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EFFECT OF IRRIGATION REGIME AND PHOSPHORUS, POTASSIUM FERTILIZATION RATES ON YIELD AND PROTEIN OF LENTIL (*LENS ESCULENTA*, MOENCH).

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ABSTRACT

Two field experiments were conducted during 2004/2005 and 2005/2006 seasons at Assiut Univ. Exp. Farm, to study the response of lentil cv. Giza 9 to irrigation management and potassium, phosphorus fertilizers rates. Three levels of water regime were applied after sowing: no irrigation (I_0), one irrigation at branching (I_1), two irrigation at branching and at pre-flowering (I_2) and three irrigation at branching, pre-flowering and pods filling (I_3). P and K fertilization rates applied were: (zero kg P and zero kg K (P_0 + K_0) (as control), 30 kg P_2O_5 + 24 kg K_2O (P_1 + K_1), 45 kg P_2O_5 + 24 kg K_2O (P_2 + K_1), 30 kg P_2O_5 + 48 kg K_2O (P_1 + K_2), and 45 kg P_2O_5 + 48 kg K_2O/fed (P_2 + K_2).

Results indicated that plants received two irrigations (I_2) produced the highest values of plant height, (42.94 cm), number of branches /plant (4.72), seed index; (27.52 g), seed yield, kg/plot (0.92) and seed yield, g/plant (1.25), while plants that received less water supply (I_0) produced the lowest values of these traits. Also, plants received 24 kg K_2O + 45 kg P_2O_5 produced the highest values of plant height, cm (44.08), number of branches/plant (5.19), number of pods/plant (44.90), seed index, (27.58 g), seed yield, kg/plot (1.29) and seed yield, g/plant (1.08), compared with unfertilized plants. Regarding to the interaction between irrigation and potassium, phosphorus fertilizers, two irrigations with 45 kg P_2O_5 + 24 kg K_2O gave the highest values for all traits.

INTRODUCTION

Lentil is an important protein source for the people all over the word especially in West, South Asia and North Africa countries. Lentil is one of the best cheapest sources of vegetable protein and provides a good source of minerals and essential amino acids for human consumption. Lentil seeds contain about 67% total carbohydrate and 24-30% crude protein. It is usually grown as a winter crop, on the marginal of valley lands where rainfall is low and soil productivity is poor. Lentil is an old traditional crop in Egypt, the cultivated area of lentil decreased drastically since 1980, reaching about 2380 fed in 2005, and 2500 fed in 2007 with total production of 1800 ton in 2007 (FAO, 2007). Total production is still below the country requirements, therefore, increasing lentil production is one of the major targets of the agricultural policy either by increasing lentil cultivated area or/and productivity. The lentil area can be expanded in reclaimed lands under rained conditions outside the Nile Valley and by planting lentil as a catch crop before cotton in the old land (Hamdi and Ezzat, 1998).The imports of lentil seeds increased to 5000 ton in 2005 with a value of 5.0 million US dollars (FAO, 2005).

In Egypt, legume crops can offer a partial solution to the protein problem. Lentil plays a dominant role in human nutrition as a protein source especially in the rural areas. Before the construction of the high dame in 1966, lentil was cultivated as a basin crop with low amount of water. Now days, lentil has been cultivated under perennial irrigation system. No fertilization was applied depending on the large amount of mud sediment from the annual flood. Average lentil yield declined under the new irrigation system after the high dame started to function, because the annual supply of potassium from flood stopped too. Water management was studied in order to maximize lentil yield under such conditions along with research on fertilizer effects on yield. Kamel *et al.* (1990) reported that the critical stage for lentil irrigation and the optimal watering regime was the double irrigations regime applied at seedling and pre-flowering. They found that three irrigations given at 3, 9 and 15 weeks (at seedling, pre-flowering and pod formation stages, respectively) from sowing produced the greatest number of seeds/plant, seed weight/plant and seed yield/fed. They added that one irrigation applied at 12 weeks (flowering stage) from planting gave the lowest values. They concluded that pre-flowering irrigation (9 weeks after sowing) was essential for lentil.

