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Phenological and Morphological Characters Analysis of Vicia Narbonensis L. and Vicia Sativa L. in a Semi-Arid Context

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Abstract: Our study focused on ten Vicia narbonensis L. ecotypes in comparison with two Vicia sativa L. ecotypes cultivated at the University of Sétif-1 experimental station. The aims work to study these twelve vetches behavior via phenological character (plant height) and some morphological stages (date: start of flowering, 50% of flowering and full flowering) monitoring, under the rainy conditions of the semi-arid region (East Algerian). The Two Vicia sativa L. ecotypes are used as controls because this species dominates forage crops in Algeria. The data collected are subjected to variance analysis based on comparison Fisher means (LSD) at the 5% threshold. The relationships between the different measured variables pairs are described and analyzed by calculating phenotypic correlations, based on genotypic means using the XLSTAT software (2014). The variance analysis indicates significant effects of ecotype, year and ecotype × year interaction ($p<0.05$), highlighting the great diversity in phenological evolution. Our results indicate that characteristics ecotype tested are strongly affected by interannual variations and the ecotypes are not stable for the parameters measured from one year to the next. According to three year average for Vicia narbonensis L., the earliest period at flowering start is recorded by ecotype N-2380 while the latest is recorded by ecotype N-2390. ANOVA indicated significant differences between ecotypes, years and their interaction for plant height. Finally, early ecotypes are preferred in semi-arid regions provided that spring frosts do not coincide with flowering. In other words, as they flower early, they can escape drought at end cycle and therefore give themselves more time to fill their pods.

Keywords: Vicia narbonensis L., Vicia sativa L., Ecotypes, Semi-arid

Introduction

Livestock farming in Algeria has always retained a traditional character, based mainly on pastoralism and the exploitation of natural resources (Carter, 1974). Among the various challenges faced by livestock farmers, feeding ruminants is particularly problematic due to its heavy reliance on natural vegetation (Merdjane and Yakhlef, 2016). Annual forage legumes, such as those of the Vicia genus, are an interesting alternative to replace the fallow year in cereal-fallow rotation (Issolah, 2008). Vetches (genus Vicia sp.) are forage legumes frequently grown in rainfed and semi-arid agricultural systems in the Mediterranean region (Turk, 1997). They

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are proving particularly suitable and promising as short-term forage crops. One of vetch's major assets is its versatility, enabling it to be grazed as green fodder or harvested and stored as silage or hay. In addition, their grains are sources of protein and energy for ruminant and non-ruminant feed (Sadeghi et al., 2009), while generally being less expensive than concentrates, particularly in developing countries. The contribution of vetch to agricultural and animal production systems worldwide is widely recognized (Berhanu et al., 2003).

Adding value to species of the Vicia sp. genus can help to guarantee sufficient, varied and balanced feed for livestock, based on protein-rich forage resources. This could also lead to a reduction in the costs associated with importing concentrated feed, thereby encouraging the development of livestock farming, as well as milk and meat production. The objective of this study is to examine the behavior of ten ecotypes of Vicia narbonensis L. in comparison to two ecotypes of Vicia sativa L. under the rainy conditions of the semi-arid region of Sétif, focusing on their phenological and morphological characteristics.

Method

Study Area Description

The trials were carried out on plots at the FERHAT Abbas Sétif1 University Campus (36o12' N; 5o21' E) under rainy conditions in the Sétif region. The climate in this region is continental, with wide annual and daily temperature variations, and two major climatic constraints: frost and sirocco. It is located in the semi-arid bioclimatic zone, at an altitude of 1,025m. Temperatures fall below 0°C in winter and reach peaks of over 40°C in summer. In addition, the difference in temperature between night and day, sometimes reaching 20°C in winter and spring, causes frost, which is very restrictive for plant growth (Bouzerzour & Benmahammed, 1994).

The soils at the test site belong to the steppe soil group (Perrier and Soyer, 1970). The physico-chemical composition of all the plots shows a silty-clay texture, a lumpy structure, a basic water pH (7.81), a total limestone content of 17.7% and an organic matter content ranging from 2.0 to 3.0%. Average annual rainfall is around 450 mm (Seltzer, 1947) and 373.8 mm for the period between 2006 and 2017 (ONM, 2017). However, rainfall is subject to very wide intra- and inter-annual variations. The trial was conducted during three cropping seasons 2017-2018; 2018-2019 and 2019-2020. Climatic conditions for the three seasons are presented in Table 2 (ONM, 2020). The three crop years are characterised by:
- Rainfall was fairly variable over the three cropping seasons, with higher amounts in the first year (469.05 mm), followed by the third year (384.56 mm), compared with only 321.20 mm in the second year;
- The maximum temperatures recorded were consistent across the three seasons, as were the minimum temperatures.

