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Impact of seeding rate, seeding date, rate and method of phosphorus application in faba bean (*Vicia faba* L. *minor*) in the absence of moisture stress

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Field experiments were conducted during the winter seasons of 1998–1999, 1999–2000 and 2000–2001 at the semi-arid region in north of Jordan, to study the effect of seeding dates (14 January, 28 January and 12 February), seeding rates (50, 75 and 100 plants m^{-2}), phosphorus levels (0, 17.5, 35.0 and 52.5 kg P ha^{-1}) and two methods of P placement (banding and broadcast). Seeding rate, seeding date, and rate of phosphorus had a significant effect on most of the measured traits and the yield determinates. Method of phosphorus application had only a significant effect on seed yield and seed weight per plant. In general high yields were obtained by early seeding (14 January), high seeding rate (100-plant m^{-2}), and Papplication (52.5 kg P ha^{-1}) drilled with the seed after cultivation (banded).
Keywords. *Vicia faba*, faba bean, sowing rates, sowing date, phosphate fertilizers, placement, application methods, application rates, Mediterranean zone, Jordan.

Impact de la densité du semis, de la date du semis, du niveau de fumure phosphatée et de son mode d'application sur la culture de féverole (Vicia faba L. minor) en absence de stress hydrique. Des expériences en champ ont été menées durant les saisons d'hiver 1998–1999, 1999–2000 et 2000–2001, dans une région semi-aride du Nord de la Jordanie, afin d'étudier les effets sur la culture de féverole des dates de semis (14 Jan., 28 Jan. et 12 Fév.), des densités de semis (50, 75 et 100 plants m^{-2}), du niveau de fumure phosphatée (0, 17,5, 35,0 et 52,5 kg P ha^{-1}) et du mode d'application de cette dernière (en bande ou en plein champ). La densité de semis, la date du semis et le niveau de fumure phosphatée ont eu un effet significatif sur la plupart des caractéristiques mesurées ainsi que sur le rendement. Le mode d'application de l'engrais phosphaté n'a de répercussion significative que sur le rendement en semences et le poids de semences par plant. En général de hauts rendements ont été obtenus pour les semis précoces (14 Jan.), à haute densité de semis (100 plants m^{-2}) et bénéficiant d'un apport élevé d'engrais phosphaté (52,5 kg P ha^{-1}) appliqué en bande au moment du semis.
Mots-clés. *Vicia faba*, féve, densité du semis, date du semis, engrais phosphaté, épandage localisé, méthode d'application, dose d'application, zone méditerranéenne, Jordanie.

1. INTRODUCTION

Faba bean (*Vicia faba* L.) is the fourth most important pulse crop in the world. It occupies the greatest area planted to legume crops in the Arab countries (Amin, 1988).

In the early years of agriculture in Jordan cereal cropping in rotation with legume was the dominant farming system. Hence the wheat/faba bean cropping system is the major system in rainfed and irrigated agriculture in Jordan. Faba bean is a valuable food legume rich in proteins and carbohydrate (Karamanos *et al.*, 1994). In Jordan faba bean is primarily consumed as fresh pods and secondarily used for dry seed production. It is grown as a winter crop under both rainfed and irrigated conditions, mainly in the Jordan valley. During 1995 the total production of dry seeds of faba bean under rainfed conditions averaged 700 tons, cultivated on area of 800 ha (Ministry of Agriculture, 1995). In general, the total production of faba bean in Jordan is low and far below the country's needs. The average seed yield in Jordan was 0.93 tons ha^{-1} during the period 1990–1995 (Ministry of Agriculture, 1995). As a result, high quantities of seed were imported. In 1992, approximately 8600 tons were imported which cost the country 3.32 million US$ (AOAD, 1993). Nevertheless, Dantuma and Thompson (1983) indicated that carefully husbanded crops of faba bean could yield more than 6 tons ha^{-1} of dry seed and provide satisfactory profits for the grower. The low yield obtained locally may be attributed to several factors, including low and erratic rainfall, the planting of traditional low-yielding cultivars and poor cultural practices, such as bad management of faba bean production (Tawaha, Turk, 2001b). A numbers of studies, from inside and outside Jordan, have reported on the optimum seeding dates for legumes. In Jordan, higher yields were obtained by seeding the legumes in early January as compared to late seeding in February (Tawaha, Turk, 2001b). In Egypt, higher yields were recorded in lentil cultivar Giza 9 seeded on 31 October than on 15 November or 1 December (Abdel-Rahman *et al.*, 1980). Krarup (1984) from Chile reported higher yields from legumes sown from mid-August to mid-September than from later sowings. In Saskatchewan, Slinkard and Drew (1980) reported higher yields when legumes were seeded in early May compared to late May or early June seeding. In general, early sowing resulted in seed yield increases and there was a frequency for seed yield to decrease with delay of sowing.

