Assessment of the productive traits of several Flax cultivars by effect of sowing dates

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Abstract. A field experiment was carried out in Zakhikha village in Heet district, Anbar governorate – Iraq during the winter season 2020-2021 in order to study the effect of sowing dates on the growth and yield of five cultivars of flax. The experiment was applied by arranging the split plots according to the randomized complete block design (RCBD) and with three replications, main plots included four sowing dates (15th October, 1st November, 15th November and 1st December), while the secondary plots were filled with (Sub-plots). Five types of flax (Sakha1, Sakha4, Sakha5, Sakha6, and local). The most important results are summarized as follows: Sakha6 was superior in most of the studied traits, with both the highest values for plant height, number of fruiting branches, number of capsules per plant, weight of 1000 seeds, and seed yield reached 109.40 cm, 21.02 branch plant⁻¹, 62.32 capsule plant⁻¹, 7.83 g and 2.377 ton ha⁻¹, except for characteristic of the number of seeds per capsule in which the variety Sakha5 outperformed, recording 8.63 seeds capsule⁻¹. The plants sown on the date 15th November outperformed in the number of fruiting branches, the number of capsules per plant, the weight of 1000 seeds, and the grain yield reached 20.26 branches plant⁻¹, 64.18 capsules plant⁻¹, 7.07 g and 2.402 ton ha⁻¹, while the plants of the first date of 15th October outperformed with the highest in all these The average plant height trait was 131.17 cm, while the 1st December plants outperformed with the highest average number of seeds per capsule amount to 8.24 seeds per capsule⁻¹.

1. Introduction

The flax crop (Linum usitatissimum L.) is one of the important dual-purpose industrial crop, which is cultivated in different parts of the world to obtain oil or fiber or both. The percentage of oil in its seeds ranges from 33 - 47 % and 11 - 25 % protein [26]. Their seeds are widely used because its oil contains a high percentage of antioxidants, such as ascorbic acid, and unsaturated fatty acids such as linoleic acid, which belongs to the omega-3 group, and linolenic acid, which belongs to the omega-6 group [10] which is used in the treatment of strokes, cardiovascular diseases, arteriosclerosis, and kidney inflammation, in addition to oleic acid, which belongs to the omega-9 group [25]. In addition to that, its oil is suitable for human use.

As for fiber flax, it is grown to obtain fibers from the stems, which are used in the manufacture of flax textiles, which are characterized by high durability after mixing with cotton, wool and silk. Choosing the appropriate variety is one of the important matters for improving productivity per unit area[8]; [19] found that flax cultivars differ among themselves in growth characteristics such as plant height, yield and their components, [14] indicated flax cultivars differed among themselves in the number of
capsules, 1000-seed weight and seed yield, [18] found that flax cultivars differed significantly among themselves in terms of plant height and number of capsules per plant. [21] indicated that the significant difference of flax cultivars in terms of plant height, number of branches, number of capsules, and weight of 1000 seeds. [1] also emphasized the significant difference of flax cultivars in seed yield and its components, [12] concluded that plant height, number of fruiting branches, number of capsules, weight of 1000 seeds, and seed yield differed significantly for different flax cultivars, [16] indicates the moral difference of plant height, number of fruiting branches and number of capsules in the plant according to the different cultivars, and the seed yield was not affected by the different cultivars. As for the sowing date, it is one of the important and influential factors in increasing the yield, as the sowing date had a significant effect on the plant height, the number of fruiting branches, the weight of 1000 seeds, and the seed yield [26]; [9] concluded that early sowing gave the highest yield. for seeds compared to the late dates, [23] also confirmed that the early dates for sowing flax gave the highest rate of the number of capsules per plant, the weight of 1000 seeds, and the seed yield. [17] indicated that sowing dates had a significant effect on plant height, number of branches, number of capsules, number of seeds in the capsule, and on seed yield. Plant and seed yield according to planting dates, this research aims to determine the effect of sowing dates on some growth characteristics and yield of several flax cultivars.