It is known P fertilizer significantly increase seed yield due to the fact that P increases the consumptive use of water and water use efficiency, resulting. from more root extension and more soil moisture utilization (Tawaha and Turk 2002). Potassium fertilizer plays a major roles in the physiological processes in plants such as transportation of solutes, stomata's movement, and enzymes activation in plants. Despite the few published studies on potassium effects on lentil, in Egypt, El-Desoky *et al.* (1993) reported that the application of 90 kg K_2O/fed significantly increased lentil yield. Phosphorus is one of the essential elements for optimum growth of lentil plants. It plays an important role in the establishment of legumes seedlings, root and shoot growth and it is especially needed for nitrogen fixation by Rhizobium bacteria.

Fertilizers management is a major factor responsible for poor lentil productivity and the plants response to the application of fertilizers depends on the available nutrient status of soils (Singh and Marok 1981). Phosphorus fertilizer increased the yield lentil more on loamy sand soil than on sandy loam soil, which may be attributes to the lower level of available phosphorus in the loamy sand soil (Sekhon *et al.*, 1983).

Accordingly, this study aimed to investigate the effect of irrigation regime and phosphorus, potassium fertilization rates on yield and quality of lentil.

MATERIALS AND METHODS

The present study was carried out at Assiut Univ. Exp. Farm. Assiut, Egypt during 2004/2005 and 2005/2006 seasons to investigate the response of lentil crop to irrigation regime phosphorus and potassium fertilization rates. Three levels of water regime were applied after sowing: no irrigation (I_0), one irrigation at branching (I_1), two irrigation at branching and at pre-flowering (I_2) and three irrigation at branching, pre-flowering and pods filling (I_3). A split - plot design with 3 replicates was used including different irrigation treatments as main plot and K and P fertilization (zero kg P and zero kg K ($P_0 + K_0$) (as control), 30 kg P_2O_5 + 24 kg K_2O ($P_1 + K_1$), 45 kg P_2O_5 + 24 kg K_2O ($P_2 + K_1$), 30 kg P_2O_5 + 48 kg K_2O ($P_1 + K_2$), and 45 kg P_2O_5 + 48 kg K_2O/fed ($P_2 + K_2$) as sub - plot. Fertilization was added as potassium sulphate 48% K_2O and calcium superphosphate 15% P_2O_5 before sowing. Nitrogen fertilizer was added with sowing at rates of 15 kg N/fed as urea 46% N. Lentil cultivar Giza 9 was used and inoculated with strain of Rhizobium (*Rhizobium leguminosarum* Vulgaris.). Sowing dates were on Nov. 10, 2004 and Nov. 15, 2005 with seeding rate of 70 kg /fed. The plot area was 10.5 m^2 (1/400 fed) containing 10 ridges 3.5 meter in length and 0.3 meter in width. All cultural practices were applied as recommended for lentil production in Upper Egypt except the treatments under investigation. Physical and chemical properties of the experimental soil were determined before sowing and presented in Table (1).

Table 1: Physical and chemical properties of a representative soil samples.

Traits	2004/2005	2005/2006
Particle size distribution		
Silt (%)	26.8	27.2
Sand (%)	25.7	24.3
Clay (%)	47.5	48.5
Texture	Clay	Clay
Organic matter (%)	1.77	1.82
Field capacity (%)	43.00	42.6
ECe (ds/m)	0.78	0.75
pH (1:1 suspension)	7.8	7.6
Total nitrogen (%)	0.68	0.70
$CaCO_3$ %	3.6	3.8
Extractable P (ppm)	8.7	9.2
Extractable K (ppm)	121	124

At maturity sample of 10 plants from each sub - plot were taken at random and the following data were recorded: Plant height (cm); Number of branches/plant; Number of pods/plant; Seed yield/plant (g) and Seed index (1000-seed weight g).

At harvest, plants grown in plot from each treatment were taken to determine: Seed yield (kg/plot); Harvest index as seed yield/ground biomass; Straw yield (kg/plot) and Protein concentration (%): Total nitrogen in seeds was determining using Micro-Kjeldahl method as described by A.O.A.C. (1980) and protein concentration was calculated by multiplying nitrogen percentage by a factor of 6.25.