Earlier studies have shown that seeding rate or planting density is an important factor affecting yield of grain legumes. Therefore, yield response of seed legumes to seeding rates were discussed by several workers, and different relative values between hay and seed yield with seeding rate were found (Murray, Slinkard, 1969; McEwen *et al.*, 1988; Martin *et al.*, 1994; Noffsinger, Santen, 1995; Tawaha, Turk, 2001). Results that describe yield response to plant population alteration in different cultivation systems are highly variable. The best faba bean yield was obtained at a plant density of 25 plants m^{-2} in Romania (Comarovschi, 1974) and France (Rebillard, Lelièvre, 1980), whereas Christensen (1974) in Denmark and Bonari and Macchia (1975), and Bianchi (1979) in Italy, obtained the highest yields at 40 and 85 plants m^{-2}, respectively. In Spain, Caballero (1987) found that increasing plant population from 10 to 50 plants m^{-2} increased seed yield from 4.59 to 5.23 tons ha^{-1}.

Leguminous crops require an adequate supply of readily available nutrients for optimum growth and yield. Legume crops can be quite responsive to P fertilization, particularly, where soils are low in available P. Soil analyses have shown that phosphate deficiency is widespread in the calcareous soils, which comprise over half of the total cultivated area of the Mediterranean region (Kassam, 1981). Field trials conducted on these soils have demonstrated large and economic response to phosphate fertilizers (Cooper, 1983; Harmsen, 1984).

The method, quantity and time of application of phosphate should be taken into account to obtain profitable results in crop growth. In Australia, phosphate is applied to the surface of the soil, although there have been few studies on the relative effectiveness of this method for crop and pasture species (Ozanne *et al.*, 1976). The advantage of drilling superphosphate compared with broadcasting has been reported by Loutit *et al.* (1968) for cereal crops. However, the information on legume crops is very limited. Currently, most farmers who use phosphate on legume crops broadcast and incorporate the fertilizer prior to seeding. However, several authors (Rudd, Barrow, 1973; Jarvis, Bolland, 1991; Turk, Tawaha, 2001) have demonstrated that the method of placement could affect positively the phosphate recovery and yield obtained.

The effect of rate and method of P application on plant growth of cereal crops has been investigated for many soils and environment but information pertaining to calcareous soils in the Mediterranean region for legume forage crops is still very scarce, despite the fact that these soils occupy a high proportion of the cultivated areas. The main objectives of this study were to develop management recommendations for producing faba bean planted in a Mediterranean type conditions. Field experiments were conducted on date of seeding, rate of seeding, and rate and methods of phosphorus placement. The results of these experiments are summarized in this paper.

2. MATERIALS AND METHODS

The local cultivar cv *Minor*, which has been obtained from local market, was used in all studies conducted in north of Jordan in the semi arid village of Houfa (32° 34´N latitude, 36° 01´ E longitude, and 520 m altitude) from 1998 to 2001. The overall climatic conditions of the site are typical Mediterranean weather with average monthly temperatures ranging from 3 °C in January to 34 °C in August. The long-term annual precipitation average for the site is 350 mm. Annual precipitation for the 1998–1999, 1999–2000 and 2000–2001 growing seasons were 184.8, 342.0 and 270 mm, respectively. The soils where faba beans are grown are uniform through all the locations [rocky and shallow, and silty clay with a pH of 8.1 and available phosphorus ranged from 2.3 to 6.0 mg·Kg^{-1} extractable P (Olsen *et al.*, 1954)]. Phosphorus was supplied in the form of Triple superphosphate (21% P). The phosphate fertilizer was drilled with the seed after cultivation. Nitrogen fertilizer was applied uniformly by hand across all treatments [20 kg N ha^{-1} at sowing in form of Urea (46% N) and 40 kg N ha^{-1} top-dressed at start flowering]. Weeds were controlled by hand as needed.

