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RESPONSE OF TWO LUPIN VARIETIES TO FOLIAR NUTRITION WITH POTASSIUM AND MAGNESIUM UNDER DIFFERENT LEVELS OF PHOSPHATIC FERTILIZATION IN SANDY SOILS

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ABSTRACT

Two field experiments were conducted during 1995/96 and 1996/97 seasons at the Agricultural Experimental Farm of Suez Canal University at Ismailia to study the effect of three levels of phosphatic fertilizer i.e. 0, 15.5 and 31 Kg P_2O_5/fad and foliar nutrition with potassium solution (36% K_2O) at a rate of 1.5cm^3/L and magnesium sulphate (49% Mg SO_4) at a rate of 1 g/L on growth, yield, yield components and yield quality of two lupin varieties.

The obtained results revealed that Balady variety significantly surpassed Roomy variety in plant height, dry weight of leaves, stems and roots/plant, number of pods/plant, pods and seed yields/plant, number of seeds/pod, shelling percentage, seed yield/fad and seed protein content %. While, Roomy variety had heavier 100-seed weight compared to Balady variety.

Applying phosphorus fertilizer up to 31 Kg P_2O_5/fad significantly increased the different studied growth characteristics, chlorophyll content in the leaves, yield, yield attributes and seed protein content %. Meanwhile, increasing P levels did not affect significantly number of seeds/pod. Also, foliar spraying with potassium or magnesium significantly increased all the studied traits compared to control, except number of seeds/pod which was not affected by foliar application of K or Mg. It is worthy to mention that foliar nutrition with potassium significantly exceeded magnesium in seed yield/plant, 100-seed weight and shelling percentage.

The all possible interactions between varieties, phosphorus rates and foliar nutrition affected significantly almost all the studied traits.

It is worthy to note that lupin plants received 15.5 Kg P_2O_5/fad and sprayed with K or Mg surpassed unsprayed plants fertilized with 31 kg P_2O_5/fad in seed yield per fad.

It is could be concluded that foliar nutrition with K or Mg increased the efficiency of lupin plants in utilizing phosphorus fertilizer which reflected in enhancing growth and yield attributes consequently, increasing seed yield. On the other hand, foliar nutrition with K or Mg could save a significant amount of the phosphorus fertilizer.

The highest seed yield/fad was obtained from Balady variety fertilized with 31 Kg P_2O_5/fad and sprayed with potassium.

There was a positive and significant correlation between lupin seed yield/fad and different studied growth traits, chlorophyll content, number of pods/plant, seeds/pod, pods and seed yields/plant and shelling percentage.

INTRODUCTION

Lupin (*Lupinus termis* L.) is one of the most important leguminous crops grown in Egypt. The seeds which had high protein content are consumed dry in human diet, meanwhile the plants are used as green manure.

Since lupin plants grow well on sandy soils which are valuable for future expansion, attention should be taken with respect to their nutritional status. Therefore, efforts are being made to increase lupin productivity from such soil by growing the new high yielding lupin varieties which produce more pods/plant, better pod characteristics, more weight of seeds/plant and higher seed yield/fad (Lopez-Bellido and Fuentes, 1990; Sharief and Abdalla, 1996; Abdel-Mottaleb, 1997), as well as by providing such high yielding varieties with their requirements from essential nutrients. Soil fertilization with phosphorus and foliar spraying with potassium and magnesium are considered an effective tool in this respect.

Phosphorus is one of the essential elements which play a highly recognized role in the growth and metabolism of leguminous plants. Phosphorus is constituent of nucleic acid (DNA and RNA) and high energy storage compounds (Miller and Donahue, 1995), stimulate cell division and metabolic processes such as photosynthesis and synthesis of protein, carbohydrate and lipids (Marschner, 1986) and enhance root growth (Russel, 1973), nodulation and N fixation (Alexander, 1961). The phosphorus content in the poor sandy soils is low, moreover the available phosphorus in Egyptian soils is too low to face the plant requirements of this element (Devlin and Witham, 1983). Furthermore, Egyptian soil pH is high which resulted in decreasing phosphorus availability. Under such conditions, phosphorus fertilization has always been important.

While, potassium is the most important cation in plant because of its important role in physiological and biochemical functions such as activation of various enzymatic systems (Evans and Sorger, 1966), stimulating synthesis of protein and many other compounds such as sugar, cellulose and cell wall (Hewitt, 1963 and Kiraly, 1976) and cell extension (Marschner, 1986).

Meanwhile Magnesium is considered a very important element in plant nutrition, it is constituent of the chlorophyll molecule, required for the formation of nucleic acid RNA in the nucleus (Marschner, 1986) and essential for synthesis of protein and high energy storage compound as well as promote most of enzyme reactions (Mengel and Kirkby, 1987). Also, magnesium plays an important role in carbohydrate metabolism (Louis and Frederick, 1979). In recent years the importance of magnesium as a fertilizer has increased especially in the poor sandy soils because of the high purity of fertilizers and increased crop yields placed a great demand for magnesium uptake (Mengel and Kirkby, 1978).

