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RESPONSE OF LUPIN TO P AND K FERTILIZATION IN A RECLAIMED CALCAREOUS SOIL UNDER ALLEY CROPPING

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ABSTRACT: Two field experiments were conducted in a reclaimed calcareous soil occupied by mandarin orchard at Wadi El-Mollak region, Sharkia Governorate during 2005/2006 and 2006/2007seasons to study the response of lupin to K (0,17 and 34 kg K_2O/fad) and to P (0, 7.5, 15, 22.5 and 30 kg P_2O_5/fad) fertilization under alley cropping . The randomized complete block design with three replicates was used.

Results indicated that number of leaves, floral groups, pods above the second-order branches (third level) per plant responded up to 17 kg K_2O/fad. Also, number of seeds on plant levels (which, formed in pods above the main stem first–order branches and second-order branches), seed and straw yield per plant showed the same response to K fertilization, whereas, both 100-seed weight in the third level and seed yield/fad continuously responded up to the high K rate. The obtained results revealed that plant height, number of leaves/plant and seed yield/fad were significantly increased with increasing P rate up to 15 P_2O_5 /fad, while, most seed yield attributes responded up to 22.5 kg P_2O_5/fad.

The interaction between K and P fertilization stated that the highest seed yield/fad was achieved by application of 34 kg K_2O/fad and 15 kg P_2O_5 /fad.

Key words: Lupin, alley cropping, P and K fertilization , yield

INTRODUCTION

Egyptian investors in the newly reclaimed sandy soils prefer planting orchards instead of planting vegetables or field crops. Citrus occupy the largest area in Eastern and Western of Nile Delta. To gain a profitable income from a citrus tree about 6 years from transplanting are needed.

A new multiple cropping pattern is called Agroforesty a collective name for land-use systems woody perennials (tree, shrubs, ect..) are grown in association with herbaceous plants (crops, pastures) in a special

arrangement. Agroforesty and alley cropping, which aims to exploit of shared ecological resources. Appropriate agroforesty and alley systems have the potential to control; erosion, maintain soil organic matter and physical properties, promote efficient nutrient cycling and increase food, fuelwood and fodder production (Young, 1989).Also, it could be added that alley cropping has the potential to weed control, maintain initial soil moisture and improve soil fertility when legume crops are interplanted.

In Egypt, some investigations were conducted in this respect, where interplanting lentil with peach trees was a successful technology to obtain double crops and to increase land and water use efficiency under rainfed conditions (Ashour *et al.*, 1992). The interplanted maize between palm trees produced an additional grain yield as a gain ranged from 78.5 to 80.7 % of solid maize planting (Sarhan, 1994). Under agro-horticultural system, wheat yielded grain ranged from 7.21 to 9.87 ardab/fad (Sarhan and Hammad , 1995). Peanut secured of 1060 and 906 kg/fad as pod yields by interplaning it with the young (5-6 yrs) and old (10-11 yrs) mandarin trees , respectively (Sarhan, 2001) The cultivar Giza 6 of berseem outyielded significantly Gemmiza 1, Serw 1 and local cultivars in both fresh and dry forage yields (25.02 and 3.101 t/fad) under agro-horticultural system (Sarhan and Abd El-Maksoud, 2002).

Many researchers have been working on potassium effects on growth, yield and yield components of lupin plants (Fayed, 1992; Sharief and Abd Alla, 1996; El-Far and El-Desoky, 1999; El-Far and Ramadan, 2000 and Ali and Mowafy, 2003).

The soil of the experimental site is poor in its fertility from almost all plant nutrients. Lupin as a leguminous crop, needs high additions from P to enhance growth and hence root multyplication cotion in turn increases sites for nodulation.

It has been chosen that K plays a great role in photosynthates portioning in crop plants and particularly in nodulating ones. Hartt (1969)stated that K^+ promotes translocation of newly synthesized photosynthates to different parts. Foliar application of potassium caused significant increases for plant height, number of pods, pods yield and seed yield/plant, shelling percentage and seed yield/fad when compound with the control treatment (zero K). Gutstein (1987) reported that potassium apparently increased number of pods/plant. Ordavas *et al.* (1988) pointed out that seed yield of lupin was slightly affected by K fertilization.

The increase in plant height and other growth characters of lupin due to raising phosphorus level may be owing to the vital role of phosphorus in he energy metabolism of the cell, protein synthesis, photosynthesis and other anabolic and catabolic pathway (Bieleski, 1973). Amin (1987) reported that lupin phosphorus fertilizer enhanced vegetative growth and increased the formation and accumulation of metabolites. Abo-Shetia (1990) applied 15.5, 31 and 46.5 kg P_2O_5/fad to lupin plants and observed that plant height, number of pods/plant, number of seeds/plant, number of seeds/pod, seed weight/plant, 100-seed weight and seed and straw yields/fad were increased with increasing P fertilization up to 46.5 kg P_2O_5/fad. Also, Hussein and El-Zeiny (1990) found that increasing P fertilization from zero to 48 kg P_2O_5/fad increased growth characters, number of pods/plant, weight of seeds/plant and 100-seed weight. Similar, results were obtained by Zeiton (1993), Abdel-Mottaleb (1997), El-Far and El-Desoky, (1999) and Ali and Mowafy, 2003).

Sharief and Abd Alla (1996) concluded that adding 15.5 kg P_2O_5 + 12 kg K_2O/fad significantly increased number of branches, pods and seeds/plant, seed yield/plant, 100-sed weight and seed yield/fad compared to unfertilized plants. Similar results were reported by Mousa (1990), El-Far and Ramadan (2000) and Asmaa Khameis (2003). Hafiz and El-Kholy (2000) reported that soil fertilization with 30 kg P_2O_5 under foliar application with K was the most favourable treatment for plant height. Increasing phosphorus fertilizer level from zero to 15 and from 15 to 30 kg P_2O_5/fad significantly increased plant height, number of pods, pods yield and yield/plant, shelling percentage, seed yield/fed. Balady lupin cultivar fertilized by phosphorus fertilization with 30 kg P_2O_5/fad and the foliar application of K gave the highest values for all the mentioned characters (yield and its components).

