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A COMPARATIVE STUDY ON NARBON VETCH AND COMMON VETCH IN THE SEMI-ARID REGION OF SETIF (ALGERIA)

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Abstract: Algeria has a limited supply of fodder. Traditional methods of raising livestock rely on the exploitation of low-quality rangelands, fallow and natural pastures with forage crops receiving little attention. The population relies on imports to meet its protein needs. Indeed, fodder production is the primary lever for improving livestock nutrition and, as a result, the productivity of the livestock systems in question. It is also crucial to the sustainability of mixed systems that combine plant and animal production. The current study was conducted to evaluate the phenological stages, analyze the performances of fodder yield, grain yield and some of its components and determine the chemical composition of the species *Vicia narbonensis* L. in comparison with *Vicia sativa* L. in order to improve the fallow year in the cereal/fallow rotation and develop the marginal lands. Trials were conducted on the plots of FERHAT Abbas University Campus under the rainfed conditions in the semi-arid region of Setif during three growing seasons (2017–2020), using 10 ecotypes of narbon vetch and 2 ecotypes of common vetch (as control ecotypes) in a randomized complete block design with three replicates. Significant effects of the ecotype, the year and the ecotype x year interaction were found, as well as a great variability in the phenological stages, agronomic characteristics and chemical composition of the ecotypes studied. A significant positive relationship ($p<0.05$) was found between grain yield and dry matter yield and a significant negative relationship ($p<0.05$) was found between full flowering date and dry matter yield and grain yield. It seems that the early flowering ecotypes produce better yields than the late flowering ones in the semi-arid region of Setif.

Key words: fallow, chemical composition, livestock, production system, rainfed conditions, semi-arid region, *Vicia narbonensis* L., *Vicia sativa* L., yields.

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Introduction

Livestock husbandry in Algeria has always had a traditional character, based primarily on nomadism and the exploitation of natural resources (Carter, 1975). These poor food resources are mainly made up of by-products (bran, straw, and stubble), grazing on spontaneous fallow crops and only occasionally growing vetches, oats, and barley (CIHEAM, 2006). The most significant limitation to the expansion of cattle husbandry is a limited availability of fodder (Bourbouze, 1999). This lack of fodder has a significant effect on animal productivity and leads to a significant increase in the importation of dairy and meat products. This is because fodder production and cultivation in Algeria remain, in many ways, a minor activity of agricultural holdings (Bekhouche, 2011).

At the national level, nearly 39.5 million hectares of land are dedicated to fodder production, divided into natural grasslands, fodder crops, stubble, pastures, rangeland, and fallow land (MADR, 2006). In 2017, more than half of the UAA was devoted to field crops, particularly cereals, with fallow land occupying more than a third of the national UAA (37.3%) (Bessaoud et al., 2019). The fallow-cereal-livestock production system is common (Nedjraoui, 2001), with the cereal/fallow system accounting for more than 80% of the total UAA (Bessaoud et al., 2019).

Cultivated fodder is usually located in the north of the country. They are predominantly composed of vetch and oats, whose hay is considered to be of poor quality (Abdelguerfi, 1987). The area under this crop accounts for around 70 to 80% of the total annual fodder consumed dry and varies from year to year, finally falling to less than 50% (Mebarkia and Abdelguerfi, 2007). The primary constraint to this weakness is its inability to adapt to all agro-ecological conditions in Algeria due to a lack of specific and varietal diversity (Açikgöz, 1982, 1988). In fact, only *Vicia sativa L.* and its Languedoc variety are grown in the various agro-ecological zones of Algeria (Açikgöz, 1982, 1988). Furthermore, this species is highly subject to abiotic stressors, pod cracking (Zulfiqar and Muhammad, 2006) and the lack of seed production (Mebarkia et al., 2003). Despite all efforts, Algerian fodder production remains considerably below the needs of cattle (Zeghida, 1987).

Many extremely interesting fodder species present throughout northeastern Algeria would have to be valorized (Issolah et al., 2001) in order to provide higher quality feed for livestock and improve soil fertility (Turk, 1997) and to be integrated into different production systems (Klein et al., 2014). Although they are of great importance, they have never taken their rightful place in Algeria.

Among all the species present in Algeria, fodder legumes alone account for 33 genera and 293 species (Issolah and Beloued, 2005). Annual forage legumes, such as those of the genus Vicia, are among the options to be considered for replacing fallow in cereal crop rotation (Issolah and Yahiaoui, 2008). Vetches (*Vicia sp.*) are common forage legumes in the rainfed, semi-arid agricultural systems of the

Mediterranean region (Turk, 1997). Vetches are more adaptable and promising as short-term fodder crop. One advantage of vetch is its versatility, which allows for a wide range of uses (Seyoum, 1994). Vetches may either be grazed as fresh forage (Haddad, 2006) or may be cut and conserved as silage or hay (Abdullah et al., 2010), which may be used as a protein supplement, while their grains are utilized as both protein and energy sources in the diets of ruminants and non-ruminants (Sadeghi et al., 2009) with less expensive costs compared to concentrates, particularly in developing countries (Seyoum, 1994). The contribution of vetch in crop-livestock production systems around the world is well recognized (Berhanu et al., 2003).