So, many investigators reported favorable effect of such essential macronutrients on growth, yield, yield components and yield quality (Moursi *et al.*, 1976; Amin , 1986; El-Moursy *et al.*, 1988; Abo-Shetaia, 1990; Hussein and El-Zeiny, 1990; Mousa, 1990; Zeiton, 1993; Sharief and Abdalla, 1996; Abdel-Mottaleb, 1997) concerning phosphorus, (El-Mansi *et al.*, 1991; Xia and Xiong, 1991; Salwau and Hassanein, 1994; Abdel-Lateef, 1996; Hassanein *et al.*, 1996 and Bastawisy and Sorial, 1998) concerning potassium and (Ibrahim *et al.*, 1995; Abdel-Mottaleb *et al.*, 1998 and Hanna and Abdel-Mottaleb, 1998) concerning magnesium. Abdel-Hadi *et al.*, (1985) mentioned that foliar spray of nutrients is readily absorbed by the leaves and not lost through fixation, decomposition or leaching. While, Baier and Baierova (1999) reported that the increased nutrients uptake through roots after foliar fertilization has been proven in the majority of field crops and they concluded that this fact can explain even often-unexpected yield gains being confronted with a small amount of nutrients applied in the form of spraying.

In respect of the interactions effect, Ozanne and Petch_(1978) stated that the amount of phosphorus resulted in production 90% of maximum yield depend on lupin species. Moreover, Wasserman (1986) revealed that there was interaction among lupin species and PK fertilization for seed yield. Sharief and Abdalla (1996) demonstrated that there was a significant interaction among lupin cultivars and each of P or PK fertilization for seed yield/plant and seed yield/fad. Also, Abdel-Mottaleb (1997) revealed that there was a significant interaction between lupin cultivars and phosphorus fertilization for plant height, dry matter/plant, number of pods/plant, seed yield/plant and seed yield/fad.

So, this study aimed to investigate the response of some lupin varieties to foliar nutrition with potassium and magnesium under different levels of phosphatic fertilization on sandy soils at Ismailia province.

MATERIALS AND METHODS

Two field experiments were conducted during 1995/96 and 1996/97 seasons at the Agricultural Experimental Farm of Suez Canal University at Ismailia to study the effect of soil phosphatic fertilization and foliar application of potassium and magnesium on growth, yield, yield attributes and yield quality of two local lupin cultivars.

Physical properties and chemical analysis of the experimental soil are presented in Table (1).

Table (1): Some physical properties and chemical analysis of the experimental soil.

Mechanical analysis :		**Chemical analysis :**	
Coarse sand (%)	17.24	pH	7.64
Fine sand (%)	76.71	E.C. (m.mohs/cm)	0.15
Silt (%)	3.47	Organic matter (%)	0.021
Clay (%)	2.58	Available N ppm	13.65
Soil texture	Sandy	Available P ppm	2.08
		Available K ppm	14.10
		Available Mg ppm	2.75

The spilt split plot design with three replications was made in use in every experiment which included 18 treatments which were the combination of two local cultivars namely Balady and Roomy, three rates of phosphorus fertilizer i.e. 0, 15.5 and 31 Kg P_2O_5/fad and three foliar application treatments i.e. tap water, potassium solution (36% K_2O) at a rate of 1.5cm^3/L and sulphate magnesium (49% $MgSO_4$) at a rate of 1g/L. The cultivars were arranged randomly in the main plots, while phosphorus fertilizer rates in the sub plots and foliar nutrition treatments in the sub sub plots.

Each experimental sub sub plot consisted of 5 ridges, 4m. in length and 60cm in width (plot area = 12m^2).

Inoculated seeds were sown on one side of the ridges in hills 15cm apart on November 2nd and 12th in the first and second seasons, respectively. After 20 days from sowing, plants were thinned to one plant per hill.

Phosphorus in the form of calcium superphosphate (15.5% P_2O_5) at the mentioned rates was applied before sowing. Potassium solution (36% K_2O) was sprayed at a rate of 1.5 cm^3/Liter, while magnesium sulphate (49% $Mg\ SO_4$) was sprayed at a rate of 1 g/Liter. All foliar nutrition treatments were applied twice after 75 and 85 days from sowing with volume spray of 400 Liter/fad.

A basal dose of 20Kg N/fad and 24Kg K_2O/fad in the form of ammonium nitrate (33.5%N) and potassium sulphate (48% K_2O) respectively, were applied to the soil for all treatments during preparing experimental soil. The normal cultural practices for growing lupin crop at Ismailia Governorate were followed.

After 110 days from sowing, five guarded plants were taken randomly from the inner ridge in each sub sub experimental plot for measuring plant height (cm), number of branches/plant, dry weight of leaves, stems and roots/plant (g), root length(cm). Also, the content of chlorophylls a, b and (a+b) in the fourth upper leaf were determined according to the method described by Wettestein (1957).

At harvest time after 150 days from sowing, ten guarded plants were taken at random from the inner ridge in each sub sub plot to determine number of pods/plant, number of seeds/pod, pods and seed yields/plant(g), 100-seed weight (g) and shelling percentage. Meanwhile seed yield per fad (Kg) was estimated from the two inner ridges in each plot. Also, seed crude protein content was determined as a total nitrogen(%) of the seeds by microkjeldahl according to A.O.A.C. (1975), then the obtained values were multiplied by 6.25 as used by Tripathi *et al.* (1971).

The analysis of variance of split split plot design was used according to Snedecor and Cochran (1982). The combined analysis of the two seasons was performed. The treatment means were compared according to LSD-test at 0.05 level of significance.