This study aimed to determintion the response of lupin to K (0,17 and 34 kg K_2O/fad) and to P (0, 7.5, 15, 22.5 and 30 kg P_2O_5/fad) fertilization under alley cropping in a reclaimed calcareous soil.

MATERIALS AND METHODS

Two field experiments were conducted in a reclaimed calcareous soil occupied by mandarin (*Citrus roticulate*) orchard at Wadi El-Mollak region., Abo- Hammad Distrect. Sharkia Governorate for two seasons 2005/2006 and 2006/2007.

Each experiment included fifteen treatments which were the

combinations of three potassium fertilization levels (0,17 and 34 kg K_2O/fad) with five phosphorus fertilization levels (0, 7.5, 15, 22.5 and 30 kg P_2O_5/fad) in factorial experiment arrange in a randomized complete block design with three replicates.

Mandrarin trees had been transplanted in 3 m space in rows of 7 m apart. Age of the trees was 3 and 4 years old. The averages of tree dimensions were 1.25 and 1.40 m for its diameter and 1.75 and 1.87 m for its height in the first and second growing seasons, respectively.

Therefore, there was an empty land as strip of 5.1 m in width between the tree rows (alley) which allowed to arrange three drip irrigation lines of 1.7 m apart. Lupin (Giza, h cv.) was planted 20 cm on both sides of the irrigation line in 25 cm apart hills with two plant/hill. The area of the plot was 15.3 m2 (5.1 x 3 m) which included six rows of 3 m length. Sowing date was 2nd and 10th of November in the first and second seasons, respectively. The preceding crop was maize in both seasons.

The soil texture of the experimental site was sandy loam. Some physical and chemical analysis of the soil in both seasons are presented in Table 1.Calcium super phosphate (15.5% P_2O_5) at the studied doses was added just before sowing, while, potassium sulfate (48 % K_2O) rates were applied at 20 days after sowing.

Nitrogen fertilizer was applied in form of ammonum sulphate (20.5 % N) at rate of 20 kg N/fad in two equal doses with irrigation water at 15 and 30 days after sowing. The other agronomic practices prevailing in the region were followed.

Recorded Data

At the flowering stage of the third level (opening the flowers above the second-order branches) of plants (130 days after sowing) ten lupin plants in the 2nd row from each plot were labled and the following characters were recorded:

1-Plant height (cm).
2-Number of branches (second and third-order branches) /plant
3- Number of leaves/plant.
4- Number of floral groups/plant.

At harvest, (175 days after sowing) ten plants were taken at random from the 5th row from each plot,then the following characters were recorded for three plant levels (the first above the main stem, the second level, above the first-order branches and the third level above the second-order branches):

1- Number of pods.
2- Weight of pods (g)
3- Number of seeds.
4- 100-seed weight (g).

In addition, seed yield (g/plant) and straw yield (g)/plant were

recorded. Also, seed yield and biological yield per faddan (which occupied by mandarin plus lupin) were calculated from the 3rd and 4th rows (3.1 m^2) of each plot.

All data were statistically analyzed according to the method described by Snedecor and Cochran (1982). Significant differences among means were judged with the help of Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Growth Characteristics

Data in Tables 2 and 3 show effects of K and P fertilization levels on plant height , number of leaves, branches and floral groups per lupin plant.

K fertilization effect

Both plant height and number of branches/plant was not affected by adding K fertilizer,whereas, number of leaves was increased by raising K fertilizer up to 17 kg K_2O/fad. This was a fact in both seasons and their combined. Number of floral groups positively and significantly responded to up to 17 kg K_2O/fad only. Similar trends were reported by Mousa (1990) and Sharief and Abd Alla (1996).

P fertilization effect

Both plant height and number of leaves/plant positively and significantly responded up to 15 P_2O_5/fad but thereafter decreased when the level of P was increased. This was a clear in the combined analysis data (Table 2). Also, number of floral groups/plant took the same decline by adding the two highest P rates (Table 3). However, the number of branches/plant was not affected by P fertilization. Similar trends were reported by Fayed(1990), Sharief and Abd Alla (1996) and Abd El-Mottalb (1997).

Both of plant height and number of leaves\plant were affected by the interaction effect between P and K levels (Table 2-a). However, the number of branches or floral groups/plant were not affected by this interaction (Table,3).

Interaction effect

Data in Table 2 a show that the tallest lupin plant was recorded by adding the highest P dose (30 kg P_2O_5/fad) under without application of K fertilizer. While, plant height took the opposite trend by adding of the highest K dose (34 kg K_2O/fad).

Under without application of P fertilizer, adding of 17 or 34 kg K_2O/fad caused a significant increase in plant height. Whereas, when 7.5 kg P_2O_5/fad was added the tallest plant recorded by adding the highest K dose.

Regarding number of leaves/plant as shown in Table 2b. under the two lower K levels, this trait positively responded to P fertilization up to 15 kg P_2O_5/fad. However, the opposite trend was founded by adding 34 kg K_2O/fad.

