Effects of seeding rate and date and phosphorus application on growth and yield of narbon vetch (Vicia narbonensis)

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Original article

Effects of seeding rate and date and phosphorus application on growth and yield of narbon vetch (*Vicia narbonensis*)

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Abstract – Field experiments were conducted during the winter seasons of 1999-2000 and 2000-2001 in the semi-arid region in the north of Jordan, to study the effect on yield responses of narbon vetch (*Vicia narbonensis*) of the following: seeding dates (14 Jan., 28 Jan. and 12 Feb.), seeding rates (40, 60 and 80 plants$\cdot$m^{-2}), phosphorus levels (17.5, 35.0 and 52.5 kg$\cdot$P$\cdot$ha^{-1}) and two methods of P placement (placed with the seed while sowing 6 cm deep [banded] or spread over the soil surface and incorporated into the top 2 cm of soil before sowing [broadcast]). The seeding rate, seeding date and rate of phosphorus had a significant effect on most of the measured traits and the yield components. The method of phosphorus application had only a significant effect on seed yield, number of pods$\cdot$plant^{-1}, number of seeds$\cdot$pod^{-1}, number of primary branches$\cdot$plant^{-1}, 100 seed weight, pod length and seed weight$\cdot$plant^{-1}. In general, the results revealed that a combination of early seeding (14 Jan.), a high seeding rate (80-plant$\cdot$m^{-2}), and P application (52.5 kg$\cdot$P$\cdot$ha^{-1}) drilled with the seed after cultivation (banded) are promising for obtaining maximum yield of narbon vetch.

narbon vetch / seeding rate / seeding date / P rate / P placement

Résumé – Effet de la densité et de la date de semis, et de l'application de phosphore sur la croissance et le rendement de la vesce de Narbonne (*Vicia Narbonensis*). Des expériences aux champs ont été conduites pendant les saisons hivernales de 1999-2000 et 2000-2001 dans la région semi-aride du Nord de la Jordanie, pour étudier l'effet sur le rendement de la vesce de Narbonne (*Vicia Narbonensis*) des facteurs suivants : date de semis (14 janvier, 28 janvier et 12 février), densité de semis (40, 60 et 80 plantes$\cdot$m^{-2}), fertilisation phosphatée (17,5, 35,0 et 52,5 kg$\cdot$ha^{-1} P) et 2 méthodes de répartition du P (placé avec la semence au moment du semis à 6 cm de profondeur [en ligne] ou dispersé sur l'ensemble de la surface du sol et incorporée dans les 2 cm de la couche superficielle du sol avant le semis [à la volée]). La date et la densité de semis et la dose de P ont un effet significatif sur la majorité des caractéristiques mesurées et des composantes du rendement. La méthode d'application du P a seulement un effet significatif sur le rendement en graine, le nombre de gousses par plante, le nombre de graines par gousse, le nombre de branches primaires par plante, le poids de 100 grains, la longueur des gousses et le poids des grains par plante. En général, les résultats ont révélé que la combinaison d'un semis précoce (14 janvier), d'une densité de semis élevée (80 plantes$\cdot$m^{-2}) et d'une application de P (52,5 kg$\cdot$ha^{-1} P) déposée avec les semences (semis en ligne) est prometteuse pour l'obtention du maximum de rendement pour la vesce de narbonne.

vesce de Narbonne / densité de semis / date de semis / taux de phosphore / répartition du P

1. INTRODUCTION

To provide better quality feed for livestock in West Asia and North Africa, and to improve soil fertility, forage legumes need to be introduced to replace fallow in the region. Vetches (*Vicia* species) are common forage legumes in the rainfed, semi-arid agricultural systems of the Mediterranean region. Vetches, whether grown in monoculture or in mixtures with cereals, are used for high quality hay production, grazing after the beginning of the pod formation stage, or for grain and straw production [38]. Vetches produce poor yields on the alkaline soils common in northern Jordan [34]. For these soils in the region, we studied whether different agronomic practices could improve production of *Vicia narbonensis*, an ancient grain legume crop of the Mediterranean region. Previous studies with different legumes have shown that the time of sowing [1, 13, 32, 35, 36], seeding rates [17, 19, 20, 21, 34, 35, 37] or plant density [3, 4, 5, 6, 7, 24, 30, 31], and rates and methods of applying phosphorus fertilizer [16, 23, 39] can be significant. In addition, soil test phosphorus values are typically low for calcareous soils in the Mediterranean region [8, 11, 14]. Calcareous soils comprise most soils used for agriculture in northern Jordan for which there are limited or no published data for all these factors for *Vicia narbonensis*.

