مجلة جامعة كركوك للعلوم الزراعية ... المجلد (9) العدد (3) 2018
Journal of kirkuk University for Agricultural Sciences ...Vol (9) No. (3) 2018

Effect of Levels of Phosphorus and Iron on Growth, Yield and Quality of Flax (*Linum usitatissumum L*)

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- Date of research received 30/6/2016 and accepted 27/2/2017

Abstract

The study include the effect of three levels of phosphorus (0, 50, 100 kg TSP ha^{-1} with three levels of Cheated iron (0, 4, 8 kg Fe-EDDHA ha^{-1}) and their combinations on growth characters, yield and quality of flax using split plot design with three replicates. The results indicated that the highest values of oil%, oil yield , P% , protein% , Fe concentration (23% , 346.47 kg .ha^{-1} ,6.65 %, 27.47 % , 151.90 ppm) were recorded from treatment combinations (P_0 Fe_1, P_1 Fe_0, P_2Fe_1, P_1Fe_0 and P_2Fe_2) respectively. While the lowest values of P%, protein and Fe concentration were recorded from (P_0Fe_0), and the lowest values of oil% and oil yield were recorded from P_0Fe_2 and P_2Fe_2 respectively. On the other hand increase in levels of applied phosphorus and iron caused increase in seed index from (5.65 to 6.53 g) and from (5.24 to 6.39 g) respectively. The highest biological yield (7031.07 kg ha^{-1}) and seed yield (1645.78 kg ha^{-1}) were recorded from treatment combinations (P_0Fe_2), while the lowest values of them (2986.20 and 868.33 kg ha^{-1}) were obtained from treatment combination (P_0Fe_0 and P_1Fe_2) respectively.
Keywords: Flax, Oil content, Chelated-Fe, Calcareous soil

تأثير مستويات الفسفور والحديد على نمو وانتاج و نوعية الكتان (Linum usitatissumum *L*)

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- تاريخ تسلم البحث 2016/6/30 وقبوله 2017/2/27

الخلاصة

تضمنت الدراسة تاثير ثلاث مستويات من الفسفور (0 و 50 و 100 كغم TSP هكتار$^{-1}$) و ثلاث مستويات من الحديد المخلبي (0 و 4 و 8 كغم Fe-EDDHA هكتار$^{-1}$) و تداخلهما على صفات النمو و انتاج و نوعية الكتان باستخدام تصميم القطع المنشقة وبثلاث مكررات. اشارت النتائج حصول اعلى القيمة لنسبه الزيت المئوية (23%) و الانتاج الزيت (346.47) كغم/ هكتارو نسبة الفسفور المئوي (6.65%) و نسبه البروتين المئوية (27.47%) و تركيزالحديد (151) ملغم/ كغم سجلت في المعاملات التداخلية (P_2Fe_2, P_1Fe_0, P_2Fe_1, P_1Fe_0, P_0Fe_1) على التوالي. بينما سجلت ادنى القيم لنسبه المئوية للفسفور و البروتين و تركيز الحديد في معاملة (P_0Fe_0) . وادنى قيمة لنسبة الزيت المئوية سجلت في (P_0Fe_0) بينما سجلت اقل نسبة لانتاج الزيت في معاملة (P_2Fe_2) . وادى استخدام مستويات الحديد و الفسفور الى زيادة حاصل البذور (من 5.65 الى 6.53) غم و من (5.24الى6.39) غم على التوالي. سجلت اعلى قيمة للانتاج الحيوي (7031.07) كغم /هكتار و انتاج البذور (1645.78) كغم/ هكتارفي المعاملة العاملية (P_0Fe_2). بينما اقل القيم (2986.20 , 868.33) كغم/ هكتار سجلت في معاملات التداخلية (P_0Fe_2, P_0Fe_0) على التوالي.
الكلمات المفتاحية: الفسفور، الحديد، الكتان.

Introduction

Flax (*Linum usitatissumum L*) for seed production has emerged as an alternative crop species that allow increased diversification of cropping system in temperate environments (Khalifa et al., 2011).

Flax is grown all over the world for the oil extraction from the seeds and for its fibers, which are made into linen and other clothes. Various parts of the plant have been used to make fabric, dye, paper, medicines, fishing nets, hair gels and soap, it is also grown as an ornamental plants.

The cultivated area of flax is decreasing yearly, due to great competition of other economic winter crops resulting a gap between production and consumption. Therefore it is necessary to increase flax productivity per unit area which could be achieved by using high yielding cultivars and improving the fertilization (Hussein, 2007) and improving the agricultural treatments (Nofal et al., 2011 and Grant et al., 2012).

