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Effect of Sowing Dates and Compound Fertilizer NPK on Growth and Yield of Flax (*Linum usitatissimum* L.)

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Abstract: Two field experiments conducted during winter growing season 2019-2020 at Ninevah Governorate at two locations: Talkief and Al-Hamdaniya. The main objective was to study the effect of two sowing dates (November 17 and December 17), and four levels of $N_{15}P_{15}K_{15}$ fertilizers (0, 100,150 and 200 kg. ha^{-1}) on growth and yield of flax under rainfed conditions. The experiment carried out in Randomized Complete Block Design (R.C.B.D.), with three replications. The results showed that there were significant differences between sowing dates in all the studied characters in the both locations, the date of sowing (November 17) gave the highest rate of plant height, number of fruiting branches.$plant^{-1}$, number of capsules.$plant^{-1}$, number of seeds.$capsule^{-1}$, 1000 seed weight , seed yield, seed oil percentage and linolenic acid percentage. Adding to the soil NPK fertilizer with 200 Kg NPK.ha^{-1} was superior in some characters i.e. plant height, number of fruiting branches.$plant^{-1}$, number of capsules.$plant^{-1}$ and number of seeds.$capsule^{-1}$ in Al-Hamdaniya location, whereas linolenic acid percentage was superior in Talkief location, Also highest seeds oil percentage was obtained in both locations. The interaction between date (November 17) with 200 kg.ha^{-1} of $N_{15}P_{15}K_{15}$ fertilizer was significantly superior in linolenic acid percentage in Talkief location only.

Keywords: Compound fertilizer, Flax, Linolenic acid, Sowing dates.

Introduction

Flax (*Linum usitatissimum* L.) is an important industrial crop and is grown either to obtain dry oil from seeds and fibers from stems. It is the third largest fiber crop and one of the five major oil crops in the world; the oil in the seeds of flax ranges between 30 -45% and its oil is non-edible because of higher content of linolenic acid (47-58%) (Mueller *et al.,* 2010). The oil is important in the manufacture of paints, soap and printer's ink and for medical purposes or for obtaining fibers from the stems are used in the manufacture of linen textiles, denomination, rugs, insulating material and tyre of cars (El-Borhamy & Khedr, 2017).

The average productivity of flax per unit area in Iraq is very low, and it is only at the levels of research, so it is necessary to expand the sowing of this crop and increase its yield per unit of area through some agricultural operations, including the dates of sowing and the use of fertilizers especially macro-nutrients including NPK Fertilizer (Berti, *et al*., 2010).

Optimum sowing date is very important management tool in minimizing the negative impact of high temperature and moisture stress during the critical flowering and seed filling periods, the appropriate sowing dates is very important since it ensures good seed germination, as well as timely appearance of seedling and optimum development of the root system (Kumari, 2020).

Application of macronutrient i.e. nitrogen, phosphorus and potassium, is essential for enhancing flax growth and productivity. Nitrogen is often the most important plant nutrients which is a structural component of nucleic acids, chlorophyll formed, nucleotides, phosphatides, alkaloides, enzymes, hormones, Vitamins so led to increase plant efficiency in water consumption, resistance to external stress, delayed aging and extend the life of the plant. phosphorous fertilizer plays a major role in regulating photosynthesis reactions, a source of energy and regulate the translocation process (Mengel *et al*., 2001).

The potassium element contributes to the formation of proteins and carbohydrates, the transfer of sugars from the leaves to the seeds, and a stimulant agent for enzymes that contribute to the process of photosynthesis. It also contributes to the regulation of the osmotic effort of the plant cell and thus maintains its swelling pressure and thus increases the plant's ability to resist conditions of drought, frost, salinity, fungi and diseases. (Abd El-Daiem & El-Borhamy, 2015).

Jana *et al.* (2018) found when using of three sowing dates (15 November, 22 November and 29 November) indicated the superiority of the first date (15 November) in the characters no. of capsules plant^{-1}, seed yield and seed oil percentage. The results of Kumari (2020) in his experiment in which he used four sowing dates (15 November, 1 December, 15 December and 31 December) showed that the date of the first sowing (15 November) was significantly better in the characters of no. of capsules. plant^{-1}, 1000 seeds weight and seed yield. Al-Juheishy (2020) used three sowing dates (1 November, 15 November and 30 November) in their study and showed that the date of the first sowing (1 November) significantly outweigh in the characters plant height , no. of fruiting branches. plant^{-1} , no. of capsules. plant^{-1} , no. of seeds. capsule^{-1} , seed yield and seed oil percentage.