2.1. Date and rate of seeding

The test was conducted in split-plot design with rates of seeding as main treatments (50, 75 and 100 plants m^{-2}) and seeding dates (14 January, 28 January and 12 February) as sub treatment. The treatments were replicated three times. All plots consisted of four rows, 6 m long with spacing of 30 cm between rows and 60 cm between plots. Aseeding depth of 6.0 cm was used.

2.2. Rate and method of phosphorus application

This test was conducted in split-plot design with rates of phosphorus as main treatments (0, 17.5, 35.0 and 52.5 kg P ha^{-1}) and placement methods (banding or broadcast) as sub treatment. Either the phosphate fertilizer was drilled with the seed after cultivation (banded) or broadcast and rotovated into the surface layer just before sowing (broadcast). The plot size was the same as the date and rate of seeding test. The seeding dates were 28 January in 1999, 26 January in 2000 and 28 January in 2001. The seeding rate used was 50 plants m^{-2} for the local cultivar cv *Minor*.

2.3. Irrigation

To monitor soil moisture status, permanent tensiometers were inserted horizontally at 150-mm depth into one lysimeter from each treatment. The tensiometers were read 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 (Rowarth *et al.*, 1997) by the application of 18 mm of irrigation water when tensiometers indicated that the moisture stress had reached 70% of field capacity. Irrigation ceased before, 15, 26, and 15 days before harvest in 1999, 2000 and 2001 respectively.

2.4. Measured variables

The following measurements were taken from each sub plot: seed yield (kg·ha^{-1}) was obtained by threshing the plants from the harvested (3 m^2) area; clean seeds were weighed, and the average seed yield ha^{-1} was calculated. Seed weight $plant^{-1}$ (g) was obtained from ten random plants. One hundred seed weight (g) was determined by mixing the whole sample; thereafter 100 seeds were randomly counted and weighted. Pods $plant^{-1}$ and number of primary branches $plant^{-1}$ were determined from ten random plants while number of seeds pod^{-1}, pod length and width (cm) were determined from ten random pods. For pod length and width, we used a standard ruler at the edges and centers of pods. Plant height (cm) was measured at 100% flowering from the soil surface to the top of plant apical, using a standard ruler. Days to flowering are the number of days from sowing to when 50% of the plants have flowers.

2.5 Statistical analysis

Data for each trait were analyzed considering a randomized complete block design (RCBD) with split–plot arrangement according to Steel and Torrie (1980). Comparisons between means were made using least significant differences (LSD) at 0.05 probability level.

3. RESULT AND DISCUSSION

No significant interaction between seasons was detected, probably due to irrigation being used (absence of moisture stress). The main source of yield variation in the Mediterranean region is variation in rainfall. Pod width did not differ significantly due to seeding dates, seeding rates, rates and methods of P application. Thus only the result on yield, 100 seeds weight, seed weight $plant^{-1}$ (**Tables 1** and **4**), number

Table 1. Seed yield, seed weight and 100 seeds weight of faba bean as affected by date and rate of seeding — *Effets de différentes dates et densités de semis en culture de féverole sur le rendement en semences (kg ha^{-1}), le poids de semences par plante (g) et le poids de 100 semences (g).*