One of these treatments is mineral fertilizers which are regarding as important factors for vigorous growth and consequently higher yield of different plant species (McKenzie and Allan, 2013). Nutritional disorders creating deficiency symptoms can be affected by unbalanced fertilizer application, on the other hand the availability of P and micronutrients such as Fe, Mn, Zn and Cu are affecting by soil pH, soil $CaCO_3$, soil organic matter and soil texture (Mengel and Frnest, 2010).

Plants need P throughout their life cycle, especially during early growth stages for cell division and during maturity stage for seed formation and increase in seed weight. Placement of P in-row with cereal and oil seed crops has been the traditional method used for P fertilization in Alberta (Lafoand et al., 2003).

Iron is an essential micro element for plant growth; it plays an important role in the formation of chlorophyll A and chlorophyll B, carbohydrate production, cell respiration and chemical reduction of nitrate (Mousa et al., 2010). Iron is also necessary for the proper functioning of many plant enzyme systems that influence respiration and plant metabolism and helps oxidize sugar for energy (Ibrahim, 2009).

Since the availability of phosphorus and iron is low in calcareous soil, due to high soil pH and high $CaCO_3$ in the soil, this reduces the ability of nutrient uptake by plants (Hocking and Jand, 1993). For these reasons this study was selected to high light on the effect of levels of phosphorus and iron on growth characters, yield and quality of flax.

Material and methods

The field experiment was laid out at Grdarasha Agricultural farm, College of Agriculture, University of Salahaddin, Erbil, during growing season of (2012-2013). The soil was Silty Clay Loam in texture, with electrical conductivity about 0.42 ds m^{-1}at 25 C^0 , neutral in reaction (pH 7.5), organic matter about 10.0 g kg^{-1} total and active $CaCO_3$ are 24.3 and 4.5 g kg^{-1} respectively, available phosphorus 2.5 mg kg-1 soil, and soluble Ca^{+2}, Mg^{+2}, Na^+, K^+, HCO_3, Cl^- and $SO_4^=$ about 2.63, 0.72, 0.43, 0.2, 2.32, 0.54 and 1.32 mmolc L^{-1} respectively. The treatments were arranged in split-plot design with three replicates, the three levels of Triple super phosphate (TSP)were assigned in the main plots (0, 50, 100 kg TSP ha^{-1} and the three levels of Cheated iron (0, 4, 8 kg Fe-EDDHA ha^{-1}) were assigned in the sub-plot at sowing time.

Seeds were sowing on (1st December, 2012) in rows 1.5 m length with 20 cm apart and each experimental unit consisted of 5 rows. Urea fertilizer (46% N) was applied to the plot (100 kg Nitrogen ha^{-1}) was applied in the form of urea 46% N to each plot before seeding. The experiment was done under rain feed condition with annual rainfall of 350 mm $year^{-1}$.The seeding rate was 55 kg ha^{-1} , at full maturity stage, ten plants were taken from each sub- plot (30 plants per treatment) to estimate or recording the following morphological and yield characters :

1-Plant height (cm). 2-Technical stem length (cm). 3- Fruiting zone length (cm). 4-Stem diameter (mm). 5- Number of fruiting branches /plant 6- Number of capsules per plant. 7- Number of seed per capsules. 8- Specific seed weight (seed index) or weight of 1000 seeds (g). 9- Biological yield kg ha^{-1}. 10 - Seed yield kg ha^{-1}. 11- Harvesting Index (HI%) .

Plants were harvested on 26th of May, 2013; capsules were removed carefully to determine straw yield and seed yield (kg ha^{-1}).Seed oil content was determined by soxhlet extraction apparatus using hexane according to the methods described by (A. O. A. C., 1975). The oil yield was calculated by multiplying seed yield ha-1 by seed oil percentage. Total Nitrogen was determined using Kjeldahl method then protein% was determined as follow:

Protein% =N % * 6.25.

P and Fe were determined using spectrophotometer and AAS respectively.

The data were statistically analyzed according to the technique of analysis of variance for Split plot design using SPSS program version 20 the difference among means of treatments were tested using Duncan's multiple range test at level of significant 5%.

Results and Discussion

Table (1) shows that the phosphorus levels affected significantly on harvesting index, stem diameter, and seed index only, the highest values of them (0.30, 2.11 mm, 6.53 g) were recorded from(P_0, P_1 , P_2 treatments respectively)

Table (1) Effect of levels of phosphorus on yield components.

	Biological yield Kg ha^{-1}	Seed yield Kg ha^{-1}	HI%	Stem length Cm	Technical length cm	Fruit length cm	Diameter mm	Brunch No	Capsule No	Seed/ capsule	Seed index g
P0	5306.93 a	1274.07a	0.24b	57.74 a	39.80 a	18.5 a	1.70 b	5.41 a	20.72 a	8.61 a	5.65 b
P1	4310.28 a	1317.85a	0.30 a	55.12 a	39.49 a	15.63 a	1.90 ab	5.58 a	21.37 a	8.71 a	5.64 b
P2	4202.34 a	1240.52a	0.29 a	60.24 a	41.89 a	18.24 a	2.11 a	5.89 a	23.11 a	8.42 a	6.53 a

This may be due to the role of applied P in root growth, nutrient uptake and seed formation (Mengel and Frnest, 2010) . On the other hand the concentration of the available phosphorus is low from most of the calcareous soils as recorded by Duhoki (2016). For this reason the plant respond to phosphorus application.