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We studied the effects of the sowing date, seeding rate and rate and method of fertilizer phosphorus application on the production of *Vicia narbonensis* on alkaline soils of northern Jordan, and the results are reported in this paper.

2. MATERIALS AND METHODS

The experiments were conducted from 1999 to 2001 in northern Jordan. The location has a Mediterranean climate with mild, rainy (300–350 mm) winters and dry, hot summers. The soils used were shallow, rocky, silty clays. As measured for samples of the top 10 cm of the < 2-mm fraction of soil collected before the experiments started, soil pH (1/1 soil-water suspensions [18]) was 8.1 and phosphorus extracted by 0.5 sodium bicarbonate at pH 8.5 [22] ranged from 2.3 to $6.0\ mg \cdot kg^{-1}$. In the date and rate of seeding experiments, phosphorus, as triple superphosphate (21% total P) was drilled 4 cm deep while sowing seed after cultivating the soil 6 cm deep. In both the seeding date and rate experiments and the phosphorus experiments, nitrogen fertilizer, as urea (46% total N) was applied uniformly by hand across all treatments, using [30 $kg \cdot N \cdot ha^{-1}$ at sowing and 40 $kg \cdot N \cdot ha^{-1}$ at the start of flowering. In all experiments, weeds were controlled by hand as needed.

2.1. Date and rate of seeding experiments

The experiments comprised a split-plot design with rates of seeding as the main treatments (40, 60 and 80 $plants \cdot m^{-2}$) and seeding dates (14 Jan., 28 Jan. and 12 Feb.) as sub-treatment. There were three replications. All plots consisted of four rows, 6 m long, with spacing of 30 cm between rows and 60 cm between plots. A seeding depth of 6.0 cm was used. The Julbaneh cultivar of *Vicia narbonensis* was used.

2.2. Rate and method of phosphorus application

These experiments comprised a split-plot design with rates of phosphorus as the main treatments (17.5, 35.0 and 52.5 $kg \cdot P \cdot ha^{-1}$) and placement methods (banding or broadcast) as sub-treatment. The triple superphosphate (21% total P) was either placed (drilled) with the seed sown 6 cm deep after the soil was cultivated (banded P) or the triple superphosphate was spread over the soil surface (broadcast) and incorporated with a rotary hoe into the top 2 cm of soil just before sowing seed 6 cm deep (broadcast). The plot size was the same as for the date and rate of seeding experiments. The seeding dates were 25 Jan. in 2000 and 23 Jan. in 2001. The seeding rate used was 60 $plants \cdot m^{-2}$ for the local cultivar Julbaneh of *Vicia narbonensis*.

2.3. Irrigation

To monitor soil moisture status, permanent tensiometers were inserted horizontally at 150 mm depth into one lysimeter for each treatment. The tensiometer data were recorded at 11 h and 16 h daily. The soil moisture content was calculated from the moisture release characteristics of the soil. To prevent moisture stress, soils were maintained between 70% and 90% of field capacity [25] by the application of 18 mm of irrigation water when tensiometers indicated that the moisture stress had reached 70% of field capacity. Irrigation ceased 10 days before harvest in 2000 and 9 days before harvest in 2001.

2.4. Measurements

The following were measured for each experiment: seed yield ($kg \cdot ha^{-1}$), seed $weight \cdot plant^{-1}$ (g), 100 seed weight (g), $pods \cdot plant^{-1}$, number of primary $branches \cdot plant^{-1}$, $seeds \cdot pod^{-1}$, pod length (cm), pod width (cm), plant height (cm) and days to flowering.

2.5. Statistical analysis

Data for each trait were analyzed for a randomized complete block design (RCBD) with split-plot arrangement according to Steel and Torrie [33]. Comparisons between means were made using least significant differences (LSD) at the 0.05 probability level.

3. RESULT AND DISCUSSION

Since the trend of results was similar in both years, only data from 2000-2001 are shown.

