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Vicia narbonensis L.: Importance of Phosphorus Fertilization and Seeding Rate under Rainfall Conditions Setif High Plains Algeria

[1]A. Mebarkia, [2]K. Abbas and [3]A. Slimani
[1]Department of Earth Sciences, Institute of Architecture and Earth Sciences,
Ferhat Abbas University of Setif, Algeria
[2]INRAA, Setif Research Unit, Algeria
[3]Department of Agronomy, Faculty of Natural Sciences and Life, University of El Taref, Algeria

Abstract: We studied the dry matter yield, grain yield and yield components of ecotype 2388 of *Vicia narbonensis* L. using three seeding rates and three levels of phosphorus. The experiment was conducted during two crop years 2009/2010 and 2010/2011 in the Agricultural Technology Institute located in the semi arid region of Setif in Algeria. The experimental design adopted was a complete randomized block with three repetitions. Phosphorus levels used are 60, 80 and 120 kg ha^{-1} and seeding rates are 40, 60 and 80 seeds m^2. Analysis of variance indicates that the dry matter yield, grain yield and agronomic traits were significantly affected by the density and phosphorus levels. Using the rate of 120 kg ha^{-1} of phosphorus results in average yields very important of dry matter of about 45.61 qx ha^{-1}, grain yield of 15.60 qx ha^{-1} , plants highest of 60.84 cm and a length of pods best of 5.19 cm. Density of 80 m^2 grains has spawned better grain yields of 15.48 and 47.62 qx ha^{-1} of dry matter. However, the number of seeds per pod and weight of 100 seeds were affected differently. The low density of 40 seeds m^2 recorded the most important weight of 100 seeds of 16.46 g and a number of seeds per pod high of about 4.94. Significant positive correlations were observed between grain yield and plant height (r = 0.825) and dry matter yield (r = 0.715) and negatively correlated with the number of grains per pod (r = -0.654, $p<0.05$).

Key words: *Vicia narbonensis* L., dry matter, grain yield, phosphorus levels, plant density

INTRODUCTION

In Algeria, culture vetch is used in association with oats only for hay production and remains a major annual forages grown under rainfall conditions, The area reserved to this crop represents about 70 to 80% compared to the total annual forages consumed dry and fluctuate from one year to another and then decrease to more than 50% (Mebarkia and Abdelguerfi, 2007).

Despite all efforts to its improvement, yield quantity and quality remain very low and can not meet the growing needs of livestock.

The main factor limiting this weakness is in reality its inability to all agro-ecological conditions of Algeria by shortage of specific and varietal diversity. Indeed, one species of vetch it is *Vicia sativa* and variety Languedoc. In addition, this species is very sensitive to abiotic stress, pod shattering (Acikgoz, 1982; Acikgoz, 1988) no seed production and finally the lack of phosphoric fertilization (Mebarkia *et al*., 2003).

While the genus *Vicia* is very diverse with about 150 species worldwide (Gurmani *et al*., 2006). Among them, the species *Vicia narbonensis* is one of the most interesting in fact several studies conducted on its agronomic potential in arid and semi-arid indicate that it is more productive forage rich in proteins, its seeds are also rich in crude protein and essential elements and cold tolerant (Abd-El-Moneim *et al*., 1988; Durutan *et al*., 1990; Castleman, 1994; Yilmaz, 2008; Mebarkia *et al*., 2010). Also, it can be used effectively in rations food for ruminants and poultry. Studies on the effects of phosphorus fertilization and plant density on yield and its components are important for optimal performance. Indeed, legumes are very sensitive to phosphorus fertilization, especially in soils low in phosphorus (Turk *et al*., 2003a). It has been reported that legumes are very demanding phosphorus to increase biomass yield and yield components (Tawaha and Turk, 2001; Yemane and Skjelvag, 2003b).

Several studies on the effects of different seeding of legumes indicate highly significant differences on yield

Corresponding Author: A. Mebarkia, Department of Earth Sciences, Institute of Architecture and Earth Sciences, Ferhat Abbas University of Setif, Algeria

and its components (McEwen *et al*., 1988; Lopez-Bellido *et al*., 2000; Turk and Tawaha, 2002; Tawaha and Turk, 2002, 2004; Turk *et al*., 2003b; Ayaz *et al*., 2004b). To date, few studies have been conducted on the species *Vicia narbonensis* L. including the agronomically under rainfed conditions in the semi-arid region of Setif, which is a promising region for the cultivation of legumes. Also, the intraspecific genetic variation, especially regarding the effects of different levels of phosphorus fertilizer application and different seeding. The objective of this study is to investigate the effects of seeding rate and phosphorus application on yield and its components in different genotypes of the species *Vicia narbonensis* L. in semi-arid region of Setif.