RESULTS AND DISCUSSION

1- Varietal effect :-

It is clearly evident from the data illustrated in Tables (2-5) that Balady cv. significantly surpassed Roomy cv. in plant height, dry weight of leaves and stems per plant, number of pods per plant, pod and seed yields per plant, number of seeds per pod, shelling percentage and seed yield per fad in both seasons and the combined data, dry weight of roots per plant (in the two seasons), the content of chlorophyll a (in the first season) and length of root, the content of chlorophylls b and (a+b) and seed protein content % (in the combined data). However, number of branches/plant was not affected by varieties in both seasons and the combined data. On the other hand, Roomy cv. had significant heavier 100-seed weight compared with Balady cv. These results may probably be due to the adaptability of Balady cv. to the local environment of Ismailia region compared to Roomy cv. and due to the genetic differences among lupin cultivars (Pate *et al.*, 1985 and Lopez-Bellido and Fuentes, 1990). Similar results were emphasized by Sharief and Abdalla (1996) and Abdel-Mottaleb (1997).

2- Effect of phosphorus fertilization :-

Data in Table (2) indicate that plant height of lupin significantly increased as phosphorus fertilizer increased from 0 to 31 Kg P_2O_5/fad in both seasons and the combined data. This result may be due to the stimulating effect of phosphorus on metabolic activity, cell division and expansion, leading to higher plants (Marschner, 1986). Similar results were reported by El-Moursy *et al.* (1988), Abo-Shetaia (1990), Mousa (1990), Zeiton (1993) and Abdel-Mottaleb (1997).

Increasing P fertilizer rate up to 31 Kg P_2O_5/fad gave significantly more number of branches/plant than those received only 15.5 Kg P_2O_5/fad and unfertilized plants in the two seasons and their combined average (Table 2). This result was expected since phosphorus is constituent of nucleic acids and high energy storage compounds (Miller and Donahue, 1995) and stimulant of the meristemic activity. Confirming results obtained by El-Moursy *et al.* (1988), Abo-Shetaia (1990), Mousa (1990), Zeiton (1993), Sharief and Abdalla (1996) and Abdel-Mottaleb (1997).

It is clearly evident from Table (3) that root length and dry weight of roots, leaves and stems per plant were significantly increased with applying phosphorus fertilizer up to 31 kg P_2O_5/fad and that was true in both seasons and their combined data. Such effects may be due to that phosphorus encourages the growth of root system (Russel, 1973), nodulation (Raguse and Taggard, 1979) and the fixation and utilization of N (Albert, 1978) as well as the role of P in enhancing photosynthesis, carbohydrate metabolism and protein synthesis (Marschner, 1986) and this in turn increased the amount of metabolites synthesized by the lupin plants as the dry weight of different parts of the plant i.e. roots, leaves and stems become great. These results are in same trend with those obtained by Hussein and El-Zeiny (1990) and Abdel-Mottaleb (1997).

The results in Table (2) reveal that chlorophylls a, b and (a+b) were more concentrated in the leaves of lupin plants receiving phosphorus fertilizer up to 31 kg P_2O_5/fad and the differences among the studied P rates were significant in both seasons and their combined average. These results may be due to the role of phosphorus in enhancing nodulation and the growth of roots, consequently increasing the efficiency of the roots in absorbing various nutrients, also P is part of high energy storage and transfer chemicals in the plant (Miller and Donahue, 1995) as well as increase the metabolic activity of the plant (Linck and Swonson, 1960). These results are in harmony with those reported by Ahmed (1988) and Hussein and El-Zeiny (1990).

Data in Table (4) indicate that no significant effect was detected on number of seeds per pod due to phosphorus application. Abdel-Mottaleb (1997) came to similar results.

The obtained results in Tables (4 and 5) demonstrate that there were a significant and consistent increases in number of pods per plant, pod and seed yields per plant and shelling percentage of lupin with increasing rate of phosphorus fertilizer from 0 to 31 kg P_2O_5/fad. Such positive responses with applied phosphorus may be due to that P caused an increase in the number of flowers and pods setting percentage, also decreased the percentage of flowers and pods abscission (Bould and Parfitt, 1973 and Moursi *et al.*, 1976). Moreover, phosphorus enhance lupin plants ability to accumulate more dry matter consequently increasing productivity of plants i.e. number of pods/plant and pod and seed yields/plant. These results are in agreement with those reported by Moursi *et al.* (1976) with number of pods/plant, El-Moursy *et al.* (1988) with number of pods/plant, Abo-Shetaia (1990) with number of pods/plant and pod and seed yields/plant, Hussein and El-Zeiny (1990) with number of pods/plant, 100-seed weight and pod and seed yields/plant, Mousa (1990) with number of pods/plant and seed yield/plant, Zeiton (1993) with number of pods/plant and seed yield/plant, Sharief and Abdalla (1996) with number of pods/plant and seed yield/plant and Abdel-Mottaleb (1997) with number of pods/plant and seed yield/plant.