Within the genus Vicia, much attention has been given to narbon vetch (*Vicia narbonensis* L.), one of the species domesticated in the early centuries of agriculture (Bryant and Hughes, 2011). Furthermore, this species has been promoted in the eastern Mediterranean as a replacement for fallow in the traditional fallow-barley rotation (Maxted, 1995). Narbon vetch is a promising forage legume (Kroschel, 2001) that can grow without support (Bryant and Hughes, 2011) and is tolerant to drought and cold (Kroschel, 2001). It grows in winter (Davies et al., 1993) and does not lose its leaves after frost (El Moneim, 1989). Its high tolerance to pests and diseases is the key reason it is used in hot and dry areas instead of faba beans or common vetch (Mateo Box, 1961). *Vicia narbonensis* L. has a greater grain production potential as a livestock feed in non-tropical arid areas than common vetch (*Vicia sativa*), bitter vetch (*Vicia ervilia*), or woolly-pod vetch (*Vicia villosa* subspp. *dasycarpa*) (Larbi et al., 2010a). Its seeds have a high protein content (Abd-el Moneim, 1992), around 20–32%, (Eason et al., 1990; Thomson et al., 1990; Abd-el Moneim, 1992), which recommends it as a soybean substitute in animal rations (Larbi et al., 2010b; Huseyin, 2014; Renna et al., 2014). The species is also very important in crop rotation systems, either as pure stands or mixed with cereals to provide high quality livestock feed (Altınok, 2002; Altınok and Hakyemez, 2002; Iptaş and Karadağ, 2009; Nizam et al., 2011).

Besides, because of its high green biomass and its ability to fix a large amount of nitrogen into the soil, it is a valuable green manure crop (Özyazıcı and Manga, 2000; Avcıoğlu et al., 2009) in the modern trends such as sustainable agriculture and organic farming (Ćupina et al., 2004). Narbon vetch is also better than the other vetch species since it leaves enough time for planting second crops (Çakmakçi et al., 1999). Trials in Syria, Iraq, Cyprus, Turkey, France, and Australia have shown that *Vicia narbonensis* L. can produce high grain yields (1.5–5.1 t/ha) under dry Mediterranean winter rainfall conditions (250–550mm/annum) (Enneking and Maxted, 1995). Little work has been done on the species of the genus Vicia, particularly *Vicia narbonensis* L., in our country.

Therefore, the current study aimed to evaluate the phenological stages, analyze the performances of fodder yield, grain yield and some of its components and determine the chemical composition of two species of the genus Vicia, including *Vicia narbonensis* L., (narbon vetch, 10 ecotypes) and *Vicia sativa* L. (common vetch, 2 control ecotypes) under the semi-arid conditions of Setif during three growing seasons (2017–2020).

Material and Methods

The trials were conducted on the plots of FERHAT Abbas University Campus Setif (36°12' N; 5°21' E) under rainfed conditions in the semi-arid region of Setif. In this region, the climate is continental with strong annual and daily thermal amplitudes, and the altitude is 1025 m. The average annual rainfall is around 450 mm (Seltzer, 1947) and 373.8 mm for the period between 2006 and 2017 (ONM, 2017). The soils of the experimental site belong to the group of steppe soils (Perrier and Soyer, 1970). The physicochemical composition indicates, for all the plots, a clay loam texture, a lumpy structure, with a basic water pH (7.81), a total calcium content of 17.7% and an organic matter content varying from 2.0 to 3.0%.

The trial was conducted during three agricultural seasons (2017–2020). The climatic conditions of the three seasons are presented in Table 1 (ONM, 2020). The three agricultural campaigns are characterized by:

- The good distribution of rainfall P (mm), with larger quantities during the first growing season (469.05 mm), followed by the third one (384.56 mm) against only 321.20 mm in the second growing season;
- The maximum temperatures (MaxT °C) recorded were homogeneous during the three growing seasons, as well as the minimum temperatures (MinT °C).

Plant material: The experiment was carried on two species of the genus Vicia represented by 10 ecotypes of *Vicia narbonensis* L. from different origins and 2 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 2). The sowing was carried out from the same batch of seeds, on January 4th, 2018 for the first year, on December 22nd, 2019 for the second year and on December 23rd, 2020 for the third year. All the ecotypes were sown manually and separately in a randomized complete block design with 3 replicates in a plot having a cereal (durum wheat) as a previous crop. Each elementary plot had 4 rows 4 m long, spaced 30 cm apart. In each of these plots, 336 seeds/plot (70 seeds/m^2) of vetch were sown.

Various cultural practices were carried out on this trial. Deep plowing (25 cm) was carried out using a disc plow just after the first autumn rains (September and October) followed by two cross passes of cover crops to reduce weed infestation and get a good seedbed. During the three trial campaigns, the plots were weeded manually as needed throughout the growing season and no fertilizers were used. The harvest was carried out from May 30th to June 19th for the first year; from June 11th to July 2nd for the second year and from June 17th to 28th for the third year.

Table 1. Climatic conditions in the semi-arid region of Setif.