	Seed yield (kg·ha^{-1})				**Seed weight plant^{-1}** (g)				**100 seeds weight** (g)			
	Treatments				**Treatments**				**Treatments**			
	X1	**X2**	**X3**	**Mean**	**X1**	**X2**	**X3**	**Mean**	**X1**	**X2**	**X3**	**Mean**
Seeding rates (Plants m^{-2})												
50	780.0	706.7	800.0	762.2	15.0	13.6	17.3	15.3	42.0	41.0	43.0	42.0
75	903.3	850.0	866.7	873.3	11.0	9.3	14.3	11.5	36.3	35.7	37.0	36.3
100	1136.7	996.7	996.9	1043.4	9.0	7.3	12.0	9.4	32.7	33.7	33.7	33.4
LSD ($P \leq 0.05$)	98.0	101.0	57.0	-	1.5	2.0	2.3	-	3.0	1.7	3.1	-
Date of seeding												
14 January	1060.0	950.0	1133.3	1047.8	13.7	12.0	17.3	14.3	40.3	40.0	42.0	40.8
28 January	926.7	800.0	996.7	907.8	11.3	10.0	14.7	12.0	36.7	35.7	37.3	36.6
12 February	833.3	803.3	866.7	834.4	10.0	8.3	11.7	10.0	34.0	33.7	34.3	34.0
LSD ($P \leq 0.05$)	83.0	57.0	98.0	-	1.2	1.3	1.7	-	2.0	2.0	2.9	-
Interaction	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS	-

X1 = 1998–1999; X2 = 1999–2000; X3 = 2000–2001

of primary branches plant^{-1} (**Tables 2** and **5**), seeds pod^{-1}, pods plant^{-1}, plant height, pod length and days to flowering (**Tables 3** and **5**) are presented.

3.1. Seeding date

Seed yield of faba bean was influenced significantly by date of sowing (**Table 1**). The maximum seed yield of 1047.8 kg·ha^{-1} was obtained by sowing faba bean on 14 January, which was found superior to seed yield corresponding to the latter dates of sowing: a yield reduction of 13.4 and 20.4% was recorded, with dates of sowing on 28 January and 12 February, respectively. The reduction in seed yield due to delay in sowing could be attributed, among other factors, to shorter growth period at the disposal of the late sown crop as the time taken by the crop to mature decreased with delay in sowing. The delay in faba bean sowing date greatly reduced seeds pod^{-1}, pod length, 100 seeds weight, seed weight plant^{-1}, and also decreased the days to 50% flowering. These results are in general agreement with those of Tawaha and Turk (2001), who indicated that shorter growing period might result in less dry matter accumulated and fewer pods and branches plant^{-1}, which reduced seed yield.

Table 2. Number of primary branches plant^{-1}, seeds pod^{-1}, and pods plant^{-1} of faba bean as affected by date and rate of seeding — *Effets de différentes dates et densités de semis en culture de féverole sur le nombre de ramifications primaires par plant, le nombre de semences par cosse et le nombre de cosses par plants.*

	Number of primary branches plant-1				Seeds pod^{-1}				Pods plant^{-1}			
	Treatments				Treatments				Treatments			
	X1	X2	X3	Mean	X1	X2	X3	Mean	X1	X2	X3	Mean
Seeding rates												
(Plants m^{-2})												
50	3.0	2.4	3.7	3.0	3.5	3.0	3.7	3.4	9.6	8.7	10.6	9.6
75	2.3	2.0	3.3	2.5	2.4	2.1	3.1	2.5	7.0	6.3	8.7	7.3
100	1.7	1.6	2.8	2.0	2.0	1.9	2.3	2.1	6.3	5.7	8.0	6.7
LSD (P ≤ 0.05)	0.5	0.4	0.4	-	0.4	0.2	0.5	-	0.4	0.5	0.6	-
Date of seeding												
14 January	3.0	2.7	4.0	3.2	3.3	2.8	4.0	3.4	8.7	7.7	10.7	9.0
28 January	2.3	2.0	3.1	2.5	2.4	2.1	2.6	2.4	7.7	7.0	9.3	8.0
12 February	1.7	1.3	2.7	1.9	2.2	2.1	2.5	2.3	6.7	6.0	7.3	6.7
LSD (P ≤ 0.05)	0.3	0.5	0.3	-	0.2	0.3	0.3	-	0.5	0.5	0.8	-
Interaction	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS	-