2. Materials and methods
A field experiment was carried out in the winter season 2020-2021 in the Zakhikha village of Heet district on the left side of the Euphrates River in order to study the response of several cultivars of flax to sowing dates and their effect on some growth characteristics and yield. The experiment was implemented by randomized complete block design (RCBD) in the arrange of split plots and with three replications. The main plots included four dates of sowing (15th October, 1st November, 15th November and 1st December), while the secondary plots were distributed among five cultivars of flax are (Sakha1, Sakha4, Sakha5, Sakha6 and local). The experimental land was prepared by plowing, smoothing, and leveling, then it was divided into experimental units, The area of the experimental unit was (2 x 2.5) m². Each experimental unit contained 8 lines. Phosphate fertilizer was added in the form of triple superphosphate (45% P₂O₅) at a rate of 50 kg P/ha⁻¹ at once upon planting. Nitrogen fertilizer was added at a rate of 80 kg N/ha⁻¹ in the form of urea (46% N) and in two batches, the first (half the quantity) when planting and the second one month after the first batch. The seeds were planted and agricultural operations were carried out to serve the crop, including irrigation, weeding and hoeing whenever the need arose. The plants were harvested when they reached the stage of full maturity the appearance of signs of maturity on the plants, falling leaves, yellowing of the plant and drying of the capsules. Ten plants were randomly selected from the two middle lines of each experimental unit at the harvest stage to study the following characteristics:

2.1. Plant height (cm)
The average height of the main stem from the soil surface to the top of the plant was measured for the ten plants taken at random.

2.2. Number of fruiting branches in the plant (branch Plant⁻¹)
It was calculated from the average number of branches bearing the capsules in the ten plants.

2.3. Number of capsules per plant (capsule plant⁻¹)
It was calculated from the average number of capsules in the ten plants.

2.4. Number of seeds in the capsule (seed capsule⁻¹)
It was calculated by dividing the number of seeds in the capsules of the ten plants by the number of their capsules.

2.5. Weight of 1000 seed (gm)
It was calculated after mixing the seeds of plants harvested from each experimental unit, of which 1000 seeds were randomly taken and then weighed.

2.6. Seed yield (ton ha⁻¹)
A manual threshing process was carried out for one square meter of each experimental unit, and after isolating the straw from the seeds, it was converted from g. m\(^2\) to ton ha\(^{-1}\).

### 3. Results and Discussion

#### 3.1. Plant Height (cm)

The results in Table (1) that there were significant differences between flax cultivars in the average plant height, as Sakha6 cultivar excelled with the highest mean of the trait reached (109.40 cm) and did not differ significantly from the two cultivars, Sakha4 and Sakha1 who gave (109.23 and 109.14 cm) compared to Sakha5, which gave its plants the lowest average of the trait reached (84.49 cm). This difference between cultivars in the plant height may be due to the genetic nature of the variety and the extent of its response and adaptation to the prevailing environmental conditions, which gives it superiority over other cultivars. This finding is in agreement with what was found by [13]; [19]; [18]; [7]; [21]; [2]; [1]; [16]; [3], who pointed out a significant difference between cultivars among themselves in the character of plant height. From the same table, there is a significant difference between the sowing dates in the average plant height, as planting on the early date of 15\(^{th}\) October gave the highest average for the trait amounting to 131.17 cm, an increase of 64% compared to the plants planted on the late date of 1\(^{st}\) December which gave the lowest average for the trait, reaching 79.72 cm. The reason for the superiority of the early date in the characteristic of plant height is due to the long period of growth of its plants compared to other dates, which helped to increase the rate of this trait. They found a decrease in plant height with the delay in sowing date. These results are in agreement with [26]; [15]; [6], who indicated a difference in the plant height of flax plants with different sowing dates. It is noted from the same table that there is a significant overlap between cultivars and sowing dates in the average plant height. Plants of the cultivar Sakha1 when planted on the early date of 15\(^{th}\) October gave the highest value of the interference, amounted to 157.70 cm while the plants of the cultivar Sakha5 when planted on the late date of 1\(^{st}\) December gave the lowest value of the overlap, amounted to 68.90 cm.