Abd El-Daiem & El-Borhamy (2015) observed the level (185 kg N+57 kg P_2O_5+59 kg K_2O.ha^{-1}) was significantly superior in characters of plant height , no. of capsules . plant^{-1} no. of seeds capsule^{-1} and seed yield compare with the control treatment (no added the fertilizer). Kumar *et al.* (2016) found when using of three level of NPK fertilizer (50:30:20, 75: 45: 40 and 100:60:60 Kg NPK. ha^{-1}), that the level (75:45:40 kg NPK. ha^{-1}) was better in the characters of plant height, no. of capsules. plant^{-1}, number of seeds. capsule^{-1}, 1000 seed weight and seed yield. Devedee *et al.* (2017) showed a significant increase in no. of capsules. plant^{-1}, number of seeds. capsule^{-1} ,1000 seed weight and seed yield when increase added NPK fertilizer from control to 48:34.5:45 and 64:46:60 kg NPK.ha^{-1}. This study aims to determine the best planting date and the best level of NPK compound fertilizer when growing flax seed under rainfed conditions at Ninava province.

Materials & Methods

Two field Experiments carried out during winter growing season 2019-2020 at Nineveh Governorate at two locations (Talkief and Al-Hamdaniya location). In order to know the effect of two sowing dates (17 November and 17 December) and four levels of $N_{15}P_{15}K_{15}$ fertilizers (0,100, 150 and 200. kg NPK. ha^{-1})

on growth characters and yield. The experiment applied used in Randomized Complete Block Design (R.C.B.D.) with three replications. Add $N_{15}P_{15}K_{15}$ fertilizer to the soil all at once when planting. Some of the physical and chemical properties of the soil were analyzed (Table 1) at the depth of 0-30cm. The date of temperature requirement and precipitation requirement are presented in table (2).

Table (1): Some physical and chemical properties of experiments soil.

Physical characters	Talkaif location	Al-Hamdaniya location
Clay (g .kg^{-1})	203	558
Silt (g .kg^{-1})	452	364
Sand (g .kg^{-1})	345	78.0
Texture	Loam	Clay
Chemical characters		
Available N (mg .kg^{-1})	59.12	34.9
Available P (mg .kg^{-1})	48.07	35.5
Available K (mg .kg^{-1})	260.0	325.0
Organic matter (g .kg^{-1})	1.2	1.3
pH	7.3	7.8
Ec. (ds.m^{-1})	0.262	0.168

Table (2): Maximum and minimum monthly temperature (C°) and precipitation during the planting season 2019-2020 at two experimental site Talkief and Al-Hamdaniya.

Month	Temperature (C°)				Precipitation (mm)	
	Talkief		Al-Hamdaniya		Talkief	Al-Hamdaniya
	Max.	Min.	Max.	Min.		
October 2019	32.9	19.8	34.0	17.3	13.0	16.0
November 2019	23.7	9.9	24.5	8.3	3.0	5.0
December 2019	16.2	8.3	16.4	7.5	130.5	102.0
January 2020	12.8	4.8	13.7	4.6	98.0	74.0
February 2020	14.0	5.4	12.9	4.3	225.0	144.0
March 2020	20.7	10.5	19.8	9.2	31.5	28.0
April 2020	24.1	11.9	24.1	14.4	31.5	28.0
May 2020	-------	-------	35.4	19.3	0	0

The land of the experiment was plowed with a Moldboard plow, then it was set and flattened and then divided into experimental units. Each unit contained five lines and with long three meter for one line and a distance of 30 cm between one line and another. The manual weeding process was carried out several times during the growing season and the experiment was harvested when the plants reached full maturity. Ten plants were randomly selected from the midlines of each experimental unit and the following characters were studied:

Plant height (cm): It was measured from the base of the stem to the height peak in the plant at completion of maturity.

Number of fruiting branches.plant^{-1}: It was calculated as an average of ten plants randomly selected.

Number of capsules.plant^{-1}

It was calculated as an average of ten plants randomly selected at maturity .