Combined analysis of variance over years was performed on the data of two growing seasons according to Gomez and Gomez (1984), after testing the homogeneity of the error according to Bartlett, 1937. The least significant difference (L.S.D.) test at the 5% level of probability was used to compare the differences among means.

RESULTS AND DISCUSSION

Effect of irrigation

Data in Table 2 show that irrigation treatments significantly influenced all studied traits except harvest index over the two seasons. Plants received two irrigations (I_2) one at branching and the other at pre-flowering produced the highest values of plant height (42.94 cm), number of branches/plant (4.72), number of pods/plant (41.11), seed yield/plant (1.25 g), seed yield/plot (0.92 kg), straw yield/plot (1.04 kg) and seed index (27.52 g), while plants received less water supply (I_0) produced the lowest values of these traits except protein percentage. Protein content in lentil seeds was significantly affected by irrigation regimes. The maximum value of protein (22.48%) was obtained from plants received less water supply (I_0), while the lowest one (21.71%) was obtained from plants received three irrigation (I_3) Possibly by forcing the plant metabolism to increase the protein synthesis in seeds. Contrary results were reported by Abd El-Rahim *et al.* (1985) who found that crude protein was increased as irrigation frequency increased, while ash percentage tended to increase as irrigation frequency decreased.

Table 2: Main effect of irrigation (I) and potassium and phosphours fertilizers rates (K + P) on some studied traits of lentil over two seasons.

Item	Plant (height cm)	No. of branches /plant	No. of pods/plant	Seed yield/plant (g)	Seed yield (kg/plot)	Straw yield (kg/plot)	Seed index (g)	Harvest index (H.I)	Protein (%)
Irrigation regime									
I_0	40.02	3.84	36.05	1.19	0.75	5.58	25.92	0.19	22.48
I_1	41.98	4.47	41.26	1.22	0.84	5.77	27.09	0.20	22.51
I_2	42.94	4.72	41.11	1.25	0.92	6.04	27.52	0.22	22.23
I_3	41.67	4.15	40.18	1.19	0.81	6.12	27.19	0.19	21.71
L.S.D. 5%	1.47	0.54	0.28	0.04	0.09	0.21	0.25	-	0.29
Fertilizer rates									
Zero	36.67	3.34	33.7	1.14	0.65	4.95	26.25	0.20	22.16
$P_1 + K_1$	40.35	3.89	35.23	1.18	0.77	5.62	26.56	0.19	22.41
$P_2 + K_1$	44.08	5.19	44.90	1.29	1.09	6.20	27.58	0.23	22.59
$P_1 + K_2$	42.83	4.66	43.36	1.25	0.87	6.30	27.29	0.21	22.21
$P_2 + K_2$	44.34	4.39	41.06	1.22	0.78	6.33	26.97	0.19	21.78
L.S.D. 5%	1.4	0.4	1.85	0.03	0.05	0.25	0.28	-	-

(-)Not significant

In general, the increase in water supply caused an increase the plant size by increasing cell division and elongation and consequently increasing plant height (Lal *et al.*, 1988). On the other hand, the increase in plant height was accompanied by a reduction in branching; this is due to the fact that the increase in plant height reduces the activity of lateral buds and consequently reduced the ability of the plants to produce more branches (El-Far, 1994). Gendy *et al.* (1995) found that the increase in water supply caused an increase in vegetative growth by increasing cell division and elongation followed by taller plants than other treatments, but decreased seed set on the main stem and lateral branches as a result of increase in plant height which reduce the activity of lateral buds and consequently reduced the ability of the plants to produce more branches. Such increase could be attributed to the increase in pod number/plant and seed index value. Theib *et al.* (2004) reported that lentil experiences considerable drought stress during reproductive development, which reduces yields. Limited supplemental irrigation can boost and stabilize productivity. These results are in agreement with those obtained by Tomar and Singh (1991), Rathore *et al.* (1992a and b), Kumar *et al.* (1992) and El-Desoky *et al.* (1995).