Fertilizing lupin plants up to 31 kg P_2O_5/fad gave significantly heavier weight of 100-seed (Table 5). The favorable effect of increasing phosphorus rates on 100-seed weight may be due to the role of phosphorus in activation carbohydrate metabolism in the leaves and sucrose translocation as well as stimulating photosynthesis and protein synthesis, also P is constituent of high energy storage compound (Marschner, 1986). The regulatory function of P in photosynthesis and carbohydrate metabolism of leaves can be considered one of the major factors limiting growth, particularly during the reproductive stage. The level of phosphorus supply during this period regulates the starch/sucrose ratio in the source leaves and the partitioning of photosynthates between the source leaves and the reproductive organs (Giaquinta and Quebedeaux, 1980). Similar results were emphasized by El-Moursy *et al.* (1988), Abo-Shetaia (1990), Zeiton (1993), Sharief and Abdalla (1996) and Abdel-Mottaleb (1997).

It is obvious from Table (5) that there was a significant and consistent increase in seed yield per fad with increasing phosphorus fertilizer from 0 to 31 kg P_2O_5/fad. Fertilizing lupin plants with 31 kg P_2O_5/fad exceeded those received 15.5 kg P_2O_5/fad and unfertilized control in seed yield per fad by 24.13% and 61.58% in the first season, 24.03% and 62.01% in the second season and 24.08% and 61.80% in the combined data, respectively.

The positive effect of phosphorus fertilization on lupin seed yield per fad might be due to the favorable effects of phosphorus in stimulating nodulation (Raguse and Taggard, 1979) and the growth of root system (Russel, 1973), consequently increasing the efficiency of the roots in absorbing various nutrients and fixation of N (Albert, 1978). Also, phosphorus enhance the vegetative growth of lupin plants as expressed by plant height, number of branches/plant which in turn increased number of flowers and pods/plant. Moreover, P increased flowers number/plant and pods setting

percentage and decreased the percentage of flowers and pods abscission (Bould and Parfitt, 1973 and Moursi *et al.,* 1976). On the other hand, phosphorus stimulate metabolic process such as photosynthesis and synthesis of carbohydrate and protein (Marschner, 1986) subsequently increasing the amount of metabolites synthesized by the lupin plants and this increased accumulation of dry matter as well as P encourage translocation of metabolites synthesized (Giaquinta and Quebedeaux, 1980) which reflected on increasing weight of pods and seeds/plant, shelling percentage and 100-seed weight consequently increased seed yield per fad. These results are in accordance with those reported by Moursi *et al.* (1976), Abo-Shetaia (1990), Mousa (1990), Zeiton (1993), Sharief and Abdalla (1996) and Abdel-Mottaleb (1997).

Applying phosphorus fertilizer up to 15.5 kg P_2O_5/fad to lupin plants induced significant increase in seed protein content %. Increasing P rate from 15.5 to 31 kg P_2O_5/fad insignificantly increased seed protein content % in the combined data (Table 5). Increasing seed protein content% by phosphorus fertilization may be due to that P developed good root system of lupin plants and improved capacity of roots to absorb more nutrients also P stimulate nodulation and fixation of N as well as the important role of P in protein synthesis. These results are in parallel with those reported by Amin (1986), Thalooth *et al*. (1989), Haggag *et al.* (1994), Okaz *et al.* (1994) and Abdel-Wahab *et al.* (1999).

3- Effect of foliar nutrition with K and Mg :-

The data in Table (3) indicate that supplementary foliar nutrition lupin plants with magnesium or potassium significantly increased root length and dry weight of roots/plant compared to the unsprayed control, with significant difference between them in both seasons and the combined data. These results are in conformity with those obtained by Ibrahim *et al.* (1995), Abd El-Lateef (1996) and Bastawisy and Sorial (1998).

It is obvious from Table (2) that supplementary foliar application lupin plants with magnesium or potassium significantly increased plant height and number of branches per plant compared to the unsprayed plants in the both seasons and the combined data, except plant height in the first season which was not affected significantly by foliar nutrition. Similar results were reported by El-Mansi *et al.* (1991), Salwau and Hassanein (1994), Ibrahim *et al.* (1995), Abd El-Lateef (1996), Hassanein *et al.* (1996), Abd El-Mottaleb *et al.* (1998) and Bastawisy and Sorial (1998).

Dry weight of lupin leaves and stems per plant were significantly increased by foliar nutrition with Mg or K compared to the unsprayed plants in both seasons and their combined average, except dry weight of stems/plant in the first season which was insignificantly affected by foliar nutrition. However, sprayed Mg significantly surpassed K in the two aforementioned characters (Table 3). These results are in harmony with those recorded by El-Mansi *et al.* (1991), Ibrahim *et al.* (1995), Abd El-Lateef (1996) and Bastawisy and Sorial (1998).

The data presented in Table (2) reveal that chlorophylls a, b and (a+b) content in leaves of lupin plants increased consistently and significantly by supplementary foliar nutrition lupin plants with magnesium or potassium as compared with unsprayed control, however the highest content of chlorophylls was formed in the leaves of lupin plants sprayed with Mg compared to those with K and the difference among them was significant. That was held true in both seasons and their combined average. Similar results were emphasized by El-Mansi *et al.* (1991) and Bastawisy and Sorial (1998).

It is clearly evident from Table (4) that supplementary foliar application lupin plants with potassium or magnesium resulted in significant increase in number of pods per plant and pods yield per plant compared with the unsprayed plants in both seasons and the combined data, without significant difference between them, except pod yield per plant in the first season where foliar applied lupin plants with K significantly exceeded those sprayed with Mg. Confirming results were reported by El-Mansi *et al*. (1991), Salwau and Hassanein (1994), Ibrahim *et al.* (1995), Abd El-Lateef (1996), Abd El-Mottaleb *et al.* (1998) and Bastawisy and Sorial (1998).