Number of seeds. capsule^{-1}: By dividing the average number of seeds by the average number of capsules plant^{-1}.

1000 seed weight (g): After mixing the seeds of the harvested plants, a thousand seeds were randomly taken from each experimental unit and then weighted.

Seed yield (kg.ha^{-1}): This was done by harvesting the middle lines and leaving the guard lines in the experimental unit.

Seed oil percentage: Estimated by Soxhlett. Where samples were used, weighing one gram, and the oil was extracted for three hours by adding Petroleum Ether with a boiling point of 60-80°C, then the samples were dried at a temperature of 90°C (A.O.A.C.,2016)

Linolenic acid percentage: Saponification process of the oil was carried out using a basic solution where 0.1 g of oil was taken in a Soxhlet device and 3 ml of 20% solution of NaOH was added to it and 3 ml of ethanol was added to it, which replaced the heating process in a water bath for a period (90 minute), after which it was cooled. Then the volume was cooled to (10 ml) of ethanol, after which (0.1 ml) of saponification solution and lighten with ethanol to (10 ml) and then examined samples by (Specter photometer to determine the wavelength by operating condition (hmax) and after used High performance Liquid Chromatography (HPLC) from type Shimedzu Lc- 2010AHT (Takatori *et al.,* 2011) under operating condition (Table 3).

Table (3): Detaching conditions of HPLC.

Detaching conditions	Specification
Device name	High Performance Liquid Chromatography (HPLC)
Column type	C18 for dimension (4.6mm × 25mm)
Detector	U.V.
Wave length	242nm
Injecting amount	25µl
Carrier phase	70% Water : 30% Acetonitrile
Speed of flow	1ml. minute $^{-1}$
Column temperature	40°

Statistical analysis

Data were analyzed statistically according to the Randomized Complete Block Design (R.C.B.D.), and the Duncan multi – range test at the probability level 1 and 5% was used to compare the averages.

Results & Discussion

Plant height (cm)

The results in table (4) indicate that there are significant differences between sowing dates in the plant height trait in both locations of study. The first sowing date (November 17) was given the highest rate of the trait (44.2 and 46.8 cm), While the second date of sowing December 17 given less rate for the trait (42.3 and 44.0 cm) for both locations respectively. The reason of superior the sowing date November 17 compare with the sowing of date (December 17) might be due to long growth period (one month) and its suitability for the rain and temperature during period of vegetative growth. These results are in agreement with results of both of Rahimi (2014), Emam (2019) and Al-Juheishy (2020).

The results of the table (4) show the presence of significant differences between

levels of NPK fertilizer in the trait of plant height at Al-Hamdaniya location only, the highest rate of this trait was (48.3 cm) in the level of NPK fertilizer (200 kg NPK.ha^{-1}), While the lowest rate of this trait was 42.8cm when no added the fertilizer (control).

This is attributed to decrease content of soil from nutrients especially nitrogen and phosphor (Table 1); this increased the plant's response to high levels of the compound fertilizer and led to increase elongation the internodes. This is noted by Abd El-Daiem & El-Borhamy (2015) and Kumar *et al.* (2016).

The results of table (4) shows no significant differences for the interaction between sowing dates and NPK fertilizer in the trait of the plant height in both locations.

Table (4): Effect of sowing dates and $N_{15}P_{15}K_{15}$ fertilizer on Plant height (cm).

Talkief Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	43.2a± 2.0	43.4a± 1.8	44.9a± 1.8	45.3a± 2.8	44.2 a± 2.1
December 17	40.2a± 2.8	42.8a± 1.5	42.2a± 1.3	44.1a± 0.6	42.3b± 1.3
Means of $N_{15}P_{15}K_{15}$	41.7a± 0.4	43.1 a± 0.4	43.5a± 1.0	44.7a± 1.1	
Al-Hamdaniya Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	44.0a± 2.4	46.1a± 5.1	47.3a± 5.6	49.9a± 5.6	46.8 a± 4.6
December 17	41.6a± 0.4	43.1a± 0.6	44.6a± 4.3	46.7a± 1.5	44.0 b± 0.9
Means of $N_{15}P_{15}K_{15}$	42.8c± 1.2	44.6 bc±2.4	45.9 ab±3.7	48.3 a± 3.2	

The values followed by different letters in the same column differ from each other's at probability 1 and 5% levels.