Table 1. Some soil physical and chemical properties for the experimental fields (the upper 30 cm of the soil sarface)

Soil component analysis	Values	
	2005/2006	2006/2007
Physical properties :		
Sand %	69.40	68.70
Silt %	16.30	16.80
Clay %	14.30	14.50
Texture	Sandy loam	Sandy loam
Organic matter %	0.225	0.220
Field capacity	12.5%	12.60%
Permanent welting point	5.7%	5.8%
Chemical properties:		
$CaCO_3$ %	17.5	17.8
pH (1-25)	8.22	8.18
EC (dSm^{-1})	2.4	2.3
Saturation percentage	22.4	22.6
Soluble ions (meg/100 g):		
Ca^{2+}	0.19	0.21
Mg^{2+}	0.9	0.9
Na^{+}	0.21	0.20
K^{+}	0.021	0.023
HCO_3^{-}	0.10	0.11
Cl^{-}	0.25	0.25
SO_4^{2-}	0.30	0.31
Available nutrients (ppm):		
N	4.3	3.8
P	3.5	3.6
K	55.7	57.6

Table 2. Plant height (cm) and number of leaves/plant as affected by K and P fertilization levels in the two seasons and their combined

Main effects and interaction	Plant height (cm)			Number of leaves/plant		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K- fertilization level (K_2O kg/fad):						
0.0 K_0	93.93	91.76	92.85	108.7b	105.2b	106.9b
17 K_1	97.94	93.95	95.94	114.3ab	111.1ab	112.7a
34 K_2	96.44	93.12	94.78	116.1a	115.0a	115.6a
F-test	N.S.	N.S.	N.S.	*	*	*
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	97.54ab	90.34ab	93.94bc	100.4d	98.00b	99.2b
7.5 P_1	93.24b	87.20b	90.22c	104.4c	101.0b	102.7c
15.0 P_2	100.06a	99.15a	99.61a	121.6a	119.6a	120.6a
22.5 P_3	91.76b	90.97ab	91.37c	123.2a	115.0a	119.1ab
30.0 P_4	97.91ab	97.04a	97.47ab	115.9b	118.5a	117.2b
F-test	*	*	**	**	**	**
Interaction: K x P	**	*	**	**	**	**

Table 2a. Plant height (cm) as affected by the interaction between K and P fertilization (combined analysis)

K fertilization (kg K_2O/fad)	P fertilization (kg P_2O_5/fad)				
	0.0	7.5	15.0	22.5	30.0
0	B	B	B	B	A
	84.2b	88.3b	99.3a	90.3a	102.0a
17	A	B	A	B	A
	100.6a	84.8b	103.1a	91.2a	99.8a
34	A	A	AB	AB	B
	96.4a	97.4a	96.3a	92.5a	90.6b

Table 2b. Number of leaves /plant as affected by the interaction between K and P fertilization (combined analysis)

K fertilization (kg K_2O/fad)	P fertilization (kg P_2O_5/fad)				
	0.0	7.5	15.0	22.5	30.0
0	D	C	A	B	BC
	72.1b	103.0b	130.5a	118.1a	111.0b
17	B	C	A	A	A
	107.6a	87.8c	125.4a	118.4a	124.5a
34	A	A	B	A	AB
	117.9a	117.5a	105.4b	120.9a	116.1ab

Table 3. Number of branches and floral groups per plant as affected by K and P fertilization levels in the two seasons and their combined

Main effects and interaction	Number of branches/plant			Number of floral groups/plant		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K-fertilization level (K_2O kg/fad):						
0.0 K_0	11.10	10.64	10.87	12.69b	13.40b	13.05b
17 K_1	11.69	10.40	11.05	14.55a	13.90a	14.22a
34 K_2	11.94	12.27	12.11	14.52a	15.16a	14.84a
F-test	N.S.	N.S.	N.S.	*	*	**
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	11.15	10.69	10.92	15.05a	15.61a	15.33a
7.5 P_1	11.81	11.19	11.50	15.45a	14.60a	15.02a
15.0 P_2	11.39	11.32	11.36	14.47a	15.11a	14.79a
22.5 P_3	11.67	11.00	11.34	13.26b	12.73b	12.99b
30.0 P_4	11.80	11.08	11.74	11.33c	12.73b	12.04c
F-test	N.S.	N.S.	N.S.	**	**	**
Interaction:						
K x P	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Under zero or adding 30 kg P_2O_5/fad, number of leaves/plant was significantly increased by adding of 17 kg K_2O/fad. Whereas, when lupin plants received of 7.5 kg P_2O_5/fad this character was significantly decreased by adding of 17 kg K_2O/fad and increased by adding of 34 kg K_2O/fad.

Generally, it could be observed that the tallest plant was recorded by adding of 17 kg K_2O + 15 kg P_2O_5 /fad. Also, the heighest leaves number /plant was recorded by adding of 15 kg P_2O_5/fad under without application of K.

Seed Yield and its Attributes

Number of Pods/plant

Data in Table 4 show number of pods which was recorded by the three levels and its total of lupin plant as affected by K and P fertilization.

K fertilization effect

Potassium fertilization was without significant effect on the numbers of pods/plant except on those produced by the third plant level plus total pods number per plant (Table 4). Two different trends were observed in the two seasons where the addition of 17 kg K_2O/fad enough to increase the numbers of pods/ plan but, 34 kg K_2O/fad were needed in the second season in this respect. The combined results of the two seasons clearly confirm the results of the first season. Similar results were obtained by Abo-Sheaia(1990). Sharief and Abd Alla (1996), El-Far and Ramadan (2000) and Asmaa Khameis (2003)

P fertilization effect

Phosphorous fertilization had different effect on the number of pods/plan in the two seasons particularly on those produced by the second plant level. The combined analysis clearly indicate that 15 kg P_2O_5/fad were quite enough to increase the number of pods produced by the first plant level plus total pods number per plant whereas. 22.5 kg/fad were needed to increase this number by the second plant level. However, P fertilization was without significant effect on this number in the third level. These result clearly indicate that p fertilization played a role in fruit set rather than in floral production. Results in Table 3 indicate a significant decrease in the number of floral group/plant due to the increase of P level. The herein results (Table 4) indicate a significant increase in the number of pods in the first and second levels due to p fertilization. Similar results were obtained by Abo-Sheaia(1990). Sharief and Abd Alla (1996), El-Far and Ramadan (2000), Asmaa Khameis (2003) and Ali and Mowafy (2003).