Plant Material Presentation

The experiment involved two species of the Vicia genus, represented by ten ecotypes of Vicia narbonensis L. of different origins (from ICARDA) and two ecotypes of Vicia sativa L. from Algeria. The ecotypes of Vicia sativa L. were used as control ecotypes because this species is well known among Algerian farmers (Table 1).

Table 1. Origins of the Vicia narbonensis L. and Vicia sativa L. ecotypes studied

Species	Ecotype	Code	Origin
Vicia narbonensis L.	1	N-2380	Lebanon
	2	N-2383	Lebanon
	3	N-2390	Lebanon
	4	N-2392	Lebanon
	5	N-2393	Syria
	6	N-2461	Turkey
	7	N-2464	Turkey
	8	N-2466	Turkey
	9	N-2468	Lebanon
	10	N-2561	Syria
Vicia sativa L.	11	S-174	Algeria
	12	S-BBA	Algeria

Essay Presentation

Sowing was carried out from the same seed lot on 04 January 2018 for the first year, 22 December 2019 for the second year and 23 December 2020 for the third year. All ecotypes were sown manually and separately in a completely randomised block design with three replications in a plot with a cereal (durum wheat) as the previous crop. Each elementary plot consisted of 4 rows 4 m long, spaced 30 cm apart. 336 seeds/plot (at a rate of 70 seeds/m2) of vetch were sown in each of these plots.

Various cultivation operations were carried out on this trial. Deep ploughing (25 cm) was carried out using a disc plough just after the first autumn rains (September and October), followed by two cross passes of covercrop to reduce weed infestation and obtain a good seedbed. During the three trial campaigns, the plots were weeded manually throughout the growing season as and when required, and fertilisers were not used. Harvesting was carried out manually; from 30 May to 19 June for the first year; from 11 June to 02 July for the second year and from 17 to 28 June for the third year.

Studied Characteristics

Phrenological Stage

The phenological stages observed in this study comprise several key stages. Firstly, the date when flowering begins, which is determined by the number of days from germination to the appearance of the first inflorescence (Berrekia, 1985). Next, the date of 50% flowering is assessed by counting the number of days between germination and the appearance of half the flowers. Finally, the date of full flowering is measured in terms of the number of days from germination to the appearance of the maximum number of flowers. These different phenological stages provide crucial information on the development of the ecotypes studied.

Morphological Characteristics

Plant height (PH), measured in centimetres from the base to the end of the main stem at the time of full flowering.

Statistical Analysis

The collected data were processed using XLSTAT (2014) software, according to an analysis of variance based on the comparison of Fisher means (LSD) at the 5% threshold. The relationships between the different pairs of variables measured were described and analysed by calculating phenotypic correlations based on genotypic means.

Results and Discussion

For each species (Vicia narbonensis L. and Vicia sativa L.), the analysis of variance showed significant effects of ecotype, year and ecotype × year interaction ($p<0.05$), highlighting the wide diversity in phenological development and production for the different parameters measured (Table 2).

Phrenological Stage

Statistically significant differences ($P<0.05$) were found between growing seasons (years) in terms of days to reach onset of flowering; 50% flowering and 100% flowering between ecotypes of Vicia narbonensis L. and Vicia sativa L. (Table 2).This indicates that the characteristics of the ecotypes of the two species tested in the semi-arid region of Sétif are strongly affected by inter-annual variations. The days to reach the three phenological stages in the 2017-2018 growing season were significantly fewer than in the other two seasons. This is probably because the amount of precipitation during the winter months and in March was higher than during the 2019-2020 or 2018-2019 growing seasons (Table 2).

Table 2. Variance of measured parameters of vetches studied (2017-2020)

Variation source		Phrenological Stage (Days)			Morphological characteristics
	df	SF	50%F	100%F	PH (cm)
Vicia narbonensis L.					
Total	89	787.2	804.2	830.5	377.2
Ecotype	9	71.39*	21.12*	15.60*	12.55*
Year	2	10463*	11232*	11644.7*	4946.5*
Ecotype* Year	18	46.59*	10.12*	15.03*	16.33*
Overall mean		52.5	61.90	68.13	34.66
Standard deviation		16.17	16.37	16.58	11.43
Variation coefficient (%)		30.80	26.44	24.33	33.00
Vicia sativa L.					
Total	17	1482.7	1491.1	1482.7	1006.8
Ecotype	1	2.00*****	3.50*	2.00*	1.10*
Year	2	3678.5*	3708.5*	3678.5*	2474.1*****
Ecotype* Year	2	3.50*	3.50*	3.50*	1.67*
Overall mean		57.17	67.67	73.83	39.97
Standard deviation		20.97	20.98	21	17.4
Variation coefficient (%)		36.68	31.00	28.44	45.82