Effect of fertilization

Data in Table 2 indicate that increasing potassium and phosphorus fertilization rates had significant effect on all studied traits except protein percentage and harvest index during the two seasons. Plants received 45 kg P_2O_5 + 24 kg K_2O (P_2 + K_1) produced the highest values of plant height (44.08 cm), number of branches/plant (5.19), number of pods/plant (44.90), seed yield/plant (1.29 g), seed yield/plot (1.09 kg), and seed index (27.58 g), compared with the unfertilized plants. Plants received 45 kg P_2O_5 + 48 kg K_2O (P_2 + K_2) produced the highest values of straw yield/plot (6.33 kg). These results are in accordance with those reported by Bakheit *et al.* (1989). Azad and Gill (1989) found that lentil response to phosphorus application was greater when applied to soil of low available phosphorus level. El-Far (1994) found that phosphorus application at a rate of 30 kg P_2O_5/fed significantly increased plant height. The reduction in water supply forced the plant metabolism to increase the protein synthesis in seeds. El-Mahdy (1994) reported that potassium fertilization had no significant effect on lentils yield as a main factor. It seems that potassium concentration is not a limiting factor in lentil production in the particular soil type of the experimental site.

Interaction between irrigation regime and fertilization

Interaction between irrigation frequency and potassium, phosphours fertilizer rates significantly affected most of the studied traits except protein percentage over the two seasons (Table 3). Data showed that plants received 45 kg P_2O_5 + 24 kg K_2O (P_2 + K_1) under two irrigations (I_2) produced the highest values of plant height (44.6), number of branches/plant (5.83), number of pods/plant (42.6), seed yield/plot (1.25 kg), seed yield/plant (1.39 g) and seed index (28.6). The maximum value of straw yield/plot (6.58 kg) was obtained from plants received 45 kg P_2O_5 +48 kg K_2O (P_2 + K_2) under three irrigations frequency. Protein content in seeds decreased significantly by fertilization X irrigation interaction, where the highest value (22.80%) was obtained with unfertilized plants (zero kg P + zero kg K) (control) under no or one irrigation. Increasing irrigation tended to increase the vegetative growth thereby raising straw yield and lowness of seed set of plants. (Harb, 1994) found that the decrease in water supply and nutrients resulted in a decrease in plant growth. This may explain that continuing lack of water starting from developing flowers primordial till fertilization may led to low appearance of florets primordial and decrease fertile flowers which in turn reduced the number of pods/plant and seed yield/fed. On the other hand, sufficient water irrigation increased plant height; number of branches/plant and dry weight/plant which led to an increase in the number and weight of pods/plant and seed yield. Similar results were recorded by Lal *et al.*, (1988) and Attia (1988), Sharma *et al.* (1987), Greco and Cavagnaro (1991), Rathore *et al.* (1992 a) and Anaam *et al.* (2003).

Table 3: Effects of interaction between irrigation rates (I) and potassium and phosphours fertilizers rates (K + P) on some studied traits of lentil over two seasons.

Item	Fertilization rate (kg/fed)	Plant height (cm)	No. of branches /plant	No. of pods/plant	Seed yield (g/plant)	Seed yield (kg/plot)	Straw yield (kg/plot)	Seed index (g)	Harvest index (H.I)	Protein (%)
I_0	Zero	34.70	2.95	27.4	1.125	0.53	4.45	25.4	0.17	22.80
	$P_1 + K_1$	38.42	3.62	32.6	1.146	0.68	5.48	25.2	0.19	22.74
	$P_2 + K_1$	42.80	4.23	41. 5	1.225	0.94	5.84	26.2	0.22	22.45
	$P_1 + K_2$	40.54	4.25	40.2	1.248	0.82	6.03	26.4	0.20	22.23
	$P_2 + K_2$	43.62	4.15	38.6	1.230	0.78	6.10	26.4	0.18	22.14
I_1	Zero	37.32	3.72	33.6	1.133	0.65	4.73	26.2	0.20	22.80
	$P_1 + K_1$	39.82	3.87	34.5	1.177	0.77	5.64	26.5	0.18	22.72
	$P_2 + K_1$	43.70	5.45	48.3	1.287	1.15	6.15	27.8	0.23	22.62
	$P_1 + K_2$	44.24	4.87	46.7	1.257	0.88	6.12	27.5	0.22	22.43
	$P_2 + K_2$	44.83	4.42	43.2	1.246	0.77	6.23	27. 5	0.19	21.96
I_2	Zero	38.43	3.95	35.3	1.155	0.76	5.20	26.6	0.21	21.45
	$P_1 + K_1$	42.72	4.20	37.4	1.193	0.82	5.75	27.2	0.20	22.25
	$P_2 + K_1$	44.60	5.83	46.2	1.385	1.25	6.35	28.6	0.25	22.80
	$P_1 + K_2$	43.72	4.98	44.4	1.274	0.95	6.47	27.9	0.23	22.63
	$P_2 + K_2$	45.25	4.64	42.3	1.253	0.82	6.43	27.3	0.20	22.00
I_3	Zero	36.24	2.74	38.5	1.143	0.64	5.40	26.8	0.20	21.55
	$P_1 + K_1$	40.42	3.88	36.4	1.183	0.82	5.60	27.4	0.19	21.94
	$P_2 + K_1$	45.20	5.24	43.7	1.275	1.00	6.45	27.7	0.21	22.50
	$P_1 + K_2$	42.83	4.53	42.2	1.210	0.83	6.58	27.4	0.18	21.53
	$P_2 + K_2$	43.64	4.35	40.2	1.130	0.75	6.55	26.7	0.17	21.02
L.S.D.5%		4.20	1.22	2.42	0.15	0.11	0.82	0.30	-	0.50