	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Total	Mean
2006–2017													
P (mm)	33.74	30.27	31.95	27.88	39.68	43.26	41.68	52.42	27.19	33.01	12.72	373.80	
Max T°C	28.16	23.57	16.19	11.77	11.31	11.37	14.67	19.21	24.09	30.05	34.48		20.44
Min T°C	15.70	11.89	7.143	3.09	2.91	2.44	4.78	8.36	12.4	18.26	22.21		9.93
Mean T°C	21.39	17.20	11.23	7.118	6.64	6.69	9.54	13.65	18.15	23.85	28.27		14.88
2017–2018													
P (mm)	41.00	10.70	55.70	33.50	13.90	23.20	90.20	81.30	51.90	65.00	2.65	469.05	
Max T°C	28.30	22.26	14.80	9.38	11.81	9.60	13.46	17.72	21.33	27.10	35.40		19.15
Min T°C	13.50	9.63	3.60	1.19	1.05	0.60	4.20	4.70	9.47	20.00	17.30		7.72
Mean T°C	20.90	15.95	9.20	5.28	6.43	4.40	8.83	11.21	15.4	24.20	31.60		13.87
2018–2019													
P (mm)	25.00	63.70	25.70	10.80	77.10	15.10	24.00	43.80	12.40	10.90	12.70	321.20	
Max T°C	28.40	19.4	14.50	12.9	7.74	11.12	15.17	18.21	16.40	33.6	35.50		19.31
Min T°C	16.00	9.60	4.60	1.64	-0.50	-0.06	3.35	6.30	9.40	17.21	27.20		8.59
Mean T°C	22.20	14.5	9.55	7.27	3.62	5.53	9.26	12.26	12.9	28.5	31.70		14.19
2019–2020													
P (mm)	75.00	25.80	90.20	21.40	12.80	10.00	51.56	66.00	6.60	21.40	3.80	384.56	
Max T°C	27.90	22.10	12.40	12.80	11.10	16.80	14.80	19.30	26.60	29.60	33.80		20.58
Min T°C	15.40	10.30	4.20	3.70	0.30	1.90	4.30	8.00	11.80	14.50	24.60		8.95
Mean T°C	21.65	16.20	8.30	8.25	5.70	9.35	9.10	13.65	19.20	22.05	29.20		14.77

Observations and measurements: The phenological stages observed were: the date of the beginning of flowering (BF), evaluated by the number of days from the date of emergence to the appearance of the first inflorescence (Berrekia, 1985); the date of 50% flowering (50%F) and the date of full flowering (100%F), evaluated by the number of days from the date of emergence to the appearance of the maximum number of flowers. The morphological parameter was: plant height (PH), measured in centimeters from the base to the end of the main stem at the time of full flowering. At harvest, three randomly selected plants from each plot were dug up and separated to determine grain yield and its components. Agronomic parameters were as follows: dry matter yield (DMY), grain yield (GAY), hundred-seed weight (HSW), number of pods per plant (NP/P), pod length (P-Leng) and number of seeds per pod (NS/P). Dry matter yield (DMY) was determined when 100% flowering was observed. Green matter was taken from each plot and weighed as soon as possible without losing weight. The dry matter yield was calculated after drying a fresh sample of 200 g of green matter in an oven at 80° C for 48 hours. Finally, grain samples of all vetch ecotypes produced during the growing season 2019–2020 were analyzed for dry matter (DM) content, ash, crude protein (CP) content and crude fiber (CF) according to the AOAC procedures (1990).

Table 2. Origins of the ecotypes of *Vicia narbonensis* L. and *Vicia sativa* L. studied.

Species	Ecotypes	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 (Setif)
	12	S-BBA	Algeria (BBA)

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

Results and Discussion

For each species (*Vicia narbonensis* L. and *Vicia sativa* L.), the analysis of variance indicates significant effects of ecotype, year and ecotype x year interaction ($p< 0.05$), highlighting the great diversity in phenological evolution and productions for the different measured parameters (Table 3). The year effect was significant ($p<0.05$) for all the phenological variables analyzed. This indicates that the characteristics of the ecotypes of *Vicia narbonensis* L. and *Vicia sativa* L. tested in the semi-arid region of Setif were strongly affected by interannual variations.

Table 3. Variances of the measured parameters of the 12 vetch ecotypes over the three years (2017–2020).

Source of variation	Phenological stages (days)				
	DF	BF	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	10463.7*	11232.9*	11664.7*	4946.5*
Ecotype*year	18	46.59*	10.12*	15.03*	16.33*
Overall average		52.50	61.90	68.13	34.66
SD		16.17	16.37	16.58	11.43
CV (%)		30.8	26.44	24.33	33.00
	Vicia sativa L.				
Total	17	1482.7	1491.1	1482.7	1006.8
Ecotype	1	2.00*	0.50*	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 average		57.17	67.67	73.83	37.97
SD		20.97	20.98	21.00	17.40
CV (%)		36.68	31.00	28.44	45.82

Source of variation	Production (kg/ha)			Yield components		
	DMY (kg/ha)	GAY (kg/ha)	HSW (g)	P-Leng (cm)	NP/P	NS/P
	Vicia narbonensis L.					
Total	1825740	3021589	12.8	9.5	26.9	6.7
Ecotype	157395*	192427*	8.29*	0.33*	1.79*	0.46*
Year	21781607*	35458888*	28.4*	127.5*	315.7*	88.43*
Ecotype*year	145654*	205704*	3.34*	0.28*	2.75*	0.28*
Overall average	1353.62	1271.22	23.0	4.85	5.43	3.41
SD	811.85	1058.29	2.52	1.79	3.13	1.52
CV (%)	60.00	83.24	10.95	36.90	57.644	44.60
	Vicia sativa L.					
Total	3278234	3956633	0.26	9.4	153.7	8.2
Ecotype	873842*	9113*	0.10*	0.19*	55.72*	0.02*
Year	7415429*	9552692*	0.01*	22.51*	343.2*	19.59*
Ecotype*year	113520*	3327*	0.04*	0.45*	6.09*	0.02*
Overall average	1603.89	1249.39	6.86	4.98	11.57	4.62
SD	1001.01	1103.74	0.41	1.68	6.81	1.59
CV (%)	62.40	88.34	5.98	33.73	58.86	34.41

*Significant at 5%; DF: Degree of freedom; SD: Standard deviation; CV: Coefficient of variation. The significance level is 5%.