The data recorded in Table (4) demonstrate that number of seeds per pod did not significant respond to foliar nutrition with potassium or magnesium in both seasons and their combined average. These results are in a good line with those obtained by Abd El-Lateef (1996).

It is obvious from data reported in Tables (4 and 5) that supplementary foliar fertilization lupin plants with potassium or magnesium significantly increased seed yield per plant, 100-seed weight and shelling percentage compared with unsprayed plants. Meanwhile, foliar applied K gave better results than applied Mg. That was true in both seasons and the combined data except seed yield per plant and shelling percentage in the second season where the differences between the two elements were not significant. These results are in accordance with those obtained by Salwau and Hassanein (1994), Ibrahim *et al.* (1995), Abd El-Lateef (1996), Abd El-Mottaleb *et al.* (1998) and Bastawisy and Sorial (1998).

The data in Table (5) show that supplementary foliar nutrition lupin plants with potassium or magnesium significantly increased seed yield per fad compared to unsprayed control, without significant difference among them in both seasons and their combined average except in the first season where foliar applied lupin plants with K significantly exceeded those sprayed with Mg. These results are expected since potassium play a major role in cell extension and osmoregulation, activate a large group of enzymes (Mulder, 1949) and relate the changes in carbohydrate metabolism (Marschner, 1986). Also, protein synthesis and many other compounds including sugar, cellulose, cell wall, vitamins, …. etc are promoted by the availability of K (Hewitt, 1963 and Kiraly, 1976) in turn enhancing nodulation and N fixation. On the other side, magnesium increase chlorophylls content in the leaves (Singh and Gill, 1987), consequently increase photosynthesis, necessary for the enzymatic system involved in carbohydrate metabolism (Louis and Frederick, 1979) and carbohydrate supply to the root nodules and thus improve N fixation as well as Mg promotes protein synthesis and as a factor in almost all enzymes

activating phosphorylation processes (Mengel and Kirkby, 1987). Therefore for these reasons both potassium and magnesium stimulate vegetative plant growth i.e. plant height and branches number/plant as well as dry matter accumulation in the vegetative organs such as leaves (the source) a result of raising root nodules, efficiency in nitrogen fixation, increasing photosynthetic pigments content and enzymes activity, in turn enhancing plant metabolism. Furthermore, foliar nutrition with K or Mg resulted in more number of pods per plant and higher dry matter accumulated in the leaves (the source) as well as improve translocated dry matter from leaves to the reproductive organs i.e. pods and seeds (the sink), which resulted in more pods yield per plant, higher shelling percentage and heavier 100-seed weight in turn increasing seed yield per plant and subsequently resulted in higher seed yield per fad. These results are in same trend with those reported by El-Mansi *et al.* (1991), Salwau and Hassanein (1994), Abd El-Lateef (1996), Hassanein *et al.* (1996), Abd El-Mottaleb *et al.* (1998) and Bastawisy and Sorial (1998).

Data recorded in Table (5) show clearly that supplementary foliar application of potassium or magnesium significantly increased seed protein content % compared to unsprayed plants, without significant difference between them (the combined data). These results may be due to that potassium is required for protein synthesis (Hewitt, 1963 and Kiraly, 1976) and stimulate various enzymatic systems (Evans and Sorger, 1966) subsequently resulted in higher seed protein content %. While, magnesium is necessary as a factor in almost all enzymes activating phosphorylation processes and required for synthesis of high energy storage compound (ATP) as well as promote protein synthesis (Mengel and Kirkby, 1987). Also, Mg required for the formation of mucleic acid RNA in the nucleus (Marschner, 1986) which reflect on increasing seed protein content %. Similar results were emphasized by Abd El-Lateef (1996), Abd El-Mottaleb *et al.* (1998) and Bastawisy and Sorial (1998).

4- Interactions effect :

A- Interaction effect between varieties and phosphorus fertilizer rates :-

It is clearly evident from Table (6) that the highest values of number of pods per plant and seed yield per fad were obtained by Balady variety fertilized with 31 Kg P_2O_5/fad. While the lowest values of these aforementioned characters were produced by Roomy variety plants unfertilized with phosphorus. Similar results were reported by Ozanne and Petch (1978), Sharief and Abdalla (1996) and Abdel-Mottaleb (1997).

Table (6): Effect of the interaction between lupin varieties and phosphorus rates on number of pods/plant and seed yield/fad (the combined data).

P_2O_5 (kg/fad)	Varieties		Varieties	
	Balady	Roomy	Balady	Roomy
	No. of pods/plant		Seed yield/fad (kg)	
0	10.84	8.03	533.11	395.11
15.5	16.31	11.65	689.78	520.61
31	20.03	14.45	870.67	631.22
L.S.D. at 5%	0.93		29.59	

B- Interaction between varieties and foliar nutrition with K and Mg:-

It is obvious from Table (7) that foliar nutrition Balady variety plants with magnesium produced the highest response of number of pods per plant. Meanwhile Balady variety plants sprayed with potassium gave the highest value of seed yield per fad. However, unsprayed Roomy variety plants produced the lowest responses of number of pods per plant and seed yield per fad.