| Sowing Dates | Cultivars  |
|--------------|------------|
|              | Sakha 1     | Sakha 4     | Sakha 5     | Sakha 6     | Local       | Mean        |
| 15\(^{th}\) October | 157.70  | 136.4  | 98.10  | 134.6  | 129.0  | 131.17   |
| 1\(^{st}\) November    | 109.43  | 115.4  | 86.76  | 121.3  | 109.5  | 108.50   |
| 15\(^{th}\) November   | 92.80   | 103.6  | 84.20  | 98.73  | 99.73  | 95.82    |
| 1\(^{st}\) December    | 82.63   | 81.43  | 68.90  | 82.95  | 82.70  | 79.72    |
| Mean                   | 109.14  | 109.2  | 84.49  | 109.4  | 105.2  | 95.82    |
| LSD 5%                 | 3.47    | 3.47   | 3.47   | 3.47   | 3.47   | 6.94     |

#### 3.2. Number of fruiting branches in a plant (branch Plant\(^{-1}\))

Flax cultivars differed significantly among themselves in the number of fruiting branches per plant, as Sakha6 plants gave the highest average for the trait amounting to 21.02 branch Plant\(^{-1}\) compared to plants of the local variety, Table (2), which gave the lowest average for the trait, amounting to 14.64 branches Plant\(^{-1}\). Branching in Sakha6 cultivar is due to its response to environmental conditions that are related to the genetic material of the cultivar, and this is consistent with the findings of [5]; [8]; [21]; [27]; [12]; [15], who indicated that flax cultivars differed significantly in the number of branches
in the plant. The sowing dates had a significant effect on this trait, as the flax plants planted on the dates of 15th, 1st November and 15th October gave the highest average of 20.26, 20.04 and 18.21 branch plant$^{-1}$ sequentially (which did not differ from each other significantly), while the plants that were sown on the late date of 1st December give the lowest mean of the trait at 10.34 branch plant$^{-1}$. These results are in agreement with [26]; [15]; [17], who indicated that planting dates significantly affected the number of branches per plant. The results of the same table indicate that the trait of the number of branches per plant when planted Sakha6 on the date 1st November was 23.90 branches plant$^{-1}$ and did not differ significantly from the plants of the same variety planted on the dates 15th November and 15th October which gave 23.43 and 22.50 branches plant$^{-1}$. As for the local variety, its plants gave the lowest value of the interference when planted on the late 1st December, which was 8.53 branch plant$^{-1}$.

Table 2. Effect of Cultivars, Sowing Dates on the number of fruiting branches per plant (branch Plant$^{-1}$) of the flax crop for the season (2020-2021)

| Sawing Dates  | Cultivars          |               |               |               | Local   | Mean   |
|---------------|--------------------|---------------|---------------|---------------|---------|--------|
|               | Sakha 1            | Sakha 4       | Sakha 5       | Sakha 6       |         |        |
| 15th October  | 17.84              | 16.55         | 18.86         | 22.50         | 15.32   | 18.21  |
| 1st November | 19.63              | 19.10         | 21.40         | 23.90         | 16.40   | 20.04  |
| 15th November| 18.98              | 19.76         | 22.20         | 23.43         | 16.93   | 20.26  |
| 1st December | 9.50               | 8.90          | 10.53         | 14.26         | 8.53    | 10.34  |
| Mean          | 16.48              | 16.07         | 18.24         | 21.02         | 14.64   |        |