Interaction effect

Data in Table (4a) show a significant effect of the interaction between K and P fertilization on number of pods which produced

Table 4. Number of pods for the first, second and third levels of the lupin plant as affected by K and P fertilization levels in the two seasons and their combined

Main effects and interaction	The first level			The second level		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K- fertilization level (K_2O kg/fad):						
0.0 K_0	7.41	7.04	7.23	10.69	9.36	10.03
17 K_1	7.50	8.08	7.79	10.81	10.94	10.87
34 K_2	8.00	7.56	7.78	9.53	11.21	10.37
F-test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	7.31	7.37	7.34b	9.37	10.51ab	9.94b
7.5 P_1	7.40	7.20	7.30b	9.15	9.24b	9.19b
15.0 P_2	8.62	6.75	7.68ab	11.55	8.64b	10.09b
22.5 P_3	7.33	8.82	8.08a	11.37	12.20a	11.78a
30.0 P_4	7.53	7.64	7.58ab	10.26	11.93a	10.10a
F-test	N.S.	N.S.	**	N.S.	*	*
Interaction:						
K x P	*	N.S.	*	*	N.S.	*

	The third level			Total pods number per plant		
	2005/2006	2006/07	Comb.	2005/2006	2006/2007	Comb.
K- fertilization level (K_2O kg/fad):						
0.0 K_0	3.93b	3.44b	3.68b	22.04ab	19.84b	21.86b
17 K_1	5.76a	3.82b	4.79a	24.08a	22.85ab	23.46a
34 K_2	3.94b	5.69a	4.82a	21.48b	24.47a	22.98ab
F-test	*	*	**	**	**	*
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	8.84	4.09	4.46	21.53bc	21.98abc	21.75b
7.5 P_1	4.48	4.56	4.52	21.04c	21.00bc	21.02b
15.0 P_2	5.69	3.29	4.49	25.86a	18.69c	22.28a
22.5 P_3	5.04	4.18	4.61	23.75ab	25.20a	24.47a
30.0 P_4	2.67	5.49	4.08	20.47c	25.06ab	22.76a
F-test	N.S.	N.S.	N.S.	*	**	*
Interaction:						
K x P	*	*	**	**	*	*

Table 4a. Number of pods on the different levels of lupin plants as affected by the interaction between K and P fertilization (combined analysis)

K fertilization (kg K_2O/fad)	P fertilization (kg P_2O_5/fad)				
	0.0	7.5	15.0	22.5	30.0
	First level				
0	B	B	A	A	B
	5.66b	6.63a	8.80a	8.33a	6.70b
17	A	A	A	A	A
	8.43a	7.96a	7.70ab	7.33a	7.33ab
34	AB	AB	B	A	A
	7.93ab	7.30a	6.57b	8.56a	8.53a
	Second level				
0	C	BC	A	A	B
	7.00b	9.13a	12.00a	12.36a	9.62a
17	A	A	A	A	A
	11.13a	10.16a	9.86ab	11.46a	11.76a
34	A	B	B	A	A
	11.70a	8.30b	8.43b	11.53a	11.90a
	Third level				
0	C	BC	A	A	AB
	0.86b	1.86b	5.23a	6.23a	4.23a
17	A	A	AB	B	B
	7.06a	6.23a	4.56a	3.00b	3.10a
34	A	A	A	A	A
	5.46a	5.46a	3.67a	4.60ab	4.90a
	Total pods number /plant				
0	C	B	A	A	B
	13.5b	17.6b	26.0a	26.9a	20.5b
17	A	AB	C	C	BC
	26.6a	24.3a	22.1b	21.8b	22.4ab
34	A	BC	C	AB	A
	25.1a	21.0a	18.6b	24.7ab	25.3a

by the three tested levels of lupin plants as well as total pods number per plant.

Number of pods on the two lower levels of lupin plant nearly took the same trend. So, under without application of P fertilizer number of pods was significantly increased by adding of 17 kg K_2O/fad. Whereas, this number was declined when lupin plants were received the medium P rate (15 kg P_2O_5 /fad). Under the two highest P rates, number of pods did not affected by K fertilization. On the third level, number of pods were significantly increased by adding K fertilizer (17 or 34 K_2O/fad) under without or adding the lowest P rate (7.5 kg P_2O_5/fad). However, this number was significantly decreased by adding of 17 kg K_2O/fad with 22.5 kg P_2O_5/fad.

Under without application of K fertilizer, number of pods by any level of lupin plant positively responded to P fertilization up to 15 kg P_2O_5/fad and declined when lupins were received the highest P rate (30 kg P_2O_5/fad). While with adding of 17 K_2O/fad this number did not affect by P fertilization on the two lower levels but, on the third level of lupin plant number of pods was significantly decreased by adding the two highest P levels (22.5 and 30 kg P_2O_5/fad). Under application of the highest K rate, number of pods was declined when lupins were received the two lower P rates (7.5 and 15 kg P_2O_5/fad). This was true on the two lower levels of plant.

Generally, adding of 15 kg P_2O_5/fad enough to increase total pods number/plant under without application of K fertilizer. Whereas, under application of any K level lupin plant were not needed to P fertilization to increase number of pods /plant.

Weight of Pods (g)/ Plant

Data in Table 5 show weight of pods which was recorded by the three levels and its total of lupin plant as affected by K and P fertilization.