Table (7): Effect of the interaction between lupin varieties and foliar nutrition with K and Mg on number of pods/plant and seed yield/fad (the combined data).

Foliar nutrition	Varieties		Varieties	
	Balady	Roomy	Balady	Roomy
	No. of pods/plant		Seed yield/fad (kg)	
0	13.74	9.76	556.61	420.33
K	16.54	11.98	769.44	559.06
Mg	16.89	12.40	767.50	567.56
L.S.D. at 5%	0.88		28.07	

C- Interaction between phosphorus fertilizer rates and foliar nutrition with K and Mg :-

The data in Table (8) indicate that the highest value of number of pods per plant was obtained by applying 31Kg P_2O_5/fad to lupin plants and spraying with magnesium.

Table (8): Effect of the interaction between phosphorus rates and foliar nutrition with K and Mg on number of pods/plant and seed yield/fad (the combined data).

Foliar nutrition	P_2O_5 (kg/fad)			P_2O_5 (kg/fad)		
	0	15.5	31	0	15.5	31
	No. of pods/plant			Seed yield/fad (kg)		
0	8.13	11.92	15.20	349.08	491.08	625.25
K	10.05	14.61	18.12	389.75	669.00	834.00
Mg	10.13	15.41	18.40	553.50	655.50	793.58
L.S.D. at 5%	1.08			34.38		

Meanwhile, the highest response of seed yield per fad was achieved by fertilizing lupin plants with 31 kg P_2O_5/fad and foliar nutrition with potassium. On the other hand, the lowest values of the two aforementioned characters were produced from unsprayed lupin plants received no phosphorus fertilizer.

It is worthy to note that lupin plants received 15.5 kg P_2O_5/fad and sprayed with K or Mg surpassed unsprayed plants fertilized with 31 kg P_2O_5/fad in seed yield per fad.

It is could be concluded that foliar nutrition with K or Mg increased the efficiency of lupin plants in utilizing phosphorus fertilizer which reflected on enhancing growth and yield components consequently, increasing seed yield. On the other sentence, foliar nutrition with K or Mg could save a significant amount of the phosphorus fertilizer.

5- Simple correlation analysis :-

Data in Table (9) reveal the simple correlation coefficients among seed yield per fad and some studied characters (the combined data).

Table (9): Simple correlation coefficients between seed yield/fad and some growth characters and yield attributes of lupin.

Character	R
Plant height	0.901**
Root length	0.861**
No. of branches/plant	0.827**
Dry weight of leaves/plant	0.965**
Dry weight of stems/plant	0.920**
Dry weight of roots/plant	0.939**
Chlorophyll a	0.776**
Chlorophyll b	0.789**
Chlorophyll a + b	0.782**
No. of pods/plant	0.963**
No. of seeds / pod	0.537*
Pods yield / plant	0.975**
100-seed weight	0.436
Seed yield / plant	0.957**
Shelling percentage	0.857**

It is obvious that seed yield/fad was highly significant and positively correlated with each of plant height, root length, number of branches and pods/plant, dry weight of leaves, stems and roots/plant, chlorophylls a, b and (a+b) content, pods and seed yields/plant and shelling percentage. Also, seed yield/fad was correlated significantly and positively with number of seeds/pod. While, did not correlate with 100-seed weight. These results are in agreement with those obtained by Salem *et al.* (1984) for plant height, seeds number/pod and 100-seed weight; Mousa (1990) for seed yield/plant; Soliman (1992) for plant height, pods number/plant and seed yield/plant and Zeiton (1993) for number of branches and pods/plant, seeds number/pod, 100-seed weight and seed yield/plant.

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استجابة صنفين من الترمس للرش الورقى بالبوتاسيوم والمغنسيوم تحت مستويات مختلفة من التسميد الفوسفاتى فى الأراضى الرملية

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أقيمت تجربتان حقليتان بمزرعة كلية الزراعة – جامعة قناة السويس بالإسماعيلية فى موسمى الزراعة ١٩٩٦/٩٥ و ١٩٩٧/٩٦ لدراسة تأثير معدلات التسميد الفوسفاتى (صفر – ١٥,٥ – ٣١كجم فو٢ أ٥ /الفدان) والرش الورقى بالبوتاسيوم والمغنسيوم على النمو والمحصول ومكوناته وجودته لصنفين من الترمس.

استخدم فى هذه الدراسة تصميم القطع المنشقة مرتين فى ثلاث مكررات حيث وزعت أصناف الترمس فى القطع الرئيسية والتسميد الفوسفاتى فى القطع المنشقة والرش الورقى فى القطع تحت المنشقة.

ويمكن تلخيص النتائج فيما يلى :-

1- أظهر صنف الترمس بلدى تفوقاً معنوياً على الصنف رومى فى كل من :- ارتفاع النبات ، الوزن الجاف للأوراق والسيقان والجذور /النبات ، عدد القرون/النبات ، محصول القرون/النبات ، محصول البذور/النبات ، عدد بذور القرن الواحد ، نسبة التصافى ، محصول البذور/الفدان ، نسبة البروتين بالبذور. بينما تفوق الصنف رومى على الصنف بلدى فى وزن ١٠٠بذرة.