X1 = 1998–1999; X2 = 1999–2000; X3 = 2000–2001

Table 3. Plant height, day to 50 % flowering, and pod length of faba bean as affected by date and rate of seeding — *Effets de différentes dates et densités de semis en culture de féverole sur la hauteur de la plante (cm), la durée (en jours) requise pour atteindre 50 % de floraison et la longueur des cosses (cm).*

	Plant height (cm)				Day to 50% flowering (day)				Pod length (cm)			
	Treatments				Treatments				Treatments			
	X1	X2	X3	Mean	X1	X2	X3	Mean	X1	X2	X3	Mean
Seeding rates												
(Plants m^{-2})												
50	61.0	57.7	66.7	61.8	79.7	79.3	79.3	9.4	6.3	5.0	5.7	5.7
75	68.3	65.3	72.3	68.6	75.3	75.0	75.3	75.2	6.7	4.3	5.0	5.0
100	75.3	72.3	79.7	75.8	73.0	72.0	73.0	72.7	4.7	3.7	4.7	4.4
LSD (P ≤ 0.05)	3.1	7.0	5.1	-	3.0	2.7	1.7	-	0.5	0.4	0.3	-
Date of seeding												
14 January	72.0	67.7	76.7	72.1	81.7	80.7	81.7	81.4	6.3	5.0	6.3	5.9
28 January	67.3	65.0	72.0	68.1	75.0	74.7	75.3	75.0	5.3	4.7	4.7	4.9
12 February	65.3	62.7	69.0	65.7	71.3	71.0	70.7	71.0	5.0	3.3	4.3	4.2
LSD (P ≤ 0.05)	2.0	1.7	2.0	-	3.3	3.5	4.1	-	0.2	0.3	0.4	-
Interaction	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS	-

X1 = 1998–1999; X2 = 1999–2000; X3 = 2000–2001

3.2. Seeding rate

Seed weight plants^{-1}, 100 seeds weight, primary branches plant^{-1}, seeds pod^{-1}, pod length and pods plant^{-1}, were negatively related to seeding rate (**Tables 1, 2** and **3**). There was a trend for seed weight to decrease with increasing seeding rate (**Table 1**). The lowest seeding rate (50 plants m^{-2}) produced the maximum seed weight plants^{-1} (15.3 g) and *vice versa*. This might be attributed to a higher pods plant^{-1} (9.6), and heavier 100 seeds weight (42.0 g). Reduction in legume seed weights plant^{-1} associated with increasing seeding rate confirmed the findings of Hodgson and Blackman (1956), Kambal (1969) and Salih (1981). Faba bean plants at increasing seeding rates were significantly taller. Hodgson and Blackman (1956), and Sprent *et al.* (1977) also reported similar observations due to an increase in internode length, but not in the number of nodes plant^{-1}. The highest (9.6) and the lowest (6.7) number of pods plant^{-1} was recorded for the lowest (50 plants m^{-2}) and the highest (100 plants m^{-2}) seeding rates, respectively. The decrease in pods plant^{-1} in 100 plants m^{-2} was attributed to an increased competition among plants for growth factors, which finally reduced the number of effective branches. Reduction in branching by

Table 4. Seed yield, seed weight plant^{-1} and 100 seeds weight of faba as affected by rates and methods phosphorus application. — *Effets de différents niveaux et modes d'application de fumure phosphatée en culture de féverole sur le rendement en semences (kg·ha^{-1}), le poids de semences par plante (g) et le poids de 100 semences (g).*