K fertilization effect

The first K increment (17 kg K_2O/fad) reflected a significant increase in the weight of pods produced by the first plant level in the second season and those produced by the third level in the first season. The combined analysis confirmed this effect but only on the weight of pods produced by the third plant level. These results are quite interesting and these clearly indicate the role of K in photosynthate translocation to active plant sinks. Results in table 4 showed that K addition of 17 kg K_2O/fad increased the number of pods produced by the third plant level. These results obtained herein (Table 5) showed that this addition increase the weight of pods/plant.

P level effect

Phosphorus fertilization had different effects on the weight of pods produced by the three plant levels. According to the combined analysis a trend of significant increase was observed due to the addition of 22.5 kg P_2O_5/fad. These results clearly indicate that P fertilization had a positive and pronounced effect on the number of pods by the first and second plant levels (Table 4) weight of pods/plant (Table 5).

Interaction effect

The interaction effect between K and P fertilization levels on weight of pods on the three plant levels plus its total per plant was significant as shown in tables 5 and 5a.

Concerning total weight of pods plant, the results in Table 5a indicate that the heaviest pods was recorded by adding of 22.5 kg P_2O_5/fad under without application of K fertilizer. Also, under without application of P fertilizer, adding of 17 kg K_2O/fad were quite enough to produce heavy pods per lupin plant.

Number of Seeds/plant

Data in Table 6 show that number of seeds by the three plant levels plus total number of seeds/plant was effected by K and P fertilization in the two growing seasons and their combined.

K fertilization effect

Potassium fertilization had a pronounced significant effect on the number of seeds produced by the three plant levels and its total. According to the combined analysis addition of the first K increment was quite enough to increase the number of seeds/plant. Similar effect was observed in the number of pods produced by the third plant level (Table 4). Similar results were obtained by Abo-Sheaia(1990) El-Far and Ramadan (2000) and Asmaa Khameis (2003).

P fertilization effect

Results in Table 6 clearly indicate that 22.5 kg P_2O_5/fad were needed by lupin plants to maximize significantly the number of seeds produced by the three plant levels and its total. Similar effect was observed in the number of pods/ plant produced the first and second plant levels and could account for the herein results. Similar results were reported by Fayed (1992) Sharief and Abd All (1996), and Ali and Mowfay (2003).

Interaction effect

The interaction effect between K and P fertilization levels on number of seeds on the three plant levels plus its total per plant was significant as shown in Tables 6 and 6a.

Table 5. Weight of pods(g) for the first, second and third levels of the lupin plant as affected by K and P fertilization levels in the two seasons and their combined

Main effects and interaction	The first level			The second level		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K- fertilization level (K_2O kg/fad):						
0.0 K_0	14.36	14.40b	14.38	17.21	18.18	17.70
17 K_1	15.04	16.03a	15.53	19.44	19.73	19.59
34 K_2	15.85	14.14b	15.00	21.50	17.96	19.73
F-test	N.S.	*	N.S.	N.S.	N.S.	N.S.
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	13.89	13.84b	13.86ab	19.42ab	17.86a	18.64a
7.5 P_1	12.97	13.29b	13.13b	15.11b	13.02	14.07b
15.0 P_2	13.15	13.86b	15.01ab	16.31b	20.93a	18.62a
22.5 P_3	16.86	16.84a	16.85a	23.31a	21.11a	22.21a
30.0 P_4	15.53	16.44a	15.98ab	22.79a	20.20a	21.50a
F-test	N.S.	**	*	**	*	*
Interaction:						
K x P	*	N.S.	**	N.S.	*	*

	The third level			Total pods weight per plant		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K- fertilization level (K_2O kg/fad):						
0.0 K_0	5.85b	5.53	5.69b	38.41b	37.14b	37.78c
17 K_1	7.89a	4.86	6.38a	42.48a	40.34a	41.41a
34 K_2	4.28c	5.52	4.90b	38.15b	41.17a	39.66b
F-test	**	N.S.	**	*	*	**
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	6.15ab	5.17	5.66ab	38.01c	38.45b	38.23c
7.5 P_1	4.97bc	5.08	5.02b	30.97d	33.49c	32.23d
15.0 P_2	7.42a	3.75	5.58ab	44.51a	33.93c	39.22c
22.5 P_3	4.04a	6.20	6.62a	44.72a	46.35a	45.54a
30.0 P_4	4.44c	6.31	5.38b	40.18b	45.54a	42.86b
F-test	**	N.S.	**	**	**	**
Interaction:						
K x P	**	**	**	**	*	*

Table 5a: Weight of pods (g) per plant as affected by the interaction between K and P fertilization levels (combined analysis)

K fertilization (kg K_2O/fad)	P fertilization (kg P_2O_5/fad)				
	0.0	7.5	15.0	22.5	30.0
0	D	E	B	A	C
	30.0c	24.8b	44.9a	49.0a	39.0c
17	A	C	B	B	B
	45.3a	36.3a	40.5b	42.1c	42.7b
34	B	C	D	A	A
	39.3b	35.5a	31.2c	45.2b	46.8a

Table 6. Number of seeds for the first, second and third levels of the lupinplant as affected by K and P fertilization levels in the two seasons and their combined