2- أدت زيادة معدل التسميد الفوسفاتى حتى ٣١ كجم فو٢أ٥/الفدان إلى زيادة معنوية فى كل صفات النمو الخضرية وتركيز صبغات الكلوروفيل بالأوراق وجميع مكونات المحصول ومحصول البذور/الفدان ونسبة البروتين بالبذور. بينما لم تتأثر صفة عدد بذور القرن بالتسميد الفوسفاتى.

3- أدى الرش الورقى بالبوتاسيوم أو المغنسيوم إلى زيادة معنوية فى كل الصفات المدروسة ما عدا عدد بذور القرن وذلك بالمقارنة بالكنترول مع ملاحظة أن الرش بالبوتاسيوم قد حقق تفوقاً معنوياً فى كل من:- محصول البذور/النبات ، وزن ١٠٠ بذرة ، نسبة التصافى بالمقارنة مع الرش بالمغنسيوم.

4- يوجد تأثير معنوى للتفاعل بين (التسميد الفوسفاتى × الرش الورقى) على جميع الصفات المدروسة ما عدا عدد بذور القرن ونسبة البروتين بالبذور. وكذلك بين كل من (الأصناف × التسميد الفوسفاتى) و (الأصناف × الرش الورقى) و (الأصناف × التسميد الفوسفاتى × الرش الورقى) على كل الصفات المدروسة ما عدا نسبة البروتين بالبذور.

5- تحقق أعلى محصول من البذور/الفدان من إضافة ٣١ كجم فو٢ أ٥/الفدان للصنف بلدى مع الرش الورقى بالبوتاسيوم.

6- أدى الرش الورقى بالبوتاسيوم أو المغنسيوم لنباتات الترمس المسمدة بـ ١٥,٥ كجم فو٢أ٥ /الفدان إلى زيادة محصول الفدان من البذور بالمقارنة بالنباتات المسمدة بـ ٣١ كجم فو٢ أ٥/الفدان والغير معاملة بالرش الورقى.

7- أدى الرش الورقى بالبوتاسيوم أو المغنسيوم إلى زيادة كفاءة نباتات الترمس فى الاستفادة من السماد الفوسفاتى مما أدى إلى زيادة نمو النبات ومكونات المحصول وبالتالى زيادة محصول البذور.

8- لوحظ وجود ارتباط موجب وعالى المعنوية بين محصول البذور/الفدان وكل من:- ارتفاع النبات، طول الجذر ، عدد الأفرع/النبات ، الوزن الجاف للأوراق والسيقان والجذور/النبات ، تركيز كلوروفيل أ ، ب ، أ+ب ، عدد القرون/النبات ، محصول القرون/النبات ، محصول البذور/النبات ، نسبة التصافى . فى حين هناك ارتباط موجب ومعنوى بين محصول البذور/الفدان وعدد بذور القرن. بينما لم يوجد ارتباط مع وزن المائة بذرة.

Table (2) : Effect of lupin varieties, phosphorus rates and foliar nutrition with K and Mg on plant height, number of branches/plant and chlorophylls content.

Treatments	Plant height (cm)			No. of branches/plant			Chlorophyll (mg/g dry weight)								
							A			B			A+B		
	95/96	96/97	Comb.	95/96	96/97	Comb.	95/96	96/97	Comb.	95/96	96/97	Comb.	95/96	96/97	Comb.
Varieties															
Balady	64.33	64.89	64.61	10.85	9.33	10.09	5.84	5.59	5.71	2.15	2.06	2.10	7.99	7.65	7.82
Roomy	47.62	48.00	47.81	10.85	8.63	9.74	5.14	5.55	5.34	1.84	1.94	1.89	6.98	7.49	7.23
L.S.D. at %5	8.84	5.58	2.75	N.S	N.S	N.S	0.12	N.S	N.S	N.S	N.S	0.16	N.S	N.S	0.39
P_2O_5(kg/fad)															
0	44.89	47.11	46.00	7.00	6.06	6.53	3.63	4.00	3.81	1.31	1.42	1.37	4.94	5.42	5.18
15.5	56.22	56.67	56.44	11.78	9.89	10.83	5.45	5.69	5.57	1.99	2.04	2.02	7.44	7.73	7.58
31	64.61	65.56	65.08	13.78	11.00	12.39	6.64	7.39	7.02	2.41	2.66	2.54	9.05	10.05	9.56
L.S.D. at %5	5.66	1.95	2.57	0.73	0.55	0.65	0.25	0.44	0.28	0.20	0.17	0.15	0.41	0.50	0.36
Foliar nutrition															
0	53.72	52.89	53.31	9.00	7.06	8.03	3.60	3.82	3.71	1.34	1.39	1.37	4.94	5.21	5.08
K	56.67	56.56	56.61	11.22	9.94	10.58	5.17	5.57	5.37	1.88	2.01	1.94	7.05	7.58	7.32
Mg	57.56	59.89	58.73	12.33	9.94	11.14	6.94	7.70	7.32	2.49	2.73	2.61	9.43	10.43	9.93
L.S.D at %5	N.S	1.51	2.44	1.11	0.81	0.61	0.22	0.39	0.20	0.18	0.15	0.10	0.37	0.45	0.26

Table (3) : Effect of lupin varieties, phosphorus rates and foliar nutrition with K and Mg on root length and dry weight of leaves, stems and roots/plant.