MATERIALS AND METHODS

Climatic characteristics during the experiment: Tests were conducted at the Technical Institute of crops located in the semi-arid region of Setif during two crop years 2009/2010 and 2010/2011. In this region, the climate is continental with high thermal amplitudes, both annual daily; altitude is 1081 m. The soils of the experimental site belong to the group of steppe soils (Perrier and Soyer, 1970). Climatic conditions of two crop years of testing are shown in Table 1 (NOM, 2009).

The physicochemical composition indicates, for all plots, silty clay texture, a crumbly structure, pH alkaline water (8.1 to 8.5) and a high total calcium content of 33.50 at 35, 04% (Chenaffi, 1997; Belarbi, 1998). The organic matter content varies from 0.08 to 2.69% phosphorus content varies from 17.17 to 36.04 ppm and nitrogen content, 0.07%, is low (Belarbi, 1998).

Conducting the experiment: Different tillage was performed on this test. Deep plowing (25 cm) was performed using a disc plow just after the first rains of autumn (September and October). Two passages crusaders covercrop aimed at reducing the weed infestation and get a good seed bed.

During the two test campaigns just before sowing, weeding chemical was applied with the herbicide terbutryn (active ingredient) at 1.5 L in 300 L of water per hectare. Sowing was made from the same seed lot, 1 December 2009/2010 to 15 December and for the year 2010/2011.

Planting was done manually in an experimental design completely blocks-randomized with 3 replicates per block in a plot with previous crop as grain (durum wheat).

Levels of phosphorus as P_2O_5 used are 60, 80 and 120 kg ha^{-1} and seeding rates are 40, 60 and 80 seeds m^{-2}. Each elementary plot consisted of 4 rows of 4 m length spaced 30 cm.

Plant material: Ecotype 2 388 was chosen as the most suitable and best performing to be tested in this study, among a number of ecotypes from ICARDA as part scientific exchanges.

Observed variables and their statistical processing: Half of the elementary plot was used to evaluate the production of green matter and agronomic characteristics.

We counted the number of seeds per pod (NSP) on 15 plants selected at random and measured the length of pods (LPO).

Notations focused also on the number of nodules per plant (NNO) on 15 plants collected at flowering stage 100%. Also, the heights of the plants collected (HP) were measured. Productions measured are the total production of green matter (PGM), dry matter (PDM) and grain yield (GRY).

The dry matter production was estimated from a sample of 200 g of green material placed in an oven at 105°C for 24 h. Grain yield was determined for each elementary plot of 1 m^2 from the product of the harvest to the threshing finally fixed and measured the weight of 100 seeds (WCS).

The data were processed using the software StatITCF, according to an analysis of variance based on a comparison of average Newmann and Keuls.

Table 1: Climatic conditions of the two campaigns of experimentation in Setif (NOM, 2009)

	Month											
Seasons	09	10	11	12	01	02	03	04	05	06	07	Total
2009/2010												
Minimum	15	10.4	6.7	4.3	5.2	6.0	8.9	12.4	17.3	24.4	19.5	
Maximum	25	20.8	17.1	12.5	12.5	13.2	22.0	28.2	19.2	24.4	34.2	
Rainfall (mm)	78.6	13.1	28.8	33.6	31.5	37.5	55.2	72.0	46.2	18.0	3.0	417.2
2010/2011												
Minimum	9.9	11.0	6.3	2.3	2.4	1.2	4.6	8.6	10.6	10.5	19.3	
Maximum	15.3	20.9	13.7	11.5	11.1	9.6	13.3	19.7	21.9	43.2	33.5	
Rainfall (mm)	3.4	45.2	47.8	20.0	13.3	121.0	33.0	73.8	33.8	17.4	6.0	414.7

Relationships between pairs of variables measured are described and analyzed by calculating phenotypic correlations based on averages genotype.

RESULTS

No significant difference was observed between years for all variables measured (p>0.05). Indeed, the cumulative rainfall recorded was almost equivalent to two crops (Table 1). In contrast, analysis of variance showed significant differences in the seeding and phosphorus levels for most variables except the number of grains per pod, the number of nodule per plant and weight of 100 grains (Table 2).

We observed a number of significant correlations between grain yield and other measured variables. Grain yield were positively correlated with plant height; yield of green fodder and dry matter and negatively with the number of grain per pod (Table 3).