Number of fruiting branches.plant^{-1}

The results in table (5) showed that there are significant differences between sowing dates in the trait of the number of fruiting branches. plant^{-1} in both locations of study. The highest rate of the trait was 4.7 and 4.1 branch.plant^{-1} at the date of sowing (November 17), while the lowest rate was 4.4 and 3.8 branch.plant^{-1} at the date of sowing December 17 for both locations of study. This might be due to the fact that earlier of sowing date leads to long growth period (one month) and suitable of rain and temperature during vegetative growth period. This result is consistent with Emam (2019).

The results of table (5) showed that there are significant differences between levels of NPK fertilizer in the trait of number of fruiting branches plant^{-1} at Al-Hamdaniya location only, the highest rate of this trait was 4.2 branch. plant^{-1} in the level of NPK fertilizer (200 kg NPK. ha^{-1}), while the lowest rate of this trait was 3.7 branch. plant^{-1} when the control treatment. This might be due to the low content of the soil of nitrogen and phosphorous available in Al-Hamdaniya location (Table 1)

compared to Talkief location, which led to plant response to high levels of compound fertilizer, which affected the regulation and action the hormones such as auxines and cytokines, which led to an increase in the division of meristematic cells and thus giving an increase in the number of fruiting branches.plant^{-1} (Mengle *et al*., 2001).

The results of table (5) that there is no significant effect of interaction between sowing dates and NPK fertilizer in the trait of the number of fruiting branches. plant^{-1} in both locations.

Table (5): Effect of sowing dates and $N_{15}P_{15}K_{15}$ fertilizer on Number of fruiting branches. plant^{-1}.

Talkief Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of sowing dates
	0	100	150	200	
November 17	4.5 a± 0.3	4.4a± 0.5	4.8a± 0.4	5.0a± 0.7	4.7 a± 0.4
December 17	4.2 a± 0.4	4.4a± 0.2	4.5a± 0.4	4.6 a± 0.1	4.4b± 0.2
Means of $N_{15}P_{15}K_{15}$	4.4 a± 0.3	4.4 a± 0.3	4.7 a± 0.4	4.8 a± 0.4	
Al-Hamdaniya Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	3.9 a± 0.4	3.9a± 0.4	4.2a± 0.3	4.4 a± 0.2	4.1 a± 0.3
December 17	3.5a± 0.3	3.6 a± 0.1	4.0 a± 0.4	4.0 a± 0.6	3.8 b±0.3
Means of $N_{15}P_{15}K_{15}$	3.7 c± 0.3	3.8 b c± 0.2	4.1 a b± 0.3	4.2 a± 0.4	

The values followed by different letters in the same column differ from each other's at probability 1 and 5% levels.

Number of capsules.plant^{-1}

The results in table (6) shows the presence of significant differences between sowing dates in the number of capsules. plant^{-1} in both locations of study. The first time of sowing November 17 succeeds the highest rate of the trait (15.7 and 13.4 capsule. plant^{-1}), while the second time of sowing December 17 recorded the lowest rate of the trait (14.3 and 11.6 capsule. plant^{-1}) and for both locations, respectively. The cause may be due to increase number of fruiting branches. plant^{-1} (Table 5) in the first date. This result is in conformity with Jana *et al.* (2018), Emam (2019) and Kumari (2020).

The results described in table (6) showed the presence of significant differences between levels of NPK fertilizer in the number of capsules plant^{-1} at Al-Hamdaniya location only a level of NPK fertilizer (200 kg NPK.ha^{-1}) a produced the highest rate of his trait (14.7 capsule . plant^{-1}, while the control was least average of his trait (10.2 capsule. plant^{-1}). This can be attributed to the positive role of NPK fertilizer in formation of chlorophyll and increase efficiency process of photosynthesis

and then giving increase dry matter accumulation by cell divisions cell multiplication led to increase number of flowers and fruits in plant because increase efficiency and vitality pollination. This result is consistent with Abd El-Daiem & El-Borhamy (2015), Kumar *et al.* (2016) and Devedee *et al.* (2017).

The results of table (6) show non-significant differences between the date of sowing and NPK fertilizer in the trait of number of capsules plant^{-1}.