Main effects and interaction	The first level			The second level		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K- fertilization level (K_2O kg/fad):						
0.0 K_0	27.07b	25.30b	26.19b	29.56b	31.77b	30.67b
17 K_1	30.87b	30.79a	30.83a	37.15a	40.15a	38.65a
34 K_2	31.57a	33.25a	31.91a	35.83	42.02a	38.93a
F-test	*	*	*	*	*	*
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	25.06e	31.43a	28.25c	33.26c	38.42b	35.84b
7.5 P_1	29.16c	25.97c	27.57c	28.59b	35.76c	32.18c
15.0 P_2	27.40d	29.68b	28.54c	32.28b	32.52d	33.90a
22.5 P_3	35.65a	31.66a	33.67a	35.41b	43.69a	39.55a
30.0 P_4	31.91b	28.50b	30.21b	38.31a	39.50b	38.91a
F-test	**	*	**	*	**	*
Interaction:						
K x P	**	*	**	N.S.	**	*

	The third level			Total seeds number per plant		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K- fertilization level (K_2O kg/fad):						
0.0 K_0	9.88b	9.27c	9.57b	66.48c	66.33c	66.41b
17 K_1	14.82a	10.82b	12.82a	82.84a	81.75b	82.30a
34 K_2	10.61b	13.59a	12.10a	77.97b	87.86a	82.92a
F-test	*	**	*	**	**	*
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	11.93b	11.03b	11.48b	70.24c	80.89b	75.57c
7.5 P_1	10.45b	10.12b	10.29c	68.21c	71.84c	70.03d
15.0 P_2	15.11b	9.04c	12.08b	77.97b	71.24c	74.52c
22.5 P_3	14.08a	12.62a	13.35a	85.14a	87.96a	86.55a
30.0 P_4	7.22c	13.31a	10.27c	77.44b	81.31b	79.38b
F-test	**	*	*	**	**	**
Interaction:						
K x P	*	N.S.	*	*	**	*

Table 6a. Number of seeds per plant as affected by the interaction between K and P fertilization levels (combined analysis)

K fertilization (kg K_2O/fad)	P fertilization (kg P_2O_5/fad)				
	0.0	7.5	15.0	22.5	30.0
0	E	D	B	A	C
	46.6b	53.7c	76.7a	87.5a	67.4c
17	A	B	B	B	B
	89.2a	82.4a	79.1a	81.8b	78.8b
34	A	B	C	A	A
	93.8a	73.9b	67.7b	90.3a	91.8a

Number of seeds/plant was the highest by adding of 22.5 kg P_2O_5/fad under without application of K fertilizer. This results of number of seeds confirm those of number of pods per plant. On the other hand, number of seeds per plant responded up to 17 kg K_2O/fad under without application of P. Whereas, with application of the highest dose of P , this number continuously responded up to 34 kg K_2O/fad.

100 –Seed Weight

Data in Table 7 show 100-seed weight (g) as affected by K and P fertilization.

K fertilization effect

The 100-seed weight of the first plant level was significantly increased due to the increase of K level to 34 kg K_2O /fad in the first season and only 17 kg K_2O/fad in the second one. This was observed in the 100-seed weight produced by the third plant level where K increment up to 34 kg K_2O/fad produced a significant increase in seed index. Similar results were reported by Fayed (1992) Sharief and Abd All (1996), and Ali and Mowfay (2003).

P fertilization effect

It is evident from Table 7 that P fertilization had less pronounced effect on seed index except on that produced by the third plant level, where 15 kg P_2O_5/fad were needed to maximize this weight according to the combined analysis. These results confirmed to view that P played a role in number of seeds/plant whereas K fertilization played a role in seed filling.

Seed and Straw Yields per Plant

Data in Table 8 show seed and straw weights of lupin plant as affected by K and P fertilization levels in the two seasons and their combined.

K fertilization

In the first season and the combined analysis the seed weight/plant was significantly increased by adding of 17 K_2O/fad. Whereas, in the second season this trait continued to increase significantly up to 34 kg K_2O/fad. Results in Table 8 clearly indicated that 17 kg K_2O/fad were needed by lupin plants to maximize straw weight per plant. This was a fact in both seasons and their combined. Similar results were reported by Hafiz and El-Kholy (2000)

P fertilization effect

In both seasons and their combined the seed weight /plant continued to increase significantly up to the addition of 22.5 kg P_2O_5 /fad where it thereafter decreased. However, the straw weight /plant responded to the increase of P level up to only 15 kg P_2O_5/fad in the second season and the combined of the two seasons. These results confirmed the favourable effect of P fertilization on the number of pods/ plant (Table 4) as well as on the number of seeds/plant (Table 6). The seed index of the 3rd plant level was also increased due to this addition (Table 7) . These improvements in

Table 7. 100-seed weight (g) for the first, second and third levels of the lupin plant as affected by K and P fertilization levels in the two seasons and their combined

Main effects and interaction	The first level			The second level			The third level		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K- fertilization level (K_2O kg/fad)									
0.0 K_0	35.60c	36.35b	35.98b	36.64	36.27	37.46	27.85c	26.67c	27.26c
17 K_1	36.67b	37.14a	36.91a	36.87	36.52	36.70	29.20b	30.75b	29.98b
34 K_2	37.65a	37.67a	37.66a	36.67	36.78	36.73	30.61a	32.28a	31.45a
F-test	**	*	*	N.S.	N.S.	N.S.	**	**	**
P-fertilization level (P_2O_5 kg/fad)									
0.0 P_0	35.27	35.84	35.56	36.71	36.29	36.50	28.05b	29.47b	28.76b
7.5 P_1	36.55	38.64	37.60	36.99	35.59	36.29	27.36b	28.10c	27.73b
15.0 P_2	35.99	35.46	35.73	36.78	37.76	37.27	30.40a	30.68ab	30.54a
22.5 P_3	37.27	37.33	37.30	36.27	35.99	36.13	30.36a	31.86a	31.11a
30.0 P_4	36.99	37.99	37.49	36.86	36.98	36.92	29.92a	29.38b	29.65ab
F-test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	*	*
Interaction									
K x P	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 8. Seed yield (g)/plant and straw yield(g)/plant as affected by K and P fertilization levels in the two seasons and their combined