| LSD 5%        | 2.71               |               |               |               |         | 4.73   |

3.3. Number of Capsules per plant (capsule plant$^{-1}$)

Indicates that Sakha6 cultivar had the highest mean of the cultivar reached 62.32 capsule plant$^{-1}$ and did not differ significantly from the plant$^{-1}$ of cultivar Sakha5 and Sakha1 which gave 58.55 and 56.38 capsule plant$^{-1}$ compared to the plants of the local variety whose plants gave the lowest average of 42.02 capsule plant$^{-1}$. The reason for this increase may be due to the increase in the number of fruiting branches in the plant, which helped to increase the efficiency of the photosynthesis process and the transmission of its products to the reproductive organs thus increasing the number of capsules in the plant. These results are consistent with what was reached by [8]; [11]; [19]; [18]; [23]; [22]; [16], who indicated that flax cultivars differed significantly in the number of capsules per plant. The results of the same table showed a significant effect between sowing dates for this trait, as the flax plants planted on the date 15th November gave the highest average for the trait amounting to 64.18 capsules plant$^{-1}$ and did not differ significantly from the plants of the dates 1st November and 15th October whose plants gave 63.96 and 54.02 capsules Plant$^{-1}$, while the plants of the date 1st December gave the lowest average for the trait, which was 39.15 capsules plant$^{-1}$, and the reason for this increase could be attributed to the increase in the number of fruiting branches in the plant Table (2), which in turn led to an increase in the number of capsules in the plant. These results are in agreement with what was obtained by [20]; [17]; [6]; [24], who indicated a difference in the number of capsules in plants with different sowing dates. As for the interaction between the two factors of the study, it had a significant effect on the number of capsules per plant, as Sakha6 plants achieved the highest value of the interaction when planted on the 1st November date of 70.16 capsules plant$^{-1}$, while the plants of the local variety gave the lowest value when planted on the later date 1st December totaled 24.66 capsules plant$^{-1}$.
Table 3. Effect of Cultivars and Sowing Dates on the number of capsules per plant (capsule plant$$^{-1}$$) for the flax crop for the season (2020-2021)

| Sowing Dates | Cultivars | Mean |
|--------------|-----------|------|
|              | Sakha 1   | Sakha 4 | Sakha 5 | Sakha 6 | Local |      |
| 15th October | 53.36     | 52.16  | 53.80   | 62.63   | 48.13  | 54.02 |
| 1st November | 64.80     | 62.63  | 68.86   | 70.16   | 53.36  | 63.96 |
| 15th November| 64.96     | 62.40  | 69.96   | 69.63   | 53.93  | 64.18 |
| 1st December | 42.43     | 40.20  | 41.60   | 46.86   | 24.66  | 39.15 |
| Mean         | 56.38     | 54.34  | 58.55   | 62.32   | 45.02  |       |

LSD 5% 6.09 18.65 12.18

3.4. Number of Seeds in the Capsule (seed capsule$$^{-1}$$)

In table (4), there were significant differences between flax cultivars in the trait of the number of seeds in the capsule. Sakha5 variety had the highest mean of 8.63 seed capsule$$^{-1}$$, and it did not differ significantly from the plants of the variety Sakha4, whose plants gave 8.14 seed capsule$$^{-1}$$ compared to the plants of the variety Sakha6, which gave the lowest average for the trait, which was 6.83 seed capsule$$^{-1}$$. The reason for the increase in the number of seeds in the capsule may be due to the genetic variation of the cultivars and their ability to respond to environmental conditions, and thus an increase in the efficiency of the photosynthesis process and the accumulation of dry matter in the plant that begins to move to the reproductive parts and then increase the number of seeds in the capsule. These results are in line with what was found by [11]; [19];[23];[7], who indicated that flax cultivars differed significantly in the number of seeds in the capsule.

The results from the same table showed that sowing dates had a significant effect on this trait, as the plants sowing on the late date 1st December gave the highest average for this trait, amounting to 8.24 seeds capsule$$^{-1}$$, and it did not differ significantly from the plants of the date 1st November which gave 7.72 seeds capsule$$^{-1}$$, while plants sowing on 15th November gave the lowest mean of the trait, at 7.48 seeds capsule$$^{-1}$$ . This result was in agreement with [23]; [17]; [6]; [24], who found the number of seeds in the capsule varies according to sowing dates. Interaction between the two factors of study had a significant effect on this trait, as sowing in the late 1st December of the two cultivars Sakha5 and Sakha6 gave the highest and lowest value of the interaction, which amounted to 9.10 and 6.43 seed capsule$$^{-1}$$ respectively.