*: Significant at 5%; df: degree of freedom, SF: start flowering; 50%F: 50% flowering; 100%F: Full flowering; PH: plant height

Due to the favourable climatic conditions during the winter months of the 2017-2018 growing season, Vicia narbonensis L. and Vicia sativa L. ecotypes maintained their growth during the winter months, and they completed their vegetation periods and reached their flowering periods earlier in the growing season. Our results are similar to those reported by Mahdipour-Afa et al. (2021) on the possibility of introducing guar as a grain legume with various trials of pharmaceutical and cosmetic applications in the semi-arid climate of Tehran.

The days to reach the three phenological stages in the 2017-2018 growing season were significantly fewer than in the other two seasons. This is probably because the amount of precipitation during the winter months and in March was higher than during the 2019-2020 or 2018-2019 growing seasons (Table 2). Due to the favourable climatic conditions during the winter months of the 2017-2018 growing season, Vicia narbonensis L. and Vicia sativa L. ecotypes maintained their growth during the winter months, and they completed their vegetation periods and reached their flowering periods earlier in the growing season. Our results are similar to those reported by Mahdipour-Afa et al. (2021) on the possibility of introducing guar as a grain legume with various trials of pharmaceutical and cosmetic applications in the semi-arid climate of Tehran.

Table 3. Phenological stages observed in the studied ecotypes (2017-2020)

Ecotype	Flowering start (Days)				Flowering 50% (Days)				Flowering 100% (Days)			
	2017-2018	2018-2019	2019-2020	Means	2017-2018	2018-2019	2019-2020	Means	2017-2018	2018-2019	2019-2020	Means
Vicia narbonensis L.												
N-2380	33.00^{B}	57.00^{I}	50.00^{I}	46.67	40.00^{A}	70.00^{J}	68.00^{H}	59.33	46.00^{A}	78.00^{I}	78.00^{D}	67.33
N-2383	33.00^{B}	72.00^{E}	57.00^{C}	54.00	40.00^{A}	76.00^{G}	69.00^{G}	61.67	46.00^{A}	81.00^{F}	79.00^{C}	68.67
N-2390	33.00^{B}	77.00^{B}	58.00^{B}	56.00	40.00^{A}	80.00^{C}	71.00^{E}	63.67	46.00^{A}	85.00^{C}	76.00^{F}	69.00
N-2392	33.00^{B}	69.00^{G}	65.00^{A}	55.67	40.00^{A}	79.00^{D}	75.00^{C}	64.67	46.00^{A}	83.00^{E}	83.00^{B}	70.67
N-2393	32.00^{C}	72.00^{E}	55.00^{E}	53.00	40.00^{A}	78.00^{E}	69.00^{G}	62.33	45.00^{B}	84.00^{D}	74.00^{G}	67.67
N-2461	31.00^{D}	73.00^{D}	58.00^{B}	54.00	39.00^{B}	75.00^{H}	71.00^{E}	61.67	44.00^{C}	80.00^{G}	77.00^{E}	67.00
N-2464	33.00^{B}	64.00^{H}	52.00^{G}	49.67	40.00^{A}	74.00^{I}	67.00^{I}	60.33	46.00^{A}	81.00^{F}	74.00^{G}	67.00
N-2466	32.00^{C}	71.00^{F}	54.00^{F}	52.33	39.00^{B}	75.00^{H}	69.00^{G}	61.00	45.00^{B}	79.00^{H}	76.00^{F}	66.67
N-2468	33.00^{B}	74.00^{C}	51.00^{H}	52.67	40.00^{A}	77.00^{F}	70.00^{F}	62.33	46.00^{A}	86.00^{B}	77.00^{E}	69.67
N-2561	34.00^{A}	69.00^{G}	50.00^{I}	51.00	40.00^{A}	72.00^{I}	72.00^{D}	62.00	45.00^{B}	79.00	79.00^{C}	67.67
Means	32.70	69.80	55.00	52.50	39.80	75.80	70.10	61.90	45.50	81.60H	77.30	68.13
Vicia sativa L.												
S-174	32.00^{C}	82.00^{A}	56.00^{D}	56.67	39.00^{B}	85.00^{B}	78.00^{A}	67.33	45.00^{B}	92.00^{A}	85.00^{A}	74.00
S-BBA	33.00^{B}	82.00^{A}	58.00^{B}	57.67	40.00^{A}	87.00^{A}	77.00^{B}	68.00	46.00^{A}	92.00^{A}	83.00^{B}	73.67
Means	32.50	82.00	57.00	57.17	39.50	86.00	77.50	67.67	45.50	92.00	84.00	73.83