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تأثير الري ومعدلات التسميد الفوسفاتي والبوتاسي على المحصول والجودة في العدس

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أجريت تجربتان حقليتان بمزرعة التجارب بجامعة أسيوط خلال موسمي الزراعة ٢٠٠٥/٢٠٠٤و ٢٠٠٦/٢٠٠٥ لدراسه تاثير الرى والتسميد الفوسفاتي والبوتاسي على المحصول ، مكونات المحصول والجودة فى العدس حيث صممت التجربه في قطع منشقه مرتين في ثلاث مكررات

وتتلخص النتائج كما يلى :

١- كان تاثير الري معنويا لكل الصفات المدروسه ماعدا معامل الحصاد حيث تسبب اعطاء ريتين (عندالتفريع وعند التزهير) فى زيادة معنويه لكل الصفات المدروسه (طول النبات، عدد الأفرع ، عدد القرون ، معامل البذور ، محصول بذور النبات الواحد ، محصول بذور القطعه التجريبيه) بينما أدي ري نباتات العدس بثلاث ريات (عند التفريع وعند التزهير وعند امتلاء القرون) الي زيادة محصول القش كما أن اعطاء رية واحدة فقط عند التفريع أنتج أعلي محتوى بروتين فى البذور (٢٢,٤٨%).

٢- كان تاثير التسميد معنويا لكل الصفات المدروسه ماعدا معامل الحصاد و نسبه البروتين فى البذور حيث أدي استخدام التسميدالبوتاسي والفوسفاتي بمعدل ٢٤كجم بو٢أ٥ + ٤٥ كجم فو٢أ٥/ فدان الي زيادة طول النبات (سم ٤٤,٨) وكذلك عدد الأفرع (٥,١٩ فرع/ نبات) وعدد القرون (٤٤,٩ قرن/نبات) ومحصول البذرة للنبات (١,٢٩جم/ نبات) و معامل البذور (٢٧,٥٨جم) ولكن التسميد بمعدل ٤٨كجم بو٢أ + ٤٥ كجم فو٢أ٥/فدان أدي الي زيادة محصول القش (٦,٣٣كجم) .

٣- كان للتفاعل بين الري والتسميد تاثيرا معنوي على كل الصفات المدروسه حيث تسبب اعطاء ريتين (عندالتفريع والأخرى عند التزهير) مع التسميد بمعدل ٢٤كجم بو٢أ٥ + ٤٥ كجم فو٢أ٥/ فدان فى الحصول على أطول النباتات وأكثر عدد أفرع (٥,٨٣ فرع/ نبات) وعدد قرون (٤٦,٢ قرن/نبات) وأعلي محصول بذور للنبات الواحد (١,٣٩جم/ نبات) وأعلي محصول بذور القطعه التجريبيه (١,٢٥) و معامل البذور (٢٨,٦) و أعلي محتوى بروتين فى البذور (٢٢,٨٠ %) و أعلي معامل الحصاد (٠,٢٥).