Vicia narbonensis L. was very early for the beginning of flowering, 50% flowering and full flowering, at 31 to 77 days, 39 to 80 days and 44 to 86 days, respectively. *Vicia sativa* L. was the latest at 32 to 82 days, 39 to 87 days and 45 to 92 days, respectively (Table 4). A significant ecotype × year interaction ($p<0.05$) indicates that the ecotypes were not stable for the parameters measured from one year to another. In terms of plant height between the two species, *Vicia sativa* L. presented the highest average values of 37.72 and 38.22 cm compared to *Vicia narbonensis* L. with 33.24 and 36.48 cm (Table 5).

Table 4. Phenological phases of vetch ecotypes in the three-year period.

Ecotype	Beginning of flowering % (days)			
	2017–18	2018–19	2019–20	Mean
		Vicia narbonensis L.		
N-2380	33.00^{B}	57.00^{I}	50.00^{I}	46.67
N-2383	33.00^{B}	72.00^{E}	57.00^{C}	54.00
N-2390	33.00^{B}	77.00^{B}	58.00^{B}	56.00
N-2392	33.00^{B}	69.00^{G}	65.00^{A}	55.67
N-2393	32.00^{c}	72.00^{E}	55.00^{E}	53.00
N-2461	31.00^{D}	73.00^{D}	58.00^{B}	54.00
N-2464	33.00^{B}	64.00^{H}	52.00^{G}	49.67
N-2466	32.00^{C}	71.00^{F}	54.00^{F}	52.33
N-2468	33.00^{B}	74.00^{C}	51.00^{H}	52.67
N-2561	34.00^{A}	69.00^{G}	50.00^{I}	51.00
Mean	32.70	69.80	55.00	52.50
		Vicia sativa L.		
S-174	32.00^{C}	82.00^{A}	56.00^{D}	56.67
S-BBA	33.00^{B}	82.00^{A}	58.00^{B}	57.67
Mean	32.50	82.00	57.00	57.17
Ecotype	50% flowering (days)			
	2017–18	2018–19	2019–20	Mean
		Vicia narbonensis L.		
N-2380	40.00^{A}	70.00^{J}	68.00^{H}	59.33
N-2383	40.00^{A}	76.00^{G}	69.00^{G}	61.67
N-2390	40.00^{A}	80.00^{C}	71.00^{E}	63.67
N-2392	40.00^{A}	79.00^{D}	75.00^{C}	64.67
N-2393	40.00^{A}	78.00^{E}	69.00^{G}	62.33
N-2461	39.00^{B}	75.00^{H}	71.00^{E}	61.67
N-2464	40.00^{A}	74.00^{I}	67.00^{I}	60.33
N-2466	39.00^{B}	75.00^{H}	69.00^{G}	61.00
N-2468	40.00^{A}	77.00^{F}	70.00^{F}	62.33
N-2561	40.00^{A}	74.00^{I}	72.00^{D}	62.00
Mean	39.80	75.80	70.10	61.90
		Vicia sativa L.		
S-174	39.00^{B}	85.00^{B}	78.00^{A}	67.33
S-BBA	40.00^{A}	87.00^{A}	77.00^{B}	68.00
Mean	39.50	86.00	77.50	67.67

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

Continuation of Table 4. Phenological phases of vetch ecotypes in the three-year period.

Ecotype	100% flowering (days)			
	2017–18	2018–19	2019–20	Mean
		Vicia narbonensis L.		
N-2380	46.00^{A}	78.00^{I}	78.00^{D}	67.33
N-2383	46.00^{A}	81.00^{f}	79.00^{C}	68.67
N-2390	46.00^{A}	85.00^{c}	76.00^{F}	69.00
N-2392	46.00^{A}	83.00^{E}	83.00^{B}	70.67
N-2393	45.00^{B}	84.00^{D}	74.00^{G}	67.67
N-2461	44.00^{C}	80.00^{G}	77.00^{E}	67.00
N-2464	46.00^{A}	81.00^{F}	74.00^{G}	67.00
N-2466	45.00^{B}	79.00^{H}	76.00^{F}	66.67
N-2468	46.00^{A}	86.00^{B}	77.00^{E}	69.67
N-2561	45.00^{B}	79.00^{H}	79.00^{C}	67.67
Mean	45.50	81.60	77.30	68.13
		Vicia sativa L.		
S-174	45.00^{B}	92.00^{A}	85.00^{A}	74.00
S-BBA	46.00^{A}	92.00^{A}	83.00^{B}	73.67
Mean	45.50	92.00	84.00	73.83

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

This great variability observed in the characters measured for the two vetches studied makes it possible to select the appropriate species for the enhancement of fallow land according to climatic conditions and production systems for the semi-arid region of Setif.

For dry matter yield and grain production, the analysis of variance shows highly significant differences between species and within the same species (Table 3).

The best dry matter yield were recorded for the *Vicia sativa* L. species with average values of 1604 kg/ha against 1355 kg/ha for *Vicia narbonensis* L. During the 2017–2018 growing season, the highest dry matter yield was recorded in *Vicia sativa* L. with 2406 kg/ha and 2271 kg/ha in *Vicia narbonensis* L. On the other hand, the lowest yields were obtained during the 2018–2019 growing season, with 335 kg/ha and 587 kg/ha, respectively (Table 5).