$^{A, B, C, D, E, F, G, H, I, J:}$ Groups of means according to Fisher's test (LSD) at the 5% significant level

According to the average of the three years, for Vicia narbonensis L., the earliest period at the start of flowering is recorded by ecotype N-2380 while the latest is recorded by ecotype N-2390. Ecotype N-2380 is also the earliest to reach 50% flowering, while the latest is ecotype N-2392. The latter has the longest period to reach 100% flowering, while ecotype N-2466 has the shortest period. The two ecotypes of Vicia sativa L. are late for the same phenological stages compared with the ecotypes of Vicia narbonensis L. (Table 3).

Among annual fodder legume species, early flowering ecotypes are of great importance, as they not only give more time to fill their pods before the onset of hot, dry weather, but also allow sufficient time for the crops that follow (Sayar and Han, 2014). Getnet et al (2003) reported that species such as Vicia narbonensis and Vicia sativa mature relatively earlier than other vetches. Mebarkia et al. (2010) find that an average of 64.0 to 79.0 and 76.0 to 92.0 days is required to reach onset of flowering and full flowering in Vicia narbonensis L.; respectively. Yılmaz (2008) reports that 114 to 126 days are required to reach 50% flowering in Vicia narbonensis L..

The cause of the differences between previous studies and our results of days to reach onset of flowering, 50% flowering and 100% flowering may be the differences between the ecological environments in which the experiments were conducted as well as the use of different ecotypes. Variation in the phenology of vetch species and their accessions has a significant effect on forage and grain yield productivity (Gezahagn et al., 2013). According to Richards (1991), crop phenology is the most important factor influencing yield and adaptation, especially where growth factors are limited.

The semi-arid region of Sétif is characterised by two major phenomena: spring frost and drought at the end of the cycle. Early ecotypes should be the best, provided that spring frosts do not coincide with flowering. Nevertheless, flowering behaviour in Arabidopsis is opportunistic to maximise growth rather than as protection against frost damage (Kinmonth-Schultz et al., 2023). These results have implications for future population success, as climate change may modify the relationship between daylength and temperature.

Morphological Characteristics

The ANOVA indicates significant differences between ecotypes, years and their interaction for plant height (Table 2). The significance of the ecotype*year interaction indicates that the ranking of the vetch ecotypes in terms of plant height is significantly affected by the change of year. In our study, the ranking of means according to the Fisher LSD test at 5% shows that Vicia sativa L. has the highest mean values; 37.72 and 38.22 cm compared with Vicia narbonensis L.; 33.24 to 36.48 cm (Table 4).

Table 4. Average height of vetch ecotypes studied (2017-2020)

Ecotype	Plant height (cm)			
	2017-2018	2018-2019	2019-2020	Mean
Vicia narbonensis L.				
N-2380	41.72^{B}	18.89^{H}	43.78^{H}	34.80
N-2383	34.89^{I}	21.67^{A}	43.33^{I}	33.30
N-2390	36.56^{H}	20.44^{D}	45.00^{F}	34.00
N-2392	39.28^{E}	19.33^{G}	41.11^{K}	33.24
N-2393	39.11^{E}	19.33^{G}	48.33^{C}	35.59
N-2461	41.39^{C}	19.55^{F}	44.66^{G}	35.20
N-2464	40.56^{D}	21.11^{B}	47.78^{D}	36.48
N-2466	40.67^{D}	20.22^{E}	41.89^{J}	34.26
N-2468	34.17^{J}	20.78^{C}	45.67^{E}	33.54
N-2561	43.11^{A}	20.44^{D}	45.00^{F}	36.18
Mean	39.15	20.18	44.66	34.66
Vicia sativa L.				
S-174	37.72^{G}	16.89^{J}	58.56^{A}	37.72
S-BBA	38.21^{F}	18.44^{I}	58.00^{B}	38.22
Mean	37.97	17.67	58.28	37.97

$^{A, B, C, D, E, F, G, H, I, J}$: Groups of means according to Fisher's test (LSD) at the 5% significant level

The highest plant height is recorded during the 2019-2020 growing season; 44.66 cm in Vicia narbonensis L. and 58.28 cm in Vicia sativa L.; and the lowest during the 2018-2019 growing season (20.18 cm and 17.67); respectively (Table 4; Figure 1). In Vicia narbonensis L., the highest plant height is obtained for ecotype N-2393 (48.33 cm), and the lowest for ecotype N-2380 (18.89 cm); while for Vicia sativa L.; ecotype S-174 has the

highest height during the 2019-2020 growing season (58.56 cm and the lowest during the 2018-2019 growing season (16.89 cm) (Table 4; Figure 1).