3.1. Seeding rate

Seed yields increased as the amount of seed sown increased (Tab. I). There was a trend for the following traits to decrease with seeding rate: seed $weight \cdot plants^{-1}$, 100 seed weight, number of primary $branches \cdot plant^{-1}$, $seeds \cdot pod^{-1}$, pod length and $pods \cdot plant^{-1}$; these traits were negatively related to seeding rate. Our results support the results of previous studies for the effect of seeding rate on seed $weights \cdot plant^{-1}$ [10, 15, 26, 27], height of plants [15] and increase in internode length [26], and reduction in branching [28]. The decrease in $pods \cdot plant^{-1}$ at the highest seeding rate (80 $plants \cdot m^{-2}$) was attributed to increased competition between plants for growth factors, which finally reduced the number of effective branches. The increase in seed yield with increasing seeding rate at sowing was due to more pods being produced as a result of more plants being established. The influence of seeding rate on seed yield was through the increased production of pods per unit area (Tab. I) and not through the increased production of pods per plant. Increased seeding rate reduced the number of days to flowering (Tab. II), with flowering occurring 9 days earlier at the high seeding rate (80 $plants \cdot m^{-2}$) than at the low seeding rate (40 $plants \cdot m^{-2}$), supporting the results of Al-Rifaee [2].

3.2. Seeding date

Seed yield of narbon vetch was influenced significantly by the date of sowing (Tab. I). The maximum seed yield of 1200 $kg \cdot ha^{-1}$ was obtained by sowing narbon vetch on 14 January. After 14 January, reductions in seed yields of 5.0–9.6% were obtained for each delay of 14 days. The reduction in seed yield is attributed to the shorter growth period and time available for the later-sown crops to mature. The delay in sowing date greatly reduced $seeds \cdot pod^{-1}$, pod length, 100 seed weight and seed $weight \cdot plant^{-1}$, and also decreased the days to flowering. Our results are in general agreement with those of Tawaha and Turk [39].

Table I. Yield and yield components of narbon vetch as affected by date and rate of seeding.

Treatments	Seed yield (kg·ha^{-1})	Seed weight·plant^{-1} (g)	100 seed weight (g)	Number of primary branches	Seeds·pod^{-1}	Pods·plants^{-1}
Seeding rates (plants·m^{-2})						
40	918.7	3.8	18.7	2.7	3.1	9.2
60	1081.0	3.2	17.3	1.5	2.5	6.7
80	1425.7	2.4	15.3	1.3	1.9	5.7
LSD ($P \leq 0.05$)	133.0	0.5	1.3	1.1	0.4	0.9
Date of seeding						
14 Jan.	1200.0	4.0	20.0	2.8	3.1	9.2
28 Jan.	1140.0	2.9	17.0	1.9	2.6	7.0
12 Feb.	1085.3	2.6	14.3	1.0	1.8	5.4
LSD ($P \leq 0.05$)	45.0	0.2	2.7	0.6	0.4	1.3
Interaction	NS	NS	NS0	NS	NS	NS

Table II. Phenological traits of narbon vetch as affected by date and rate of seeding.

Treatments	Plant height (cm)	Pod width (mm)	Pod length (cm)	Days to 50% flowering (day)
Seeding rates (plants·m^{-2})				
40	42.6	10.0	4.7	85.0
60	46.6	10.0	4.2	80.0
80	51.0	10.0	3.8	76.3
LSD ($P \leq 0.05$)	3.2	NS	0.3	3.0
Date of seeding				
14 Jan.	54.3	10.0	4.9	90.0
28 Jan.	47.3	10.0	4.3	80.7
12 Feb.	38.6	10.0	3.8	70.7
LSD ($P \leq 0.05$)	5.3	NS	0.4	5.0
Interaction	NS	NS	NS	NS

3.3. Phosphorus rate

Phosphorus levels significantly increased seed yields and yield components (Tabs. III and IV). Spencer and Chan [29] observed that an optimal supply of P in the early stage of plant growth is a vital factor for the full development of seeds. An adequate supply of P increased the carboxylation efficiency and stimulated the ribulose-1,5-diphosphate carboxylase activity, resulting in an increased photosynthetic rate [9]. P levels significantly influenced seed yield. Increase in seed yield due to P application is well documented by many authors [38, 39]. Days to flowering decreased significantly with P application compared with control (Tab. IV), supporting previous results of Keatinge et al. [12]. This is attributed to an increased rate of crop development from emergence to floral initiation, and anthesis resulting from application of P to the P-deficient soil.

3.4. Phosphorus placement methods

Seed yield, pods·plant^{-1}, seeds·pod^{-1}, number of primary branches·plant^{-1}, 100 seed weight, pod length and seed weight·plant^{-1} were significantly greater with band placement than with the broadcast method of phosphorus application. Pod width, plant height and days to flowering were not affected by P placement methods. For the soil used, seed yield of narbon vetch can be increased in soil with a moderate P status (10 mg Olsen soil test P·kg^{-1}·soil). The banded P treatment was probably more effective because the P was intercepted by plant roots growing into soil that was moist for longer during the growing season [39].