Table (6): Effect of sowing dates and $N_{15}P_{15}K_{15}$ fertilizer on Number of capsules. Plant^{-1}.

Talkief Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of sowing dates
	0	100	150	200	
November 17	15.6a± 2.4	14.6a±1.9	15.3a± 0.5	17.4a±3.4	15.7 a± 1.7
December 17	12.5a± 2.3	13.7a±1.1	15.9a± 2.2	15.1a±2.1	14.3 b± 1.5
Means of $N_{15}P_{15}K_{15}$	14.0a ± 2.3	14.2a±1.5	15.6 a± 1.0	16.2a±2.0	
Al-Hamdaniya Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	11.1a± 0.7	12.6a±0.9	14.2 a± 0.9	15.6a±1.7	13.4 a± 0.9
December 17	9.3 a± 1.8	10.8a±0.8	12.4a± 0.7	13.9a±1.0	11.6 b± 0.3
Means of $N_{15}P_{15}K_{15}$	10.2 d± 1.2	11.7c±0.8	13.3 b± 0.2	14.7a±0.6	

The values followed by different letters in the same column differ from each other's at probability 1 and 5% levels.

Number of seeds.capsule^{-1}

The results in table (7) show the presence of significant differences between sowing dates in the trait of number of seeds. capsule^{-1} for both locations of study. The highest rate of the trait was 9.3 and 9.2 seed. capsule^{-1} at the date of sowing November17, while the date of sowing December 17 gave the lowest rate of this trait (9.1 and 9.0 seed. capsule^{-1}) for both locations respectively. This can be attributed to the delay of sowing dates that leads to negative effect of sudden rise temperature and increase water stress during the period of flowering and the period of seed fullness addition short of period from flowering until the harvest and result less number of seeds. capsule^{-1}. This result agreement with those Sohair *et al.* (2015) and Al-Juheishy (2020).

The results in table (7) show that there are significant differences between the levels of NPK fertilizer in the trait of number of seeds. capsule^{-1} at Al-Hamdaniya location only. The highest medium of this trait reached (9.3 seed. capsule^{-1}) at level of NPK fertilizer (200 kg NPK.ha^{-1}) whereas the least medium for this trait was (8.8 seed. capsule^{-1}) at control

treatment. The reason increase number of seeds. capsule^{-1} when increase levels NPK fertilizer due to role of NPK fertilizer in enhanced growth of plant and increase efficiency photosynthesis and increase of fertilization in flowers leads to increase number of seeds capsule^{-1}. This result consistent with results of both Abd El-Daiem & El-Borhamy (2015), Kumar *et al.* (2016) and Devedee *et al.* (2017).

The results of table (7) show no significant effect of interference between sowing dates and levels of NPK fertilizer in the trait of number of seeds .capsule-1 for both locations of study.

Table (7): Effect of sowing dates and $N_{15}P_{15}K_{15}$ fertilizer on Number of seeds. capsule^{-1}.

Talkief Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	9.2a± 0.1	9.4a± 0.2	9.3a± 0.1	9.5a± 0.1	9.3 a± 0.1
December 17	9.0a± 0.1	9.0 a± 0.3	9.4a± 0.3	9.2 a± 0.1	9.1 b± 0.1
Means of $N_{15}P_{15}K_{15}$	9.1a± 0.1	9.2a± 0.2	9.3a± 0.1	9.4a± 0.1	
Al-Hamdaniya Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	8.9 a± 0.1	9.1a± 0.1	9.3a± 0.3	9.5a± 0.1	9.2 a± 0.1
December 17	8.7 a± 0.6	8.8 a± 0.1	9.1a± 0.3	9.2a± 0.2	9.0 b± 0.1
Means of $N_{15}P_{15}K_{15}$	8.8 b±0.3	8.9 b± 0.1	9.2 a± 0.2	9.3 a± 0.1	

The values followed by different letters in the same column differ from each other's at probability 1 and 5% levels.

1000 seed weight (g)

Table (8) shows that the sowing dates significantly affected on the 1000 seed weight in both locations of the study. The date of sowing November 2017 was better in giving the highest average of the trait (7.3 and 7.8 g), While the date of sowing December 17 given less average for the trait (6.9 and 7.4g) for both locations, respectively. The cause increase 1000 seed weight due to increase dry matter. plant^{-1} where earlier of sowing led to long growth period and this led increase of transfer for the products of photosynthesis from leaves to seeds and increase of accumulation it and this led to increase of seed weight until maturity compare with the delay of sowing date. This result agreement with the results of both of Rahimi (2014), Emam (2019) and Kumari (2020).