Table (2) Explains that the levels of applied iron affected significantly on biological yield, harvest index and seed index, the highest values of them (5994.07 kg ha^{-1}, 0.30, 6.39 g) were recorded from treatments (Fe_1, Fe_0, Fe_2) respectively this may be due to the role of iron in chlorophyll formation then increase in biological yield and seed index similar results were obtained by Sharif (2016) since most of the studied soils in Kurdistan region contains low concentration of available iron or the concentration of iron is below the critical value (2.57 mg kg^{-1} soil).

Table (2) Effect of Iron levels on yield components on flax.

Fe levels	Biological yield Kg ha^{-1}	Seed yield Kg ha^{-1}	HI%	Stem length Cm	Technical length cm	Fruit length cm	Diameter mm	Brunch No	Capsule No	Seed/ capsule	Seed index g
Fe_0	3858.75b	1180.22a	0.30a	55.46 a	39.16 a	16.30 a	1.82 a	5.44 a	20.11 a	8.91 a	5.24 b
Fe_1	5994.07a	1476.85a	0.28ab	56.40 a	39.48 a	17.34 a	1.87 a	5.46 a	21.52 a	8.42 a	6.18 a
Fe_2	4666.73ab	1175.37a	0.26b	61.26 a	42.54 a	18.71 a	2.01 a	5.98 a	23.57 a	8.41 a	6.39 a

The statistical analysis indicated that the interaction treatments influenced significantly at level of significant 0.05 on biological yield ,harvest index and seed index only (table 3), the highest values (7031.07 kg.ha^{-1} , 0.31 % 7.09 g) were recorded from treatment combinations(P_0Fe_2, P_2Fe_0, P_2Fe_1) respectively, while the lowest values 2986.20 kg.ha^{-1} ,0.21 and 4.58g were obtained from (P_0 Fe_0 , P_0 Fe_1 , P_1 Fe_0) this may be due to the single role of phosphorus as mentioned before or this may be due to the single effect of the studied factors or the interaction between P_2 and Fe_1 may create the best condition for plant growth.(Hocking and Jand, 1993; Mengel and Frnest, 2010). Or may be due to the low available concentration of both iron and phosphorus inn the studied soils since the concentration of Fe and P for most of the studied and soil were not adequate for plant growth (Sharif, 2016; Ismael and Esmail, 2014).

Table (3): Interaction effect of P and Fe on yield components and growth characters of flax.

Interaction p and Fe	Biological yield Kg ha^{-1}	Seed yield Kg ha^{-1}	HI%	Stem length cm	Technical length cm	Fruit length Cm	Diameter mm	Brunch No	Capsule No	Seed/ capsule	Seed index g
P_0 Fe_0	2986.20^{d}	905.33^{a}	0.30^{ab}	55.73^{a}	38.90^{a}	16.83^{a}	1.58^{a}	4.77^{a}	15.63^{a}	8.57^{a}	5.13^{bc}
P_0 Fe_1	5903.51^{ab}	1271.11^{a}	0.21^{c}	56.07^{a}	37.93^{a}	19.80^{a}	1.75^{a}	5.60^{a}	21.53^{a}	6.97^{a}	5.89^{ab}
P_0 Fe_2	7031.07^{a}	1645.78^{a}	0.23^{bc}	61.43^{a}	42.57^{a}	18.87^{a}	1.83^{a}	5.57^{a}	25.00^{a}	6.71^{a}	5.91^{ab}
P_1 Fe_0	5138.73^{abcd}	1549.55^{a}	0.29^{ab}	52.93^{a}	37.13^{a}	15.80^{a}	1.8^{a}	5.37^{a}	20.13^{a}	7.61^{a}	4.58^{c}
P_1 Fe_1	4563.31^{bcd}	1535.67^{a}	0.34^{a}	59.47^{a}	42.23^{a}	17.23^{a}	2.14^{a}	6.00^{a}	23.57^{a}	7.31^{a}	6.17^{ab}
P_1 Fe_2	3228.80^{cd}	868.33^{a}	0.26^{abc}	57.70^{a}	41.43^{a}	16.27^{a}	2.14^{a}	6.20^{a}	24.57^{a}	6.97^{a}	6.00^{ab}
P_2 Fe_0	3451.31^{cd}	1085.77^{a}	0.31^{a}	60.17^{a}	41.40^{a}	18.43^{a}	2.11^{a}	5.40^{a}	22.63^{a}	7.07^{a}	6.50^{a}
P_2Fe_1	5415.38^{abc}	1623.78^{a}	0.29^{ab}	62.87^{a}	42.83^{a}	20.03^{a}	2.07^{a}	6.07^{a}	22.13^{a}	7.64^{a}	7.09^{a}
P_2Fe_2	3740.33^{bcd}	1012.00^{a}	0.28^{abc}	52.97^{a}	39.10^{a}	13.87^{a}	1.76^{a}	5.37^{a}	20.40^{a}	7.64^{a}	6.16^{ab}