For grain yield, *Vicia narbonensis* L. was more efficient with 1271 kg/ha, followed by *V. sativa* L. with 1249 kg/ha (Table 5). It should be noted that the semi-arid region of Setif is characterized by very low temperatures, below 4°C, which most often harmonizes with the flowering of field crops (Baldy, 1974). These low temperatures affect the fertility of the vetches by reducing the number of flowers and thus the grain yield. Ridge and Pye (1985) estimated that 68% of the variation in pea yield was due to extreme temperatures at the flowering stage in the Australian Mediterranean climate.

Table 5. Plant height, dry matter yield and grain yield in vetch ecotypes.

Ecotype	Plant height (cm)			
	2017–18	2018–19	2019–20	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}	19.55F	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
Ecotype	Dry matter yield (kg/ha)			
	2017–18	2018–19	2019–20	Mean
	Vicia narbonensis L.			
N-2380	2410^{C}	546^{G}	1037^{G}	1331
N-2383	1783^{H}	754^{A}	1212^{F}	1250
N-2390	2239^{E}	588^{E}	1188^{F}	1338
N-2392	2597^{B}	519^{H}	1458^{D}	1525
N-2393	2261^{E}	621^{C}	925^{I}	1269
N-2461	1986^{G}	581^{F}	1459^{D}	1342
N-2464	2717^{A}	502^{I}	1647^{C}	1622
N-2466	2329^{D}	514^{H}	1003^{H}	1282
N-2468	2055^{F}	631^{B}	854^{J}	1180
N-2561	2330^{D}	609^{D}	1253^{E}	1397
Mean	2271	587	1204	1355
	Vicia sativa L.			
S-174	2075^{F}	269^{K}	1807^{B}	1384
S-BBA	2736^{A}	401^{J}	2335^{A}	1824
Mean	2406	335	2071	1604

$^{A, AB, B, C, D, DE, E, F, G, H, I, J, K}$ The groups of means according to the Fisher's test (LSD) at the 5% level.

Continuation of Table 5. Plant height, dry matter yield and grain yield in vetch ecotypes.

Ecotype	Grain yield (kg/ha)			
	2017–18	2018–19	2019–20	Mean
	Vicia narbonensis L.			
N-2380	2679^{D}	273^{D}	1014^{F}	1322
N-2383	2746^{C}	447^{A}	824^{H}	1339
N-2390	2850^{A}	298^{C}	1010^{F}	1386
N-2392	2267^{G}	303^{C}	1268^{C}	1279
N-2393	2345^{F}	210^{G}	1089^{E}	1215
N-2461	2317^{F}	250^{F}	1301^{B}	1289
N-2464	2591^{E}	253^{F}	1393^{A}	1412
N-2466	2809^{AB}	265^{E}	1128^{D}	1401
N-2468	2246^{G}	338^{B}	815^{H}	1133
N-2561	1508^{H}	194^{H}	1104DE	935
Mean	2436	283	1095	1271
	Vicia sativa L.			
S-174	2581^{E}	134^{J}	965^{G}	1226
S-BBA	2676^{D}	172^{I}	967^{G}	1272
Mean	2629	153	966	1249

$^{A, AB, B, C, D, DE, E, F, G, H, I, J, K}$ The groups of means according to the Fisher's test (LSD) at the 5% level.

Table 6. Hundred-seed weight and number of pods per plant in vetch ecotypes.

Ecotype	Hundred-seed weight (g)				Number of pods/plant			
	2017–18	2018–19	2019–20	Mean	2017–18	2018–19	2019–20	Mean
	Vicia narbonensis L.				*Vicia narbonensis* L.			
N-2380	23.67^{A}	23.00^{D}	25.27^{A}	23.98	9.00^{E}	2.11^{F}	5.00^{G}	5.37
N-2383	22.67^{C}	26.47^{A}	23.87^{G}	24.34	7.33^{G}	1.22^{J}	5.33^{F}	4.63
N-2390	22.67^{C}	24.83^{B}	24.20^{D}	23.90	10.33^{C}	2.22^{E}	5.00^{G}	5.85
N-2392	22.00^{E}	21.80^{F}	24.00^{EF}	22.60	7.33^{G}	1.78^{H}	7.00^{C}	5.37
N-2393	23.00^{B}	22.56^{E}	24.03^{E}	23.20	8.67^{F}	1.45^{I}	5.67^{E}	5.26
N-2461	22.00^{E}	21.23^{G}	23.93^{EFG}	22.39	6.67^{H}	2.11^{F}	7.00^{C}	5.26
N-2464	22.67^{C}	24.10^{C}	25.10^{B}	23.96	9.00^{E}	2.56^{C}	7.00^{C}	6.19
N-2466	21.67^{F}	21.73^{F}	24.33^{C}	22.58	10.00^{D}	1.78^{H}	6.00^{D}	5.93
N-2468	22.33^{D}	21.11^{GH}	22.63^{H}	22.02	8.67^{F}	2.00^{G}	5.00^{G}	5.22
N-2561	19.67^{G}	21.03^{H}	23.90F^{G}	21.53	7.33^{G}	2.66^{B}	5.67^{E}	5.22
Mean	22.24	22.79	24.13	23.05	8.43	1.99	5.87	5.43
	Vicia sativa L.				*Vicia sativa* L.			
S-174	6.94^{H}	6.82^{I}	7.03^{I}	6.93	20.00^{A}	3.67^{A}	16.33^{A}	13.33
S-BBA	6.78^{I}	6.83^{I}	6.73^{J}	6.78	15.00^{B}	2.44^{D}	12.00^{B}	9.81
Mean	6.86	6.83	6.88	6.86	17.50	3.06	14.17	11.58

$^{A, B, C, D, E, EF, EFG, F, FG, G, GH, H, I, J}$ The groups of means according to the Fisher's test (LSD) at the 5% level.