Main effects nd interaction	Seed weight (g)/ plant			Straw weight (g)/ plant		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K-fertilization level (K_2O kg/fad):						
0.0 K_0	22.19b	21.96c	22.08b	22.36b	24.10b	23.23b
17 K_1	28.37a	28.48b	28.43a	27.25a	29.22a	28.23a
34 K_2	27.29a	31.26a	29.28a	27.14a	30.48a	28.81a
F-test	*	**	*	**	**	**
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	23.42c	27.39b	25.41bc	23.95	25.73b	24.84c
7.5 P_1	29.94c	24.51c	23.72c	25.46	25.71b	25.58bc
15.0 P_2	26.75b	24.67c	25.71bc	26.46	30.22a	28.34a
22.5 P_3	29.41a	30.84a	30.13a	26.06	29.64a	27.85a
30.0 P_4	26.79b	28.28b	27.53b	25.97	28.37ab	27.17ab
F-test	*	*	*	N.S.	*	**
Interaction:						
K x P	N.S.	N.S.	N.S.	**	**	**

Table 8a. Straw yield per plant as affected by the interaction between k and P fertilization (combined analysis)

K fertilization (kg K_2O/fad)	P fertilization (kg P_2O_5/fad)				
	0.0	7.5	15.0	22.5	30.0
0	C	C	A	AB	B
	15.60b	18.66b	30.30a	27.00b	46.60b
17	A	A	A	B	AB
	29.50a	29.63a	30.86b	23.50b	27.70ab
34	A	B	C	A	AB
	29.43a	28.46a	23.86b	33.06a	29.23a

yield attributes could account for the increase observed herein in seed weight/plant due o P fertilization.

The results further indicate that P level increase was in favour of more dry matter partitioning towards seeds rather the than shoots, as the increase of straw weight/plant was up to the addition of 15 kg P_2O_5/fad whereas that of seed weight/plant was up to the addition of 22.5 kg P_2O_5/fad. Similar results were reported by Hafiz and El-Kholy (2000)

Interaction effect

Data in Table 8a show a significant effect of interaction between K and P fertilization levels on straw weight /plant.

Straw weight per plant was significantly increased by adding of 17 K_2O/fad under without application of P fertilizer as well as by raising K level to 34 kg K_2O/fad with 22.5 P level.

Under without application of K fertilizer, straw weight/plant positively responded to 15 kg P_2O_5/fad whereas, when adding 17 kg K_2O/fad this weight was declined by raising P fertilizer over.

Seed and Biological Yields per Fad

Data in Table 9 show seed and biological yields per fad as affected by K and P fertilization

K fertilization effect

It is obvious that seed yield (kg/fad) was significantly increased when lupin plants were received the highest K fertilizer rate (34 kg K_2O/fad). This was a true in both growing seasons and their combined. Response of seed yield/fad to K fertilization may be due to accumulation of increases were occurred in number of leaves and floral groups per plant as well as number of pods on the third levels of lupin plant and 100- seed weight by adding K fertilizer (Tables 2,3 and 4) . Also, this essential nutrient in the base is important for the synthesis of high energy phosphate molecules (ATP), which are required in both photosynthesis and respiration of the translocation of sugars (Gladstones, 1970). Similar results were reported by Fayed (1992) Sharief and Abd All (1996), and Ali and Mowfay (2003) .

Biological yield (t/fad) did not affected by K fertilization in both growing seasons. The same results were obtained by Fayed (1992), Sharief and Abd All (1996), and Asmaa Khameis (2003) .

P fertilization effect

The results in Table 9 indicate that seed yield /fad was significantly increased to application of P fertilizer up to 15 kg P_2O_5/fad, and there is not yield response for any increment over, while, seed yield /fad was declined when lupin received of the highest P rate (30 kg P_2O_5/fad in the first season and of 22.5 kg P_2O_5/fad in the second one. This response of seed yield to P

Table 9. Seed yield kg/fad and biological yield (ton/fad) as affected by K and P fertilization levels in the two seasons and their combined

Main effects and interaction	Seed yield kg/fad			Biological yield ton/ fad		
	2005/2006	2006/2007	Comb.	2005/2006	2006/2007	Comb.
K- fertilization level (K_2O kg/fad):						
0.0 K_0	415.6b	425.3b	420.5 b	1.245	1.247	1.246
17 K_1	431.6b	434.8b	433.2 b	1.234	1.231	1.233
34 K_2	460.7a	464.7a	462.7 9a	1.190	1.289	1.239
F-test	**	**	**	N.S.	N.S.	N.S.
P-fertilization level (P_2O_5 kg/fad):						
0.0 P_0	289.1d	306.4d	297.8 c	0.861c	0.846d	0.853d
7.5 P_1	359.9c	354.9c	357.4 b	1.192b	1.156c	1.174c
15.0 P_2	514.8ab	521.5ab	518.1 a	1.322a	1.405b	1.364b
22.5 P_3	525.5a	485.6b	505.6 a	1.354a	1.380b	1.367b
30.0 P_4	490.7b	539.8a	515.3 a	1.385a	1.490a	1.437a
F-test	**	**	**	**	**	**
Interaction K x P	**	**	**	**	**	**

Table 9a. Seed yield (g) and biological yields as affected by the interaction between K and P fertilization (combined analysis)