Treatments	Root length (cm)			Dry weight of leaves/plant (g)			Dry weight of stems/plant(g)			Dry weight of roots/plant(g)		
	95/96	96/97	Comb.	95/96	96/97	Comb.	95/96	96/97	Comb.	95/96	96/97	Comb.
Varieties												
Balady	20.15	20.78	20.46	10.19	11.49	10.84	9.88	11.65	10.76	3.61	4.13	3.87
Roomy	18.53	19.35	18.94	6.49	8.14	7.31	6.66	8.24	7.45	2.23	3.18	2.70
L.S.D. at %5	N.S	N.S	1.21	1.94	1.98	0.51	2.37	1.63	0.50	0.80	0.77	N.S
P_2O_5(kg/fad)												
0	15.23	16.04	15.63	5.54	6.74	6.14	5.43	6.43	5.93	1.82	2.31	2.06
15.5	20.68	21.19	20.93	8.88	10.33	9.61	8.37	10.00	9.19	3.04	3.87	3.45
31	22.12	22.96	22.54	10.60	12.37	11.49	11.00	13.39	12.20	3.90	4.79	4.34
L.S.D. at %5	3.48	0.89	0.31	0.79	0.87	0.47	0.94	0.56	0.47	0.41	0.20	0.35
Foliar nutrition												
0	17.24	18.23	17.37	7.14	7.98	7.56	7.99	8.57	8.28	2.41	3.05	2.73
K	19.73	20.17	19.95	8.65	10.27	9.46	8.30	10.19	9.24	2.97	3.80	3.38
Mg	21.05	21.79	21.42	9.22	11.19	10.20	8.52	11.06	9.79	3.38	4.01	3.75
L.S.D at %5	0.38	0.36	0.27	0.75	0.46	0.45	N.S	0.68	0.45	0.26	0.18	0.20

Table (4) : Effect of lupin varieties, phosphorus rates and foliar nutrition with K and Mg on number of pods/plant, pods yield/plant, seed yield/plant and number of seeds/pod.

Treatments	No. of pods/plant			Pods yield/plant (g)			Seed yield/plant (g)			No. of seeds/pod		
	95/96	96/97	Comb.	95/96	96/97	Comb.	95/96	96/97	Comb.	95/96	96/97	Comb.
Varieties												
Balady	13.35	18.10	15.72	16.63	24.42	20.52	10.05	15.81	12.93	2.87	3.09	2.98
Roomy	9.79	12.97	11.38	11.17	17.77	14.47	6.25	10.96	8.61	2.01	2.48	2.25
L.S.D. at %5	2.04	0.77	0.71	0.42	0.24	0.73	0.35	0.31	0.48	0.55	0.45	0.16
P_2O_5(kg/fad)												
0	7.74	11.40	9.44	9.63	14.46	12.05	4.55	7.90	6.23	2.31	2.86	2.59
15.5	11.73	16.52	14.12	13.64	20.38	17.01	8.00	12.84	10.42	2.49	2.78	2.64
31	15.79	18.68	17.24	18.70	28.44	23.57	11.91	19.42	15.66	2.52	2.72	2.62
L.S.D. at %5	1.24	0.88	0.66	0.86	0.47	0.68	0.56	0.39	0.45	N.S	N.S	N.S
Foliar nutrition												
0	9.67	13.82	11.75	10.51	15.46	12.99	4.68	7.99	6.34	2.39	2.83	2.61
K	12.10	16.42	14.26	16.15	23.61	19.88	10.55	16.09	13.32	2.52	2.74	2.63
Mg	12.93	16.37	14.65	15.05	24.20	19.62	9.23	16.07	12.65	2.42	2.79	2.61
L.S.D at %5	0.92	0.88	0.63	0.91	1.12	0.64	0.48	0.81	0.13	N.S	N.S	N.S

Table (5) : Effect of lupin varieties, phosphorus rates and foliar nutrition with K and Mg on 100-seed weight, seed yield/fad, shelling percentage and seed protein content %.

Treatments	100-seed weight(g)			Seed yield (kg/fad)			Shelling percentage			Seed protein content %.
	95/96	96/97	Comb.	95/96	96/97	Comb.	95/96	96/97	Comb.	Comb.
Varieties										
Balady	23.11	22.24	22.67	666.85	728.85	697.85	56.87	62.25	59.56	40.35
Roomy	28.74	29.56	29.15	487.04	544.26	515.65	53.39	59.01	56.20	33.77
L.S.D. at %5	0.25	0.80	0.52	40.88	18.75	22.39	0.76	1.28	1.13	0.12
P_2O_5(kg/fad)										
0	21.29	20.44	20.87	441.83	486.39	464.11	47.50	53.87	50.68	36.25
15.5	27.04	26.34	26.69	575.11	635.28	605.19	56.68	61.65	59.17	37.21
31	29.43	30.91	30.17	713.89	788.00	750.94	61.22	66.36	63.79	37.72
L.S.D. at %5	0.77	1.08	0.49	27.49	43.89	20.92	1.01	2.14	1.06	0.57
Foliar nutrition										
0	18.65	19.70	19.18	468.72	508.22	488.47	43.63	50.69	47.16	36.07
K	30.48	29.68	30.08	645.06	683.44	664.25	62.61	66.31	64.46	37.48
Mg	28.64	28.30	28.47	617.06	718.00	667.53	59.16	64.88	62.02	37.63
L.S.D at %5	0.71	0.47	0.46	21.95	36.90	19.85	1.33	1.55	1.00	0.90