The highest 100-seed weight was recorded in *Vicia narbonensis* L. during the three growing seasons, while the lowest was recorded in *Vicia sativa* L. (Table 6). The difference in 100-seed weight may be due to the inherent variation in seed size complemented by environmental conditions. This agronomic trait is important for determining the seeding rate of vetch species (Gezahagn et al., 2013).

The ecotypes of *Vicia sativa* L. had the highest number of pods/plant, pod length and number of seeds/pod over the three growing seasons compared to the ecotypes of *Vicia narbonensis* L. (Tables 6 and 7). The number of pods is generally considered to be one of the most important yield elements for many grain legumes (Mikić et al., 2013). The increase and decrease in the number of pods per plant were probably due to the distribution of rainfall during the vegetative stage. Büyükburç and İptas (2001) also reported that the amount of rainfall had more effect on the number of pods per plant.

Table 7. Pod length and number of seeds per pod in vetch ecotypes.

Ecotype	Pod length (cm)				Number of seeds/pod			
	2017–18	2018–19	2019–20	Mean	2017–18	2018–19	2019–20	Mean
	Vicia narbonensis L.				*Vicia narbonensis* L.			
N-2380	6.22^{B}	2.77^{C}	6.34^{E}	5.11	4.67^{C}	2.07^{C}	4.67^{B}	3.80
N-2383	5.71^{F}	1.71^{G}	6.11^{H}	4.51	4.00^{E}	1.00^{L}	4.67^{B}	3.22
N-2390	5.78^{D}	2.86^{B}	6.33^{E}	4.99	4.00^{E}	1.33^{G}	4.33^{C}	3.22
N-2392	5.44^{K}	2.44^{D}	6.64^{A}	4.84	4.00^{E}	1.37^{F}	4.67^{B}	3.35
N-2393	5.63^{I}	1.80^{F}	6.45^{C}	4.63	4.67^{C}	1.11^{K}	4.67^{B}	3.48
N-2461	5.40^{L}	2.47^{D}	6.34^{E}	4.74	4.33^{D}	1.18^{I}	4.67^{B}	3.39
N-2464	5.65^{H}	2.80^{C}	6.45^{C}	4.97	4.33^{D}	1.15^{J}	4.33^{C}	3.27
N-2466	5.49^{J}	2.24^{E}	6.50^{B}	4.74	4.00^{E}	1.29^{H}	4.00^{D}	3.10
N-2468	5.69^{G}	2.86^{B}	6.42^{D}	4.99	5.00^{B}	1.81^{E}	4.33^{C}	3.71
N-2561	5.75^{E}	3.09^{A}	6.14^{G}	4.99	4.00^{E}	2.00^{D}	4.67^{B}	3.56
Mean	5.68	2.50	6.37	4.85	4.30	1.43	4.50	3.41
	Vicia sativa L.				*Vicia sativa* L.			
S-174	6.31^{A}	3.05^{A}	5.89^{I}	5.08	5.67^{A}	2.63^{A}	5.67^{A}	4.66
S-BBA	5.89^{C}	2.43^{D}	6.31^{F}	4.88	5.67^{A}	2.44^{B}	5.67^{A}	4.59
Mean	6.10	2.74	6.10	4.98	5.67	2.54	5.67	4.63

$^{A, B, C, D, E, F, G, H, I, J, K, L}$ The groups of means according to the Fisher's test (LSD) at the 5% level.

Significant differences were observed in seed quality (Table 8). *Vicia sativa* L. produced the seeds with the highest contents of crude protein (41.06%), dry matter (89.69%), crude fiber (11.79%) and ash (3.37%) compared to *Vicia narbonensis* L. which produced 33.18%, 89.18%, 11.01% and 3.31%, respectively (Table 9). Thanks to the ability of fodder legumes to exploit atmospheric nitrogen via symbiosis with rhizobia at the level of their nodules, the crude protein content of *Vicia sativa* L. and *Vicia narbonensis* L. grains was high, suggesting that these species could be a complementary food source for animals in semi-arid areas. These two species, thanks to their richness in crude proteins, can be incorporated in the manufacture of concentrated feed intended for feeding ruminants. The trials conducted by Benyoussef (2019) and Kahlaoui et al. (2021) on adult sheep showed that soybean meal can be replaced by *Vicia narbonensis* L. in grains by 23% without negative effects on the performances.

Table 8. Analysis of variance of the chemical composition of *Vicia narbonensis* L. and *Vicia sativa* L.

Sources of variation	DF	Dry matter %	Ash (%DM)	Crude protein (%DM)	Crude fiber (%DM)
		Vicia narbonensis L.			
Total	29	0.208	0.116	3.757	10.749
Ecotype	9	0.18*	0.10*	3.67*	9.53*
Overall average		89.182	3.313	33.184	11.009
SD		0.278	0.204	1.096	1.949
CV (%)		0.312	6.163	3.303	17.706
		Vicia sativa L.			
Total	5	0.181	0.008	2.963	3.271
Ecotype	1	0.14*	0.003*	2.84*	0.09*
Overall average		89.693	3.370	41.062	11.788
SD		0.253	0.064	0.815	1.600
CV (%)		0.282	1.886	1.986	13.573

*Significant at 5%; SD: Standard deviation; CV: Coefficient of variation. The significance level is 5%.