The results of table (8) show there is no significant differences between levels of NPK fertilizer in the trait of rate of 1000 seed weight for both locations.

The results of table (8) indicate no significant effect of interaction between sowing dates and levels of NPK fertilizer in the trait of the 1000 seed weight for both locations.

Table (8): Effect of sowing dates and $N_{15}P_{15}K_{15}$ fertilizer on 1000 seed weight (g).

Talkief Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	7.2a± 0.1	7.3a± 0.1	7.4a± 0.2	7.4a± 0.1	7.3 a± 0.1
December 17	7.7a± 0.1	6.8a± 0.3	6.9a± 0.4	7.1 a± 0.1	6.9 b± 0.2
Means of $N_{15}P_{15}K_{15}$	7.0 a± 0.1	7.1a± 0.2	7.1a± 0.1	7.3a ± 0.1	
Al-Hamdaniya Location					
SowingDates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	7.6 a± 0.6	7.8 a± 0.7	7.9a± 0.3	7.9 a± 0.2	7.8 a± 0.4
December 17	7.2a± 0.2	7.1 a± 0.4	7.4 a± 0.3	7.7 a± 0.3	7.4b± 0.1
Means of $N_{15}P_{15}K_{15}$	7.4a± 0.2	7.5a ± 0.4	7.6a± 0.3	7.8a± 0.1	

The values followed by different letters in the same column differ from each other's at probability 1 and 5% levels.

Seed yield (kg. ha^{-1})

The results in table (9) shows the presence of significant differences between sowing dates in the seed yield in both locations of study. The date of sowing November 17 has been the highest rate of this trait (1507.2 and 1383.6 kg. ha^{-1}), while the date of sowing December 17 produced the lowest rate of this trait (1303.3 and 1194.6 kg. ha^{-1}) for both locations respectively. This is attributed to the increase in the number of capsules. plant^{-1}, number of seeds. capsule^{-1} and 1000 seed weight (Table 6,7 and 8) which increase seed yield in the date of sowing (November 17). This result agreement with those of Rahimi (2014), Jana *et al.* (2018) and Kumari (2020).

Table (9) shows that there are significantly differences between levels of NPK fertilizer in this trait for both locations. The highest rate of this trait was 1533.7 and 1404.9 kg. ha^{-1} in the level of NPK fertilizer (200 kg NPK. ha^{-1}), while the lowest rate of this trait was 1294.4 and 1204.2 kg NPK.ha^{-1} in the control treatment for both locations, respectively. This is attributed to the increase in the number of capsules.plant^{-1} and number of seeds.capsule^{-1} (Tables 6 and 7). This result is consistent with the results of Abd El-Daiem & El-Borhamy (2015), Kumar *et al.* (2016) and Devedee *et al.* (2017).

It is clear from table (9) that there are significant effect of interaction between sowing dates and levels of NPK fertilizer in this trait in Talkief location only and the highest rate of this trait was 1707.6 kg. ha^{-1} in the date of sowing November 17 and the level of NPK fertilizer (200 kg NPK. ha^{-1}), While the lowest rate of this trait was (1227.6kg. ha^{-1}) in the date of sowing December 17 and control treatment .

Table (9): Effect of sowing dates and $N_{15}P_{15}K_{15}$ fertilizer on Seed yield (kg.ha^{-1}).

Talkief Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	**100**	**150**	**200**	
November 17	1361.3 c ± 516.1	1405.8c± 368.4	1554.3b± 225.4	1707.6a ± 304.77	1507.2 a± 341.1
December 17	1227.6d± 251.4	1265.9 d± 133.9	1359.8c± 166.7	1359.8 c± 166.0	1303.3 b± 58.5
Means of $N_{15}P_{15}K_{15}$	1294.4 c± 380.1	1335.8c± 250.1	1457.1b± 72.5	1533.7a± 160.6	
Al-Hamdaniya location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	**100**	**150**	**200**	
November 17	1319.5a± 249.0	1310.3a± 149.6	1407.3a± 365.9	1497.3a± 230.9	1383.6 a± 162.8
December 17	1088.9a± 158.8	1151.2a± 172.9	1225.8 a± 261.3	1312.5 a± 173.3	1194.6 b± 160.1
Means of $N_{15}P_{15}K_{15}$	1204.2c± 203.6	1230.8c± 143.3	1316.5b± 212.2	1404.9 a± 196.1	

The values followed by different letters in the same column differ from each other's at probability 1 and 5% levels.