Effects of phosphorus levels: The increase of phosphorus resulted in significant improvements yield and its components. Dhumale and Mishra (1979) showed that plant height contributes substantially and significantly in the green matter yield and dry matter. The analysis indicated a proportionality between the level of phosphorus and plant height. Best plant heights were recorded with high rates of p = 120 kg ha^{-1} against the lowest for low p = 60 kg ha^{-1} (Table 2). In other words the increase is about 16%. In addition, phosphoric fertilization significantly improved yields of green matter and dry matter and the highest yield was obtained with the highest P fertilization. Indeed, the high dose of phosphorus increased yields compared to the low dose of 8.6% phosphorus and 12% green and dry matter, respectively. An increase of approximately 17% was obtained for grain yield in a dose of 120 kg ha^{-1} of phosphorus compared at the dose of 60 kg ha^{-1} (Table 2). The number of seeds per pod, the length of the pod and the number of nodules per plant increased as the same dose of phosphorus = 120 kg ha^{-1} of 12, 8 and 7%, respectively. No significant effect of phosphoric fertilization was observed on the weight of 100 seeds. In contrast, low levels of phosphorus (60 kg ha^{-1}) recorded a weight of 100 seeds most important than the highest rate (120 kg ha^{-1}) of 4%.

Effects of plant densities: Regarding the plant densities, the analysis revealed no significant differences for the following variables: the number of seeds per pod and the number of nodules per plant. Otherwise when the density increases, these variables decrease (Table 2). In fact the best yield of forage, dry matter and grain were given the highest density (80 kg ha^{-1}) with 8, 19 and 18%

Table 2: Phosphoric fertilization effect, the seeding rate and year on the variables studied

	HP (cm)	PGM (qx ha^{-1})	PDM (qx ha^{-1})	GRY (qx ha^{-1})	WCS (g)	NSP	LPO (cm)	NNO
Densities (plants m^{-2})								
D1 (40)	49.17	138.38	38.36	12.77	16.46	4.94	5.05	46.28
D2 (60)	52.35	145.76	40.79	14.00	15.93	4.92	5.08	47.62
D3 (80)	54.29	151.29	47.62	15.48	15.65	4.81	4.67	45.94
F	**	*	**	**	**	ns	*	ns
Phosphorus (kg ha^{-1})								
P1 (60)	49.28	138.77	40.12	12.88	16.30	4.59	4.77	43.99
P2 (80)	51.69	144.75	41.04	14.00	16.15	4.86	4.84	47.73
P3 (120)	60.84	151.89	45.61	15.50	15.59	5.22	5.19	48.12
F	*	*	**	**	ns	*	*	*
Effect								
A1	51.77	145.09	42.39	13.88	16.10	4.84	4.93	46.80
A2	52.11	145.19	42.12	14.36	15.93	4.94	4.93	46.43
F	ns	ns	ns	ns	ns	ns	ns	ns

HP: Plant height at the stage of full flowering, PGM: Production green matter yield, PDM: Production dry matter yield, GRY: Grain yield, WCS: Weight of 100 seeds, NSP: No. of seeds per pod, LPO: Pod length, NNO: Nodule number per plant, *,**Significant at $p \leq 0.05$ et $p \leq 0.01$

Table 3: Simple correlation coefficients between the variables studied

	HP	PGM	PDM	GRY	WCS	NSP	LPO	NNO
HP	1.000							
PGM	0.920	1.000						
PDM	0.807	0.831	1.000					
GRY	0.825	0.834	0.715	1.000				
WCS	-0.034	0.079	-0.239	-0.089	1.000			
NSP	0.782	0.724	0.671	-0.654	0.018	1.000		
LPO	0.260	0.320	-0.007	0.072	0.325	0.444	1.000	
NNO	0.614	0.543	0.379	0.455	0.296	0.441	0.248	1.000

UP: Plant height at the stage of full flowering, MVT: Total green matter yield, MST: Total dry matter yield, RGA: Grain yield, PCG: Weight of 100 grains, NGG: No. of seeds per pod, LGO: Pod length, NOD: Nodule number per plant respectively compared with the lowest density (40 kg ha^{-1}). Plant height, weight of 100 seeds and pod length has also evolved in proportion to the seeding. In fact the best average values were obtained by the highest density and lowest were recorded by the low density. In other words, the dose of 80 kg ha^{-1} was increased by 19 and 18% at the dose of 40 kg ha^{-1} dry matter yield and grain respectively. Finally, the lowest density gave the best pod lengths of about 8% compared with the highest density.

DISCUSSION

In the semi-arid region of Setif which is characterized by cold spring usually coinciding with flowering legumes and especially vetch, earliness to flowering is a very important criterion. Mebarkia *et al.* (2010) show a negative regression between flowering and fertility.