Table 9. Mean values of the chemical composition of the grains of vetch ecotypes.

DF	Dry matter %	Ash (%DM)	Crude protein (%DM)	Crude fiber (%DM)
		Vicia narbonensis L.		
N-2380	89.11^{H}	3.70^{A}	30.89^{L}	10.97^{E}
N-2383	89.03^{I}	3.32^{F}	32.72^{J}	8.80^{I}
N-2390	89.16^{G}	3.28^{H}	33.73^{F}	9.78^{G}
N-2392	89.31^{E}	3.42^{C}	33.53^{G}	8.93^{H}
N-2393	89.30^{f}	3.31^{G}	34.30^{D}	9.79^{G}
N-2461	88.77^{K}	3.04^{L}	33.20^{H}	12.99^{B}
N-2464	88.89^{J}	3.18^{J}	31.92^{K}	13.05^{B}
N-2466	89.30^{f}	3.47^{B}	34.11^{E}	11.71^{D}
N-2468	89.59^{B}	3.25^{I}	34.36^{e}	10.34^{F}
N-2561	89.37^{D}	3.16^{K}	33.07^{I}	13.72^{A}
Mean	89.18	3.31	33.18	11.01
		Vicia sativa L.		
S-174	89.54^{e}	3.35^{E}	41.75^{A}	11.66^{D}
S-BBA	89.84^{A}	3.39^{D}	40.37^{B}	11.91^{C}
Mean	89.69	3.37	41.06	11.79

$^{A, B, C, D, E, F, G, H, I, J, K, L}$ The groups of means according to the Fisher's test (LSD) at the 5% level.

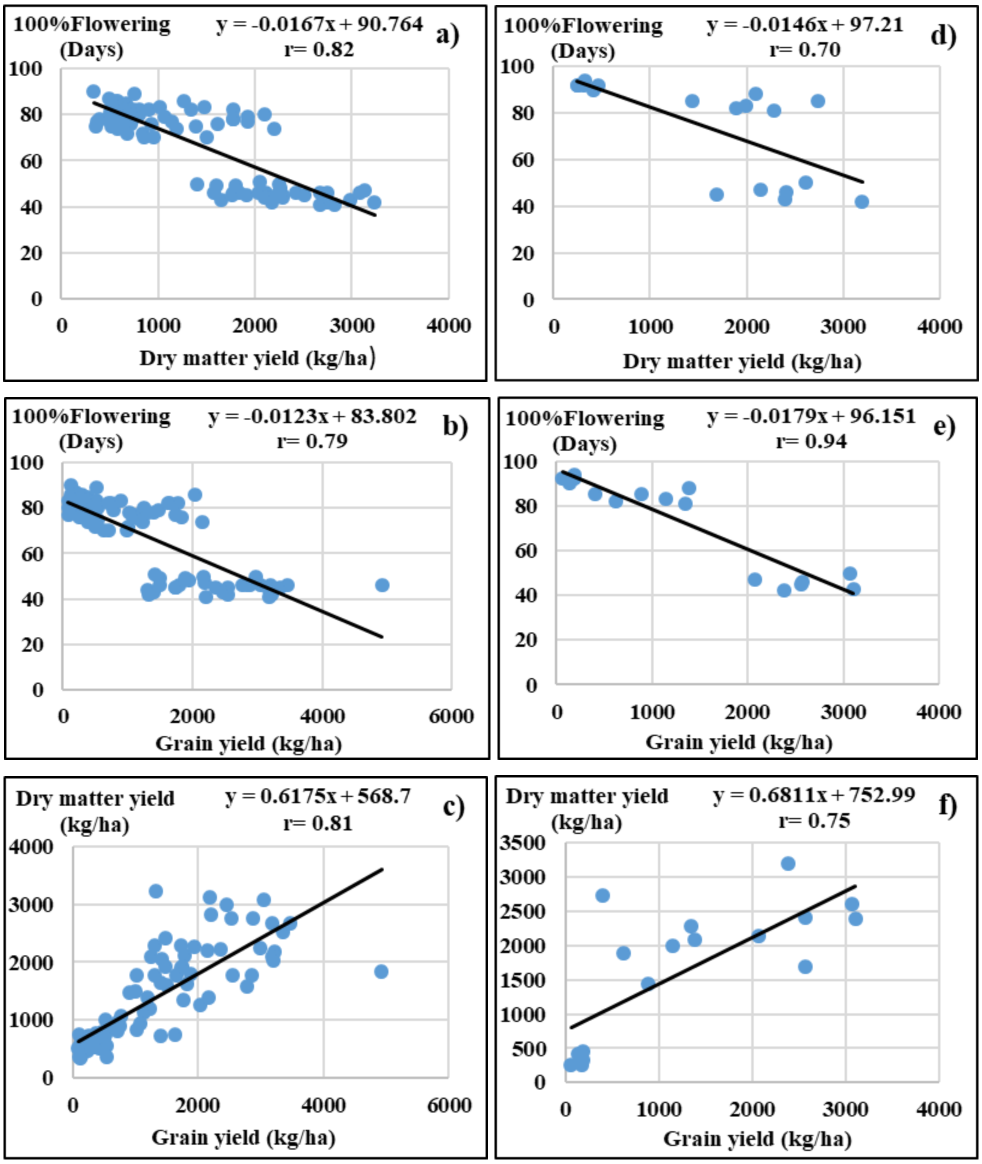

Figure 1. Relationships observed between a) dry matter yield and flowering date; b) grain yield and flowering date; c) grain yield and dry matter yield in *Vicia narbonensis* L. and between d) dry matter yield and flowering date; e) grain yield and flowering date; f) grain yield and dry matter yield in *Vicia sativa* L. over the three years of experimentation.