Seed oil percentage

The results shown in table (10) indicate the presence of significant differences between sowing dates in the trait of seed oil percentage in the study locations. The highest rate of this trait (38.8 and 41.0%) at the date of sowing November 17, while the date of sowing December 2017 gave the lowest rate (37.9 and 40.3%) for both locations, respectively. The reason of decrease in seed oil percentage when delay the sowing date due to impact of unfavorable weather conditions, especially high temperature and increase water stress during the period of seed fullness that led to decrease trans of nutrient mobility from leaves to seeds and this decrease seed oil percentage. This result is consistent with Sohair *et al.* (2015) and Emam (2019).

The result in table (10) shows the presence significant differences between levels of NPK fertilizer in this trait for both locations. The highest rate of this trait was 40.1 and 41.9% at level of NPK fertilizer (200 kg NPK. ha^{-1}), while the lowest rate of this trait was 37.0 and 39.6% at control treatment for both locations, respectively. The increase of seed oil percentage when increase levels of fertilizer is attributed to the turning a large amount of carbohydrates by the process of photosynthesis to the fats either the rest has been transformed to protein and resulting increase seed oil percentage at the expense of protein percentage.

Table (10) shows the presence of no significant differences for the interaction

between sowing dates and levels of NPK fertilizer in this trait for both locations.

Table (10): Effect of sowing dates and $N_{15}P_{15}K_{15}$ fertilizer on Oil (%).

Talkief Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	37.4a± 0.4	37.8 a± 0.6	39.7a± 1.1	40.4 a± 0.7	38.8 a± 0.6
December 17	36.5a± 0.3	37.4a± 0.8	38.0a± 0.9	39.7a± 1.5	37.9 b± 0.5
Means of $N_{15}P_{15}K_{15}$	37.0 c± 0.4	37.6 c± 0.6	38.9 b± 0.6	40.0 a± 0.9	
Al-Hamdaniya Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	40.1a± 1.4	40.4a± 0.9	41.3a± 0.5	42.3 a± 0.2	41.0 a± 0.7
December 17	39.1a± 1.4	39.9a± 0.9	40.7a± 0.5	41.5 a± 0.2	40.3 b± 0.6
Means of $N_{15}P_{15}K_{15}$	39.6 c± 1.0	40.1 bc±0.7	41.0ab±1.1	41.9 a± 0.1	

The values followed by different letters in the same column differ from each other's at probability 1 and 5% levels.

Linolenic acid percentage: The results in table (11) indicate the presence of significant differences between sowing dates in the trait of linolenic acid percentage in the locations of study. The highest rate of this trait was 46.9 and 47.1 % at the date of sowing November 17, while the lowest rate of this trait was 45.3 and 46.0% at the date of sowing December 17 for both locations, respectively. The reason increase Linolenic acid when planting early is low temperature in flowering period and the length of time necessary for ripening and increase the accumulation of oil especially linolenic acid. Green (1986) indicated that the temperature when is high and water stress during the period of seed fullness reduce linolenic acid percentage in several crops including flax.

The results of the table (11) show the presence of significant differences between levels of NPK fertilizer in the trait of linolenic acid percentage at Talkief location only, the highest rate of this trait was 47.8% in the level of NPK fertilizer (200Kg NPK.ha^{-1}), While the lowest rate of this trait was 44.8% when control treatment. The increase of linolenic acid when increase levels of compound fertilizer due to the turning a large amount of carbohydrates to the fats either the rest has been transformed to protein and resulting increase linolenic acid compared with low levels of compound fertilizer.

Table (11) shows the existence of significant differences of interaction between sowing dates and levels of NPK fertilizer in this trait in Talkief location only and the highest rate of

the mentioned trait reached (50.0%) in the date of sowing November 17 and the level of NPK fertilizer (200 kg NPK.ha^{-1}), while the lowest rate was 43.5% in the date of sowing December 17 and control treatment.