	Seed yield (kg·ha^{-1})				**Seed weight plant^{-1}** (g)				**100 seeds weight** (g)			
	Treatments				**Treatments**				**Treatments**			
	X1	**X2**	**X3**	**Mean**	**X1**	**X2**	**X3**	**Mean**	**X1**	**X2**	**X3**	**Mean**
P rates (Kg·ha^{-1})												
P0 (0)	743.4	775.0	877.5	798.6	8.2	7.0	11.0	8.7	33.0	30.0	34.5	32.5
P1 (17.5)	876.7	948.0	925.0	916.6	10.2	9.5	13.0	10.9	36.5	35.5	37.5	36.5
P2 (35.0)	1066.7	1025.0	1025.0	1038.9	14.3	12.5	16.0	14.3	42.5	40.0	44.0	42.2
P3 (52.5)	1220.0	1100.5	1250	1190.0	16.0	15.0	17.0	16.0	44.5	44.5	46.5	45.5
LSD ($P \leq 0.05$)	99.3	65.0	40.0	-	1.4	1.6	2.0	-	1.5	1.8	1.9	-
P placement methods												
Band	1040.0	1024.3	1062.5	1042.3	13.3	12.0	15.5	13.6	39.3	37.8	44.3	39.5
Broadcast	913.4	900.0	1204	1005.8	11.1	10.0	13.0	11.4	38.8	37.3	40.5	38.9
LSD ($P \leq 0.05$)	88.0	97.0	113	-	1.7	1.8	1.9	-	NS	NS	NS	-
Interaction	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS	-

X1 = 1998–1999; X2 = 1999–2000; X3 = 2000–2001

Table 5. Number of primary branches plant^{-1}, seeds pod^{-1}, and pods plant^{-1} of faba bean as affected by date and rate of seeding — *Effets de différents niveaux et modes d'application de fumure phosphatée en culture de féverole sur le nombre de ramifications primaires par plant, le nombre de semences par cosse et le nombre de cosses par plant.*

	Number of primary branches plant^{-1}				**Seeds pod^{-1}**				**Pods plant^{-1}**			
	Treatments				**Treatments**				**Treatments**			
	X1	**X2**	**X3**	**Mean**	**X1**	**X2**	**X3**	**Mean**	**X1**	**X2**	**X3**	**Mean**
P rates (Kg·ha^{-1})												
P0 (0)	1.7	1.3	2.3	1.8	2.0	1.8	3.0	2.3	5.0	4.5	6.0	5.2
P1 (17.5)	2.5	2.3	3.0	2.6	2.4	2.0	3.3	2.6	7.3	5.0	7.7	6.7
P2 (35.0)	3.0	2.7	3.6	3.1	3.5	3.1	3.7	3.4	9.8	9.0	10.1	9.6
P3 (52.5)	4.2	3.3	4.2	3.9	4.4	3.4	4.0	3.9	12.0	11.0	13.0	12.0
LSD ($P \leq 0.05$)	0.4	0.4	0.5	-	0.4	0.3	0.3	-	1.8	1.9	1.3	-
P placement methods												
Band	2.8	2.5	3.3	2.9	3.1	2.6	3.5	3.1	8.4	7.3	9.3	8.3
Broadcast	2.9	2.3	3.2	2.8	3.1	2.5	3.5	3.0	8.6	7.4	9.2	8.4
LSD ($P \leq 0.05$)	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS	-
Interaction	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS	-

X1 = 1998–1999; X2 = 1999–2000; X3 = 2000–2001

increasing seeding rate has been reported previously (Singh *et al.*, 1992). On the other hand, yield was directly related to seeding rate. Seed yield increased as seeding rate increased, with highest yield being obtained at 100 plants m^{-2}. The yield increase observed with increase in seeding rate is due to a better plant establishment and therefore a higher number of pods produced. The influence of seeding rate on seed yield was related to the increased production of pod per unit area (**Table 1**) and not to the increased production of pods per plant. High seeding rate promoted phenological development (days to flowering); flowering occured 7 days earlier with the high seeding rate (100 plants m^{-2}) than the low seeding rate (50 plants m^{-2}). Al-Rifaee (1999) also found that plant from a low seeding rate flowered significantly latter than those from higher seeding rate.

3.3 Phosphorus placement methods

Seeds pod^{-1}, pod length, pod width, 100 seeds weight, plant height, and days to flowering, were not affected by P placement methods (**Tables 4, 5** and **6**). On the other hand, seed yield, pods $plant^{-1}$, seed weight $plant^{-1}$, and number of primary branches $plant^{-1}$ were significantly greater with band placement than with the broadcast methods of phosphorus application. The superiority of band placement was probably due to a better fertilizer efficiency as developing roots are in intimate contact with the P-enriched soil adjacent to the fertilizer granule (Turk, Tawaha, 2001).