K fertilization (kg K_2O/fad)	P fertilization (kg P_2O_5/fad)				
	0.0	7.5	15.0	22.5	30.0
	Seed yield (kg/fad)				
0	D 247.4c	C 380.1a	B 479.3b	B 471.9b	A 523.5a
17	C 292.9b	B 343.9b	A 508.7b	A 503.3b	A 517.3a
34	C 3529a	C 348.1b	A 566.3a	A 541.4a	B 504.9a
	Biological yield (ton/fad)				
0	D 0.805b	C 1.179a	B 1.300b	B 1.306b	A 1.641a
17	C 0.930a	B 1.165a	A 1.341ab	A 1.312b	A 1.412b
34	C 0.826ab	B 1.178a	A 1.449a	A 1.448a	B 1.260c

fertilization may be due to a result increases were accumulated by number and weight of pods, number of seeds on the different levels of lupin plant and 100-seed weight on the third one (Tables 4,5 and 6). The increases in these seed yield attributes was nearly caused by increasing of plant height and number of leaves per plant in this study. In addition to the improvement in growth and seed yield of lupin was a result of P element important, which on essential constituent of nucleic acid of phytin and phospholipids, as well as is a constituent of sugar phosphates, ADP and ATP. Also, phosphorus is involved in metabolic processes of plant and activation of number of enzymes. Similar results were reported by Zeiton (1993), Abd El-Mottleb (1997) and Ali and Mowfay (2003).

Regarding biological yield (t/fad), it can be noted that this yield positively and significantly responded to P fertilization up to the highest tested rate (30 kg P_2O_5/fad). This was true in the second season and the combined analysis, whereas, in the first season that response reached only up to 15 kg P_2O_5/fad. The increase in biological yield /fad may be due to as a result of increases in growth and seed yield of lupin by adding P to 17 kg K_2O/fad under without application of P fertilizer, more responded up to 34 kg K_2O/fad fertilizer. Similar results were reported by), Sharief and Abd All (1996) and Ali and Mowfay (2003).

Interaction effect

Data in Table (9a) show a significant effect of the interaction between K and P fertilization on seed yield (kg/fad) and biological yield (t/fad).

Under without application of P, seed yield /fad was continuously and significantly increased by raising of K fertilizer rate, also this yield responded to the highest K rate when lupin plants received of 15 or 22.5 kg P2O5/fad. However, seed yield /fad was reduced by adding K fertilizer with 7.5 kg P2O5/fad.

Under without application of K, seed yield /fad positively and significantly responded up to the highest P rate (30 kg P_2O_5 /fad). This result is an agreement with finding of Khamis (2005) He reported that application of phosphatic fertilizers to soils, promote K release from soil, thus increasing their K-supplying rate. While, when K fertilizer was added this yield responded only up to 15 kg P_2O_5/fad. The highest seed yield/fad was achieved by adding of 34 kg K_2O + 15 kg P_2O_5/fad.

Biological yield/fad positively and significantly responded up under 15 or 22.5 kg P_2O_5/fad. However, when lupins received the highest P rate (30 kg P_2O_5/fad) this

yield was continuously and significantly decreased by any increment of K fertilizer.

Biological yield /fad took the same trend of seed yield/fad for P fertilization under the three K rates.

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استجابة محصول الترمس للتسميد الفوسفاتي والبوتاسي في الأراضي الجيرية المستصلحة حديثا تحت نظام الزراعة المتداخلة بين الأشجار

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أقيمت تجربتان حقليتان في أرض مستصلحة مشجرة باليوسفي (عمر ٣ و ٤ سنوات) بمنطقة وادي الملاك بمحافظة الشرقية خلال الموسمين ٢٠٠٥/٢٠٠٦ و ٢٠٠٦/٢٠٠٧ لدراسة استجابة محصول الترمس للتسميد البوتاسي ٠صفر ، ١٧ و ٣٤ كجم بو ٢أ /فدان) والفوسفاتي (صفر ، ٧,٥ ، ١٥ ، ٢٢,٥ و ٣٠ كجم فو٢أ٥/فدان) تحت نظام الزراعة المتداخلة بين الأشجار . وكانت شحيرات اليوسفي مزروعة علي أبعاد ٣ م في صفوف المسافة بينها ٧ م ومن ثم أمكن استغلال مسافة ٥,١ م بعد ٣ أنابيب الري علي أبعاد ١,٧ م وزراعة الترمس علي بعد ٢٠ سم و علي جانبي الأنابيب. وقد نفذت التجربة العاملية باستخدم تصميم القطاعات العشوائية الكاملة في ثلاث مكررات كل موسم.

ويمكن تلخيص أهم النتائج فيما يلي:-

١- استجاب عدد كل من الأوراق والمجاميع الزهرية والقرون/نبات بالمستوي الثالث (التي تكونت أعلي الفروع الثانوية) لإضافة ١٧ كجم بو٢أ /فدان، وكذلك استجاب عدد البذور/نبات عند أي مستوي للنبات (أي بالقرون المتكونة أعلي الساق الرئيسي، الفروع الأولية والفروع الثانوية) ، ومحصول البذور والقش للنبات للتسميد البوتاسي.

٢- استمرت استجابة كل من وزن المائة بذرة بالقرون المتكونة أعلي الفروع الثانوية وكذلك محصول الفدان من البذور لإضافة الجرعة الأكبر من التسميد البوتاسي (٣٤ كجم بو٢أ /فدان)

٣- حققت إضافة ١٥ كجم فو٢أ٥/فدان أعلي القيم لكل من ارتفاع النبات وعدد الأوراق /نبات والمحصول الأكبر من البذور/فدان. بينما استمرت استجابة غالبية مساهمات محصول البذور حتى الجرعة التالية (٢٢,٥ كجم فو٢أ٥/فدان).

٤- أظهر التفاعل بين التسميد البوتاسي والفوسفاتي أن أكبر محصول بذور من الفدان أمكن الحصول عليه بإضافة ٣٤ كجم بو٢أ + ١٥ كجم فو٢أ٥/فدان.