4. CONCLUSION

Narbon vetch yields were substantially increased by early sowing (14 Jan.), a high seeding rate (80-plant·m^{-2}), and by (52.5 kg·P·ha^{-1}) banded with the seed after cultivation. Our results should apply to similar soils and environments in West Asia and North Africa.

Table III. Yield and yield components of narbon vetch as affected by rates and methods of phosphorus application.

Treatments	Seed yield (kg·ha^{-1})	Seed weight·plant^{-1} (g)	100 seed weight (g)	Number of primary branches	Seeds·pod^{-1}	Pods·plants^{-1}
P rate (kg·ha^{-1})						
P1 (17.5)	959.0	2.6	16.0	1.6	2.8	6.5
P2 (35.0)	1131.0	3.5	19.0	3.2	3.3	8.0
P3 (52.5)	1475.0	4.2	19.0	3.3	3.4	11.0
LSD ($P \leq 0.05$)	150.0	0.6	2.2	1.3	0.4	1.4
P placement methods						
Band	1235.3	3.7	19.0	2.9	3.2	9.3
Broadcast	1141.3	3.1	17.0	2.5	2.8	7.6
LSD ($P \leq 0.05$)	88.0	0.5	2.0	0.4	0.4	1.4
Interaction	NS	NS	NS	NS	NS	NS

Table IV. Phenological traits of narbon vetch as affected by rates and methods of phosphorus application.

Treatments	Plant height (cm)	Pod width (mm)	Pod length (cm)	Days to 50% flowering (day)
P level				
P1 (17.5)	37.0	9.8	4.0	84.0
P2 (35.0)	42.0	10.0	6.0	80.0
P3 (52.5)	43.0	10.0	6.0	74.0
LSD ($P \leq 0.05$)	3.1	NS	1.3	3.0
P placement methods				
Band	41.3	10.0	6.3	79.3
Broadcast	40.0	9.9	4.3	79.3
LSD ($P \leq 0.05$)	NS	NS	1.2	NS
Interaction	NS	NS	NS	NS

REFERENCES

[1] Abdel-Rahman K.A., Shalaby E.M., Abdallah M.M., Seed yield and quality of lentil as affected by different seeding dates and irrigation frequency, Field Crop Abstr. 33 (1980) 10338.

[2] Al-Rifaee M.K., Effect of seed size and plant population density on yield and yield components of local faba bean, M.Sc. Thesis, Jordan University of Science and Technology, Irbid, Jordan, 1999.

[3] Bianchi A.A., Results of three years of experimental trials on the cultural techniques of the horse bean for seeding (Vicia faba minor Beck). 2. Plant densities and distance between the rows, Rev. Agron. 3 (1979) 201–206.

[4] Bonari E., Macchia M., Effect of plant density on yields and yields components of (Vicia faba L. minor) Beck, Rev. Agron. 9 (1975) 416–423.

[5] Caballero R., The effects of plant population and row width on seed yields and yield components of field beans, Res. Dev. Agric. 4 (1987) 147–150.

[6] Christensen S.P.L., Various seed rates and row spacing for yield beans and inter-row cultivation in field bean, Tidsskr. Planteavl 78 (1974) 379–388.

[7] Comarovschi G., Effect of sowing method on yield of bean, Field Crops Abstr. 32 (1974) 944.

[8] Cooper P.G.M., Crop management in rainfed agriculture with special reference to water use efficiency, in: Proceedings of the 17th Colloquium of the International potash Institute, Rabat, Morocco, 1983, pp. 19–35.

[9] Jacob J.E., Lawlor D.W., Dependence of photosynthesis of sunflower and maize leaves on phosphate supply, ribulose-1,5-bisphoshate carboxylase/oxygenase activity and ribulose 1,5-bisphoshate-pool size, Plant Physiol. 98 (1992) 801–807.

[10] Kambal A.E., Components of yield in field beans (*Vicia faba* L.), J. Agric. Sci. 72 (1969) 359–363.

[11] Kassam A.H., Climate, soil and land resources in Northern Africa and West Asia, Plant and Soil 58 (1981) 1–29.

[12] Keatinge J.D.H., Neate P.J.H., Shepherd K.D., The role of fertilizer management in the development and expression of crop drought stress in cereals under Mediterranean environmental condition, Exp. Agric. 21 (1985) 209–222.

[13] Krarup H.A., The effect of sowing dates and rates on lentil yield components, LENS 11 (1984) 18–20.

[14] Harmsen K., Dry land barley production in Northwest Syria. I. Soil conditions", in: Proceedings of the Soils Directorate/ICARDA Workshop fertilizer use in the dry areas, 1984, pp. 12–41.