Thus, it is inferred from the above results that seed yield of faba bean (*Vicia faba* L.) can be increased further with the addition of P to soils with medium available P status (10 mg Olsen's P kg^{-1} soil). Results also showed a significant effect of P placement method. In general, Papplication by band placement is more efficient due to a better contact with moist soil.

3.4 Phosphorus rate

Faba bean (*Vicia faba* L.) responded well to P application. At low rates of applied P (P0 and P1) faba bean expressed some P deficiency symptoms, such as dwarf growth and purpling of the leaves; such effects were absent at high P rates (P2 and P3). Similar results were found by Turk (1997). Seed yield, seed weight $plant^{-1}$, 100 seeds weight, seeds pod^{-1}, plant height, pod length, pods $plant^{-1}$, and branches $plant^{-1}$ were increased significantly with P application compared with the control. Values were higher at P3 than at either P0 or P1. Days to flowering decreased significantly with P application compared with control (**Table 6**). This could be attributed to the fact that P application increased the rate of crop development from emergence to floral initiation and anthesis. Similar results were reported by Keatinge *et al.* (1985), who found that P fertilizer decreased the number of days to 50% flowering.

4. CONCLUSION

No significant interaction between seasons was detected. The cultivar cv *Minor* reached flowering 72–82 days after sowing, set some pods from these flowers and pod filling was largely completed before the onset of high temperatures in spring. In this way, faba bean escaped drought in these experiments despite being sensitive to high temperatures. Seeding

Table 6. Plant height, day to 50 % flowering, and pod length of faba bean as affected by rates and methods of phosphorus application — *Effets de différents niveaux et modes d'application de fumure phosphatée en culture de féverole sur la hauteur de la plante (cm), la durée (en jours) requise pour atteindre 50 % de floraison et la longueur des cosses (cm).*

	Plant height (cm)				**Day to 50% flowering (day)**				**Pod length (cm)**			
	Treatments				**Treatments**				**Treatments**			
	X1	**X2**	**X3**	**Mean**	**X1**	**X2**	**X3**	**Mean**	**X1**	**X2**	**X3**	**Mean**
P rates (Kg·ha^{-1})												
P0 (0)	61.0	58.0	68.0	62.3	80.0	81.0	80.0	80.7	4.7	4.0	5.0	4.6
P1 (17.5)	68.0	65.0	72.0	68.3	75.0	76.0	78.0	76.3	5.7	4.5	6.2	5.5
P2 (35.0)	74.0	71.0	75.0	73.3	72.0	71.0	75.0	72.7	6.4	6.0	6.4	6.3
P3 (52.5)	78.0	74.0	79.0	77.0	70.0	70.0	73.0	71.0	6.5	6.2	6.8	6.5
LSD ($P \leq 0.05$)	5.0	2.8	2.7	-	2.0	2.0	1.7	-	0.2	0.2	0.2	-
P placement methods												
Band	70.5	67.3	74.0	70.6	74.3	74.5	76.5	75.1	5.8	5.2	6.1	5.7
Broadcast	70.0	66.8	73.0	69.9	74.3	74.5	76.5	75.1	5.8	5.2	6.1	5.7
LSD ($P \leq 0.05$)	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS	-
Interaction	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS	-

X1 = 1998–1999; X2 = 1999–2000; X3 = 2000–2001

rate, seeding date, and rate of phosphorus had a significant effect on most of the measured traits and the yield components. Method of phosphorus application had a significant effect only on seed yield and seed weight per plant. Our study demonstrates good prospects for improving faba bean production in Jordan as well as in the West Asia and North Africa, where similar environmental conditions are prevailing. The major constraint to increasing yield is the lack of agronomic management technology suited to the various conditions under which the crop is grown. Input management, furthermore, is almost unknown to Jordanian faba bean farmers. However, as recent researches show, faba bean yields can be increased substantially with early seeding (14 January), high seeding rate (100-plant m^{-2}), and Pband application (52.5 kg P ha^{-1}) drilled with the seed after cultivation.

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