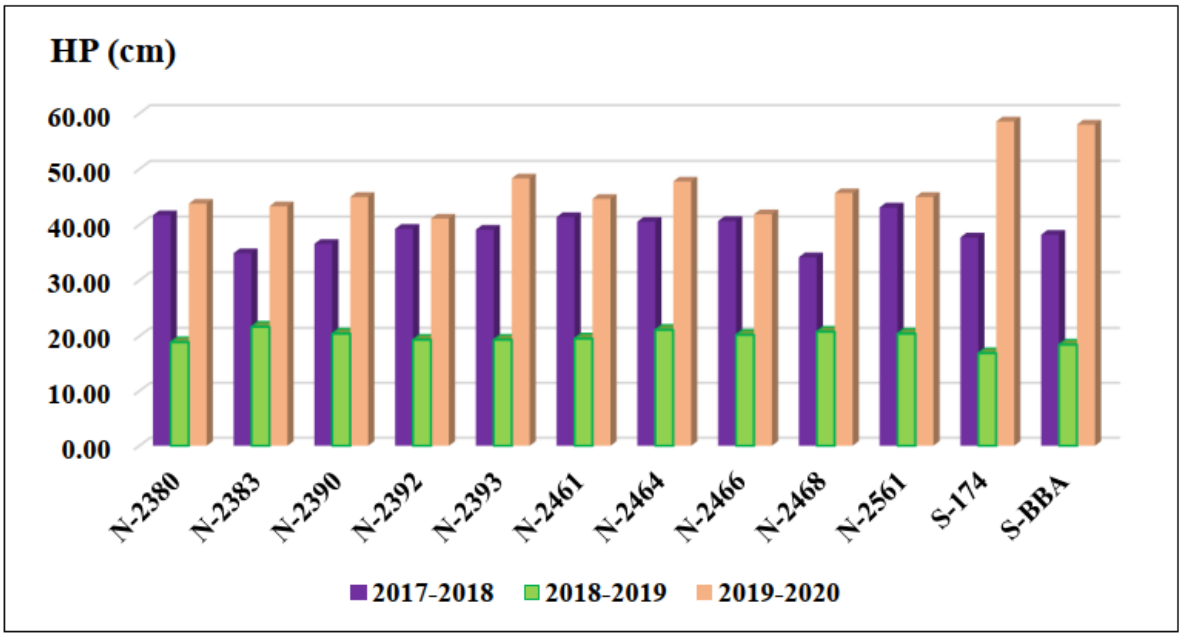

Figure 1. Heights of vetches studied (2017-2020)

Our results are lower in comparison with previous reports on Vicia sativa plant height reported by Gezahagn et al. (2013) (57.7-131.1 cm). These same authors find that plant height in Vicia narbonensis L. varies from 38.5 to 60.7 cm; which is consistent with the results of our study. Büyükburç and İptas (2001) report that plant height is a genotypic characteristic of Narbonne vetch, this characteristic is strongly affected by spring rainfall; i.e. in a year with a relatively high amount of spring rainfall, plant height is also relatively higher. Siddique et al. (1999) consider that plant height is the least stable characteristic, although it is the variable that best expresses the differences between the ecotypes studied.

Conclusion

Our findings indicate that the characteristics of the tested ecotypes are significantly affected by interannual variations, and that these ecotypes are not consistent in the measured parameters from one year to the next. Over the three-year average for *Vicia narbonensis* L., ecotype N-2380 exhibits the earliest flowering onset, while ecotype N-2390 shows the latest. ANOVA reveals significant differences among ecotypes, years, and their interactions concerning plant height. Ultimately, early-flowering ecotypes are favored in semi-arid regions, as long as spring frosts do not coincide with their flowering period. This early flowering allows them to avoid late-cycle droughts, providing more time for pod filling.

Recommendations

Early ecotypes are preferred in semi-arid regions, provided that spring frosts do not coincide with flowering. In other words, because they flower early, they can escape the drought at the end of the cycle and thus have more time to fill their pods.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM Journal belongs to the authors.

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