Table (4) refers to significant effect of phosphorus on oil content (%), oil yield ($kg.ha^{-1}$), phosphorus %, protein % Fe concentration (ppm) of flax , the highest value of them (21.92%, 288.87 $kg.ha^{-1}$, 6.00% , 24.31% , 141.89 ppm) were recorded from P_1 treatment except the highest value of P% in flax (6.0%) and Fe concentration (141.89 ppm) were recorded from P_2 treatment respectively , this explain that the application of phosphorus fertilizer to a certain level (P_1) caused a significant increase in most of the studied character ,this may be due to obtaining the best nutrient balance in plant in case of treatment (P_1) but at the highest level of P (treatment P_2) the concentration of (P) increased in plant then caused decrease in protein % of plant (table 4).

Table (4) Effect of phosphorus levels on chemical characters of flax.

P levels	Oil %	Oil yield	P%	Protein	Fe ppm
P_0	20.47_b	260.80_a	4.07_c	21.51_b	112.60_b
P_1	21.92_a	288.87_a	4.73_b	24.31_a	123.11_b
P_2	18.40_c	228.26_b	6.00_a	23.70_a	141.89_a

Table(5) indicated to significant effect of iron on oil% ,phosphorus content, protein% and Fe concentration (ppm) of flax ,the highest values of them(21.40%, 5.35%, 24.53% , 158.80) were recorded from treatments (Fe_0 , Fe_2 , Fe_0 and Fe_2) respectively . Similar results were recorded by (Narina et al., 2012 ; Mahmood and Sarkees, 2014).

Table (5) Effect of Iron levels on some chemical properties of flax.

Fe levels	Oil %	Oil yield	P%	protein	Fe ppm
Fe_0	21.40a	252.57a	4.90 b	24.53 a	112.60b
Fe_1	20.15b	297.58a	4.55 c	22.93 ab	146.89a
Fe_2	19.23c	226.02a	5.35 a	22.06 c	158.80a

The highest oil and protein percentage may be due to the dilution effect since oil yield, seed yield & nitrogen content of seed with decrease in seed yield in Fe_2 then the highest protein contented was recorded from control treatments. The soil or foliar application of Fe significantly increased N and P uptake from soil and increased their content in flax plants (El-Nagdy et al., 2010 and You et al., 2007).

Table (6) shows the significant effect of interaction treatments at level of significant 5% on studied chemical properties ,the highest value of oil%, oil yield, P%, protein% and Fe concentration were recorded (23%, 346.47, 6.65, 27.47, 151.90) from (P_0 Fe_1, P_1 Fe_0, P_2Fe_1, P_1Fe_0, P_2Fe_2)respectively. This may be due to the single effect of the studied factors. Or the interaction between phosphorus levels and iron created different growth conditions for plant growth which caused above results (Mahmood and Sarkees, 2014).

Table (6) Interaction effect of P and Fe on some chemical properties of flax.

Interaction P and Fe	Oil %	Oil yield	P%	protein	Fe ppm
P_0 Fe_0	21.15_{bc}	190.68^{ab}	4.15^{cd}	20.94^{c}	109.70^{a}
P_0 Fe_1	23.55_{a}	299.66^{ab}	3.55^{d}	26.50^{ab}	111.50^{a}
P_0 Fe_2	16.70_{d}	278.23^{ab}	4.50^{cd}	17.09^{d}	116.60^{a}
P_1 Fe_0	22.35_{ab}	346.47^{a}	4.90^{bc}	27.47^{a}	113.11^{a}
P_1 Fe_1	23.45_{a}	308.55^{ab}	4.90^{bc}	22.56^{bc}	119.00^{a}
P_1 Fe_2	20.70_{c}	303.65^{ab}	5.65^{b}	25.19^{ab}	137.22^{b}
P_2 Fe_0	16.95_{d}	224.60^{ab}	5.70^{b}	19.38^{cd}	132.89^{b}
P_2Fe_1	17.55_{d}	275.29^{ab}	6.65^{a}	26.53^{ab}	$140.88b^{c}$
P_2 Fe_2	19.95_{c}	177.53^{b}	4.40^{cd}	22.91^{bc}	151.90^{c}

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