Thomson *et al.* (1997) reported that early in flowering in *Vicia faba* resulted in a good growth vigor, rapid development and good dry matter production. Some studies, good fertilization phosphoric and a high density and a high density results in a reduction of a few days of flowering. In fact, Turk *et al.* (2003a) show that with a phosphorus content of 52.5 kg ha^{-1}, *Vicia narbonensis*, flowers 10 days earlier with the rate of 17.5 kg ha^{-1}.

Also, the increase of phosphorus fertilization has improved all variables except the measured weight of 100 seeds. It seems that the phosphoric fertilization reduces the weight of 100 seeds of most legumes. The same results were found by Yemane and Skjelvag (2003a) on peas and Yilmaz (2008) on *Vicia narbonensis*. Our study, phosphorus was significantly improved plant height, as reported in other studies on several legumes (Ghizaw *et al.*, 1999; Turk *et al.*, 2003a, b).

A significant positive correlation between dry matter yield and Seed yield seems to be common to several species of *Vicia*, including *Vicia narbonensis* (Berger *et al.*, 2002; Mebarkia and Abdelguerfi, 2007; Mebarkia *et al.*, 2010; Ghizaw *et al.*, 1999; Yemane and Skjelvag, 2003b).

In *Vicia narbonensis*, grain is considered the most important character, because of its richness in protein (Mebarkia *et al.*, 2010; Abd-El-Moneim, 1993) could be used in livestock rations. in this study, it emerges that the phosphoric fertilization improved grain yield, which is confirmed by Turk *et al.* (2003a), Yemane and Skjelvag (2003b), Berg Jr and Lynd (1985), French (1990) and Bolland *et al.* (2001). Also, phosphoric fertilization affected the pod length and number of seeds per pod. Similar observations Were reported by Turk *et al.* (2003a) and Yemane and Skjelvag (2003b). Singh (1976) studying various doses of phosphorus on the development of nodulation of *Trifolium* sp. found that doses higher the phosphorus tended to give a dry weight of roots and nodules than those obtained with low doses. Erman *et al.* (2009) studying the effect of doses of P_2O_5 ha^{-1}, showed that the dry weight of nodules increased with increasing doses of P2 O5. In our study, the number of nodules per plant is proportional to the rate of phosphorus (Sarkar and Mukherjee, 1991; Ankomah *et al.*, 1996) showed that fertilization phosphoric cheek a stimulatory role of nodulation. High densities are generally intended to increase the heights of plants in most legumes including *Vicia narbonensis* (Turk *et al.*, 2003a, b; Tawaha and Turk, 2004; Ghizaw *et al.*, 1999). Our results clearly indicate increased heights for high densities, due to the heightened competition of plants. Our results indicate that high densities significantly improve the performance green forage and dry matter, which in agreement with other studies carried out over several grain legumes (Ayaz *et al.*, 2004a, b). The grain yield was significantly increased by using high densities. Tawaha and Turk (2004) on pea, showed that grain yield was improved by more than 50% for a density of 90 plants m^2 in compared with a density of 30 plants m^2.

In *Vicia narbonensis*, Turk *et al.* (2003a) have achieved a gain of grain yield over 35% with a density of 80 plants m^2 than with a density of 40 plants m^2. In this study, it seems that high densities negatively affect the number of seeds per pod and weight of 100 seeds, like was the case in other legumes (Mebarkia and Abdelguerfi, 2007; Mebarkia *et al.*, 2010; Ayaz *et al.*, 2004b; Yilmaz, 2008). Significant positive correlations between grain yield with the height and forage yield explaining that vigorous plants produce better grain yield. Indeed, Buyukburc and Iptas (2001), suggest that the increase in plant height engender an improved grain yield. The significant negative relationship between grain yield and number of grains per pod, seems very common in legumes (Mebarkia and Abdelguerfi, 2007; Mebarkia *et al.*, 2010; Tosun *et al.*, 1991; Buyukburc and Iptas, 2001; Yilmaz, 2008).

In this study, we also observed the same correlation, which explains the presence of poorly developed seeds in pods.

CONCLUSION

The results show that the phosphoric fertilization and seeding rate in the species *Vicia narbonensis* L. significantly improve the yield and its components in semi-arid regions of Setif whose average annual rainfall does not exceed 350 mm. The best grain yield and dry matter were obtained by high seeding rates and the highest phosphorus in occurrence density of 80 seeds per m^2 and 120 kg ha^{-1} phosphorus.

The present study clearly indicates that the species *Vicia narbonensis* L. is very exacting in phosphorus, which deserves special attention to fertilize the soil and especially those who are deficient in this element. Also, it should think changing the seeding rate to be able get yields encouraging.

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