a			e
	V3	18.403 bc	2.600 b	19.820 bcde	0.690 a	2.431 d	13.905 de	0.179 de
80	V1	19.997 abc	3.293 ab	19.990 bcde	0.683 a	3.565 c	15.835 cde	0.225 cde
	V2	18.493 bc	3.023 ab	20.517 abcd	0.727 a	4.040 bc	13.200 e	0.308 ab
	V3	19.700 abc	3.330 ab	20.887 abc	0.910 a	3.432 c	14.613 de	0.236 bcd
100	V1	19.510 abc	3.517 ab	22.073 a	1.280 a	5.801 a	17.898 abc	0.326 a
	V2	19.807 abc	3.403 ab	21.247 ab	1.423 a	3.666 bc	19.981 a	0.186 de
	V3	18.183 c	4.103 a	18.723 de	1.367 a	5.558 a	18.904 a	0.294 abc
120	V1	20.757 abc	3.840 ab	19.807 bcde	1.023 a	4.574 b	18.548 ab	0.247 bcd
	V2	21.890 ab	3.797 ab	19.713 bcde	0.693 a	3.809 bc	18.087 abc	0.212 de
	V3	20.340 abc	3.340 ab	20.087 bcde	0.777 a	4.157 bc	16.168 bcd	0.259 abcd

Means that do not share a letter are significantly different.

This investigation provides insight into the performance of bitter vetch at different seeding rates and types. Variety No. 3 demonstrated exceptional performance in terms of both fresh yield and dry matter content, indicating its ability to produce a substantial amount of biomass. When sowing at a rate of 120 kg/ha, Variety No. 2 demonstrated the highest leaf stem ratio, indicating better quality fodder. The best harvest index, 100-seed yield, and seed yield were continuously produced by Variety No. 1, demonstrating its versatility and effectiveness in producing seeds at all planting rates. For best results, we suggest using Variety No. 1 at a seeding rate of 100 kg/ha. Further research is needed to refine management practices for bitter vetch cultivation in our region.

References

1) Sakandar, H. A., Chen, Y., Peng, C., Chen, X., Imran, M., & Zhang, H. (2023). Impact of fermentation on antinutritional factors and protein degradation of legume seeds: A review. **Food Reviews International, 39**(3), 1227–1249.

2) Bakoglu, E., Bagci, H., & Ciftci, J. (2009). **Journal of Food Agriculture and Environment, 7**(2), 343.

3) Samarah, N., Allataifeh, N., Turk, M. A., & Tawaha, A. M. (2003). Effect of maturity stage on germination and dormancy of fresh and air-dried seeds of bitter

vetch (**Vicia ervilia** L.). **New Zealand Journal of Agricultural Research, 46**, 347–354.

4) International Center for Agricultural Research in the Dry Areas (ICARDA). (2004). In **ICARDA Annual Report 2003** (pp. 30–32). Aleppo, Syria.

5) Germplasm Resources Information Network (GRIN). (2008). Taxonomy for plants. United States Department of Agriculture, Agricultural Research Service, Beltsville Area. Available at: http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?41481

6) Abdullah, A. Y., Muwalla, M. M., & Harb, M. Y. (1999). Evaluation of various protein sources for growing and finishing Awassi lambs. **Turkish Journal of Veterinary and Animal Sciences, 23**, 475–482.

7) Sadeghi, G., Pourreza, J., Samie, A., & Rahmani, H. (2009). Chemical composition and some anti-nutrient content of raw and processed bitter vetch (**Vicia ervilia**) seed for use as feeding stuff in poultry diet. **Tropical Animal Health and Production, 41**, 85–93.

8) Zohary, D., & Hopf, M. (2000). **Domestication of plants in the Old World** (3rd ed.). Oxford University Press.

9) Hadad, S. G. (2006). Bitter vetch grains as a substitute for soybean meal for growing lambs. **Livestock Science, 99**, 221–225.

10) Sadeghi, G., & Pourreza, J. (2007). Serum proteins and some biochemical parameters in broiler chickens fed with raw and treated bitter vetch (**Vicia ervilia**) seeds. **Pakistan Journal of Biological Sciences, 10**, 977–981.

11) Yalçin, S., Tuncer, I., Yalçin, S., & Onbasilar, E. E. (2003). The use of different levels of common vetch seed (**Vicia sativa** L.) in diets for fattening rabbits. **Livestock Production Science, 84**, 93–97.

12) Farran, M. T., Halaby, W. S., Barbour, G. W., Uwayian, M. G., Sleiman, F. T., & Ashkarian, V. M. (2005). Effects of feeding ervil (**Vicia ervilia**) seeds soaked in water or acetic acid on performance and internal organ size of broilers and production and egg quality of laying hens. **Poultry Science, 84**, 1723–1728.

13) Dzvene, A. R., Tesfuhuney, W. A., Walker, S., & Ceronio, G. (2023). Management of cover crop intercropping for live mulch on plant productivity and growth resources: A review. *Air, Soil and Water Research, 16*, 11786221231180079. https://doi.org/10.1177/11786221231180079

14) Rehman, A. U., Ali, M. A., Atta, B. M., Saleem, M., Abbas, A., & Mallahi, A. R. (2009). Genetic studies of yield-related traits in mungbean (*Vigna radiata* L. Wilczek). *Australian Journal of Crop Science, 3*, 352–360.

15) Kaplan, M., Kokten, K., & Uzun, S. (2011). Fatty acid and metal composition of the seeds of *Vicia ervilia* varieties from Turkey. *Chemistry of Natural Compounds, 50*(1), 117–119. https://doi.org/10.1007/s10600-014-0881-4

16) Sayar, M. S., Yucel, C., Tekdal, S., Yasak, M. S., & Yildiz, E. (2009). Determination of yield and yield components of some common vetch (*Vicia sativa* L.) lines in

Diyarbakır conditions. In *Proceedings of the Eighth Field Crops Congress of Turkey* (Vol. 1, pp. 518–521). Hatay, Turkey.
17) Mihailović, V., Mikić, A., Vasiljević, S., Katić, S., Karagić, Đ., & Ćupina, B. (2008). Forage yields in urban populations of hairy vetch (*Vicia villosa* Roth.) from Serbia. In *Biodiversity and Animal Feed: Future Challenges for Grassland Production* (pp. 281–283). Swedish University of Agricultural Sciences.
18) Tan, E., & Celen, E. (2001). The effect of harvesting time on the yield and quality characteristics of some forage crops species and mixtures. In *Proceedings of the Fourth Field Crops Congress of Turkey* (Vol. 3, pp. 137–142). Tekirdag, Turkey.
19) Orak, A., & Nizam, I. (2009). Genotype × environment interaction and stability analysis of some narbonne vetch (*Vicia narbonensis* L.) genotypes. *Agricultural Science and Technology, 1*(4), 108–112.
20) Cil, A., & Yücel, C. (2006). Adaptation of some common vetch (*Vicia sativa* L.) genotypes in Harran Plain conditions. *Harran University Journal of the Faculty of Agriculture, 10*(1/2), 53–61.
21) Sayar, M. S. (2016). Dry matter yield and forage quality of promising bitter vetch (*Vicia ervilia* (L.) Willd.) lines. *Journal of Field Crops Science*.