[15] Hodgson G.L., Blackman G.E., An analysis of the influence of plant density of the growth of Vicia faba. I. The influence of density on the pattern of development, J. Exp. Bot. 7 (1956) 147–165.

[16] Loutit A., Stall Wood P., Cox W.J., Drilled versus top dressed superphosphate for cereal production, J. West. Aust. Dep. Agric. 9 (1968) 418–421.

[17] Martin I., Tenoria J.L., Ayerbe L., Yield growth and water use of conventional and semi leafless peas in semiarid environments, Crop Sci. 34 (1994) 1576–1583.

[18] Mc-Lean E.O., Soil pH and Lime Requirement, in: Page Miller A.L., Keeny D.R., Methods of Soil Analysis. Part II (2nd ed.), 1982, pp. 59–69.

[19] McEwen J., Yeoman D.P., Moffitt R., Effect of seed rates, sowing dates and methods of sowing on autumn-sown field beans (*Vicia faba* L.), J. Agric. Sci. 110 (1988) 345–352.

[20] Murray G.A., Slinkard A.E., Austrian winters peas planting dates and rates, Idaho Agric. Exp. Sta. Inf. Series 112, 1969.

[21] Noffsinger L.S., Santen E., Yield and yield components of spring-sown white lupin in the south-eastern USA, Agron. J. 87 (1995) 493–497.

[22] Olsen S.R., Cole C.V., Watunable F.S., Dean L.A., Estimation of available phosphorus in soil by extraction with sodium bicarbonate, US Dep. Of Agric. Circ. (1954) 393.

[23] Ozanne P.G., Howes K.M.W., Peatch A., The comparative phosphate requirements of for annual pastures and two crops, Aust. J. Agric. Res. 27 (1976) 479–488.

[24] Rebillard J., Leliever F., Effect of population density and structure on the seed yield of field bean (*Vicia faba* var. minor), Compte Rendu des Séances de l'Académie d'Agriculture de France 66 (1980) 757–770.

[25] Rowarth J.S., Chapman H.M., Novis P., Rolston M.P., Water stress and seed yield in perennial ryegrass grown in pots, J. Appl. Seed Prod. 15 (1997) 89–92.

[26] Salih F.A., A review of the effect of seed rate and plant population, FABIS 7 (1981) 32.

[27] Salih F.A., Effect of nitrogen application and plant population per hill on faba bean (*Vicia faba* L.) yield, FABIS 17 (1987) 27–30.

[28] Singh S.P., Singh N.P., Panilety R.K., Performance of faba bean varieties at different plant densities, FABIS 30 (1992) 29–31.

[29] Spencer K., Chan C.K., Critical phosphorus levels in sunflower plants, Aust. J. Exp. Agric. Anim. Husb. 21 (1991) 91–97.

[30] Sprent J.I., Bradfort A.M., Norton C., Seasonal growth patterens in field beans as affected by population density shading and its relationship with soil moisture, J. Agric. Sci. 88 (1977) 293–301.

[31] Slinkard A.E., Lentil seeding rate studies in Saskatchewan, LENS 3 (1976) 32–33.

[32] Slinkard A.E., Drew B.N., Lentil production in westeran Canada, Extension Division, University of Saskatchewan, Saskattoon, Sask. Publ. 413, 1980, p. 3.

[33] Steel R.G.D., Torrie J.H., Principles and Procedures of Statistics, Mc Graw-Hill Book Company, 1980.

[34] Tawaha A.M., Turk M.A., Effect of date and rate of sowing on yield and yield components of narbon vetch under semi-arid condition, Acta Agron. Hung. 49 (2001) 103–105.

[35] Tawaha A.M., Turk M.A., Crop-weed competition studies in faba bean (*Vicia faba* L.) under rainfed conditions, Acta Agron. Hung. 49 (2001) 299–303.

[36] Thompson R., Taylor H., Yield components and cultivar, sowing date and density in field bean (Vicia faba), Ann. Appl. Biol. 86 (1977) 313–330.

[37] Turk M.A., Effect of sowing rate and irrigation on dry biomass and grain yield of bitter vetch and narbon vetch, Indian J. Agric. Sci. 69 (1999) 438–443.

[38] Turk M.A., Comparison between common vetch and barley to phosphorus fertilizer application, Legume Res. 20 (1997) 141–147.

[39] Turk M.A., Tawaha A.M., Common vetch productivity as influenced by rate and method of phosphate placement in Mediterranean environment, Agric. Mediterr. 131 (2001) 108–111.