Table (11): Effect of sowing dates and $N_{15}P_{15}K_{15}$ fertilizer on Linolenic acid (%).

Talkief Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	46.0bc±2.8	45.9 bc±2.2	45.9 bc±1.1	50.0 a ± 2.2	46.9 a± 1.0
December 17	43.5 c ± 0.5	44.4 c ± 1.8	47.7 ab±0.2	45.6 bc±1.0	45.3 b± 0.2
Means of $N_{15}P_{15}K_{15}$	44.8 c± 1.1	45.1 bc±1.9	46.8 ab±0.7	47.8 a± 1.6	
Al-Hamdaniya Location					
Sowing Dates	$N_{15}P_{15}K_{15}$ (Kg . ha^{-1})				Means of Sowing dates
	0	100	150	200	
November 17	46.8 a± 1.1	46.1a± 1.5	47.4a ± 2.8	48.2a± 2.7	47.1 a± 2.0
December 17	44.7a± 0.2	46.6a± 1.2	46.3 a± 0.4	46.5 a± 0.3	46.0 b ± 0.3
Means of $N_{15}P_{15}K_{15}$	45.8a± 0.6	46.3a± 0.1	46.9a± 1.2	47.4a ± 1.5	

The values followed by different letters in the same column differ from each other's at probability 1 and 5% levels.

Conclusions

The determining factor for the timing of planting flax under semi-arid conditions is the climatic conditions and it is preferable to early planting in order to obtain a high seed yield. The accumulation of oil in the seeds is determined by temperature, soil readiness, moisture, fertilizer quantity and their interactions. The proportion of linolenic acid in flax oil increases with increasing temperature, the length of time the crop is in the soil, and the increase in NPK levels.

Contributions of authors

R.F.A.A.: Traits Measurement, Data Collection, Laboratory and Statistical Analysis.

A.T.S.: Follow up on laboratory analysis, reading and revised of the manuscript.

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Conflict to interest

The authors declare that they have no conflict of interest.

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تأثير مواعيد الزراعة والسماد المركب NPK في نمو وحاصل الكتان *Linum usitatissimum* L.

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المستخلص: أجريت هذه الدراسة خلال الموسم الزراعي الشتوي 2019/ 2020 في موقعين الأول في ناحية تلكيف والثاني في ناحية الحمدانية ضمن حدود محافظة نينوى ، لدراسة تأثير موعدين زراعين (2017/11 و 2017/12) وأربعة مستويات من السماد المركب $N_{15}P_{15}K_{15}$ (صفر و 100 و 150 و 200 كغم .هـ$^{-1}$) في نمو وحاصل الكتان تحت الظروف الديمية، نفذت التجربة حقلياً وفق أسلوب التجارب العاملية بتصميم القطاعات العشوائية الكاملة (R.C.B.D.) وبثلاثة مكررات. أشارت النتائج إلى تفوق موعد الزراعة المبكر 11/17معنوياً في الصفات: ارتفاع النبات وعدد التفرعات الثمرية.نبات$^{-1}$ وعدد الكبسولات.نبات$^{-1}$ وعدد البذور.كبسولة$^{-1}$ ووزن 1000 بذرة وحاصل البذور والنسبة المئوية للزيت في البذور والنسبة المئوية لحامض اللينولينيك ولكلا الموقعين . تفوق مستوى السماد المركب 200 كغم NPK.هـ$^{-1}$معنويا في الصفات: ارتفاع النبات وعدد التفرعات الثمرية. نبات$^{-1}$ وعدد الكبسولات.نبات$^{-1}$ وعدد البذور.كبسولة$^{-1}$ في موقع الحمدانية ، بينما تفوقت النسبة المئوية لحامض اللينولينيك في موقع تلكيف ، كما بلغت النسبة المئوية للزيت في البذور اعلى مقدار لها في كلا الموقعين . اظهر تداخل موعد الزراعة 11/17 مع مستوى السماد المركب 200 كغم NPK.هـ$^{-1}$ تفوقاً معنوياً في صفة النسبة المئوية لحامض اللينولينيك في موقع تلكيف فقط .

الكلمات المفتاحية: السماد المركب، الكتان، حامض اللينولينيك، مواعيد الزراعة.