The study of the relationship between the date of flowering and the yields of dry matter and grains in the two species of vetch highlights some rather interesting information:

- A significant negative relationship ($p<0.05$) between dry matter yield and flowering date in the two species – *Vicia narbonensis* L. and *Vicia sativa* L. (Figure 1);

- Also a significant negative relationship ($p<0.05$) between grain yield and flowering date (Figure 1). It seems that the early ecotypes of the two species produced the best yields in dry matter and grain production. These ecotypes, which flower early, can escape from the drought at the end of the fodder legume cycle.

These negative relationships between grain and dry matter yields with the flowering stage suggest that the late ecotypes of these two species were strongly affected by heat and drought, unlike the early ecotypes.

- A significant positive relationship ($p<0.05$) between grain yield and dry matter yield in both species suggests that selection of ecotypes for dry matter resulted in good grain production (Figure 1).

This study emphasized the behavior of two species of the genus Vicia in altitude conditions characterized by water and thermal stress. The species *Vicia narbonensis* L. seems more cold tolerant than *Vicia sativa* L. The latter, characterized by its long and late flowering period, could allow it to escape the cold. These results corroborate those obtained by Keatinge et al. (1991) and Abd El Moneim (1992), who recommended the two species, *Vicia narbonensis* L. and *Vicia sativa* L., for semi-arid regions.

Conclusion

The results obtained in this study reveal that *Vicia narbonensis* L. has very interesting agronomic and qualitative characteristics. It has been shown to be more cold tolerant than *Vicia sativa* L.

It is possible to select the ecotype or ecotypes best suited to be included in the context of the fallow recovery land or in the development of marginal lands in semi-arid areas, depending on the climatic characteristics and the nutritional needs of the different production systems practicing a cereal/fallow rotation. This is due to the great variability of the parameters measured among the 10 ecotypes of *Vicia narbonensis* L., especially the different potential yields of dry matter and grains.

Compared to *Vicia sativa L.*, *Vicia narbonensis* L. is well adapted to seed production because it does not shatter at maturity so as not to soil the subsequent crop and has an erect habit allowing mechanical harvesting. Due to the high crude protein content in the grains, narbon vetch-based feeds can be utilized as an alternative source of protein instead of expensive and imported concentrates to meet the needs of national livestock.

It remains essential to evaluate and valorize this species and to encourage the production of seeds based on appropriate and adequate methodologies to alleviate the existing fodder shortage. The cultivation and production of *Vicia narbonensis* L. will probably be the key of the tomorrow's semi-arid agricultural system, making it profitable.

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UPOREDNO ISTRAŽIVANJE O NARBONSKOJ GRAHORICI I OBIČNOJ GRAHORICI U POLUSUŠNOM REGIONU SETIFA (ALŽIR)

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R e z i m e

Alžir ima ograničenu ponudu stočne hrane. Tradicionalne metode uzgoja stoke oslanjaju se na iskorišćavanje niskokvalitetnih pašnjaka, ugara i prirodnih pašnjaka, a krmnim kulturama se posvećuje malo pažnje. Stanovništvo se oslanja na uvoz da bi zadovoljilo svoje potrebe za proteinima. Zapravo, proizvodnja stočne hrane je primarna poluga za poboljšanje ishrane stoke i kao rezultat toga, produktivnost stočarskog sistema o kojima je reč. Takođe je ključno za dugoročnu održivost sistema kombinovane proizvodnje koji integrišu biljnu i životinjsku proizvodnju. Ova studija je sprovedena radi procene fenoloških faza, analize performansi prinosa stočne hrane, prinosa zrna i nekih njegovih komponenti, kao i određivanja hemijskog sastava vrste *Vicia narbonensis L.* u poređenju sa *Vicia sativa L.,* a sa ciljem poboljšanja ugarne godine u plodoredu žitarica/ugar i poboljšanja marginalnih zemljišta. Ispitivanja su sprovedena na parcelama Kampusa Univerziteta FERHAT Abbas u uslovima prirodnog vodnog režima u polusušnom regionu Setifa tokom tri vegetacione sezone (2017–2020), koristeći 10 ekotipova narbonske grahorice i 2 ekotipa obične grahorice (kontrola) u potpunom slučajnom blok dizajnu sa tri ponavljanja. Utvrđeni su značajni uticaji interakcije ekotipa, godine i interakcije između ekotipa i godine, kao i širok spektar varijabilnost u fenološkim fazama, agronomskim karakteristikama i hemijskom sastavu proučavanih ekotipova. Značajna pozitivna veza ($p<0,05$) utvrđena je između prinosa zrna i prinosa suve materije, a značajna negativna veza ($p<0,05$) između datuma punog cvetanja i prinosa suve materije i prinosa zrna. Čini se da ranostasni ekotipovi postižu bolje rezultate od kasnostasnih u polusušnom regionu Setifa.

Ključne reči: ugar, hemijski sastav, stočni fond, sistem proizvodnje, uslovi prirodnog vodnog režima, polusušni region, *Vicia narbonensis L.*, *Vicia sativa L.*, prinosi.

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