Table 4. Effect of cultivars and sowing dates on the number of seeds in the capsule (seed capsule$$^{-1}$$) for the flax crop for the season (2020-2021)

| Sowing Dates | Cultivars | Mean |
|--------------|-----------|------|
|              | Sakha 1   | Sakha 4 | Sakha 5 | Sakha 6 | Local |      |
| 15th October | 7.00      | 7.60   | 8.16    | 7.13    | 7.60  | 7.58 |
| 1st November | 7.23      | 8.13   | 8.73    | 7.13    | 7.36  | 7.72 |
| 15th November| 7.40      | 7.90   | 8.56    | 6.56    | 7.06  | 7.48 |
| 1st December | 8.66      | 8.93   | 9.10    | 6.43    | 8.53  | 8.24 |
| Mean         | 7.57      | 8.14   | 8.63    | 6.83    | 7.63  |      |

LSD 5% 0.53 0.61 1.06
3.5. Weight of 1000 seeds (g)

The results of Table (5) showed that there was a significant difference between the flax cultivars in the weight of 1000 seeds, as the Sakha6 variety had the highest average of 7.83 g, and it did not differ significantly from the weight of the Sakha1 cultivars, which amounted to 6.84 g, compared to the plants of the Sakha5 cultivar, which achieved the lowest results for the phenotype, amounting to 6.01 g. The reason for the decrease in the weight of 1000 seeds of plants of the variety Sakha5 compared to the plants of other cultivars is due to their superiority in the number of seeds in the capsule Table (4), as the increase in the number of seeds in the capsule increased competition between them for the metabolic compounds of photosynthesis and thus the distribution of these products over a greater number of seeds and then reduced weight. This is in line with what was reported by [8]; [14]; [19]; [1];[23]; [12]; [15]; [22], who found a significant difference between flax cultivars in the weight of 1000 seeds.

Planting dates significantly affected the weight of 1000 seeds, as the sowing of the date of 15th November achieved the highest average of 7.07 g and did not differ significantly from the plants of the date of 15th October which gave 6.97 g, while the plants of the late date 1st December gave the lowest average of 6.13 g, perhaps the reason for this increase in the number of seeds in the capsule for plants of the date 15th November Table (4), which led to the seed obtaining a greater amount of metabolites and then an increase in its weight. This result is in agreement with both [26]; [23]; [15]; [6]; [24], who indicated that the dates of sowing led to a significant difference in the weight of 1000 seeds in flax.

The interaction between the two factors of the study had a significant effect on the characteristics of the weight of 1000 seeds per plant, as the plants of the cultivar Sakha6, when sowing on 15th November, gave highest value of the interaction, which was 8.03 g, while the plants of the local variety that were sown on the date 1st December gave the lowest value of 5.33 g.

Table 5. Effect of cultivars and sowing dates on the weight of 1000 seeds (g) of flax crop for the season (2020-2021)

| Sowing Date     | Cultivars |          |          |          | Mean |
|-----------------|-----------|----------|----------|----------|------|
|                 | Sakha 1   | Sakha 4  | Sakha 5  | Sakha 6  |      |
| 15th October    | 7.00      | 7.16     | 6.20     | 7.60     | 6.9  |
| 1st November    | 7.03      | 6.98     | 6.30     | 7.96     | 6.20 |
| 15th November   | 7.16      | 7.00     | 6.01     | 8.03     | 7.0  |
| 1st December    | 6.20      | 6.90     | 5.46     | 7.76     | 5.33 |
| Mean            | 6.84      | 6.75     | 6.01     | 8.05     | 6.33 |
| LSD 5%          |           |          |          |          | 2.06 |

3.6. Seed yield (ton ha⁻¹)

Results of Table (6) indicate that flax cultivars differed significantly among themselves in seed yield, as Sakha6 plants outperformed them by giving them the highest average for the trait amounting to 2.377 ton ha⁻¹, with an increase of 34% compared to plants of the local variety, which gave the lowest average of 1.762 ton ha⁻¹. Increase in the seed yield of the Sakha6 variety is due to its superiority in the most important components of the yield, as it gave the highest average number of capsules per plant (Table 3) and the weight of 1000 seeds Table (4), which helped to increase the seed yield, and this is similar to the results reached by many researchers like, Such as [14]; [23]; [20]; [27]; [1]; [2]; [12]; [15]; [22]; [4], who indicated that flax cultivars differed significantly in seed yield, same table also shows that the sowing date of 15th November was significantly superior in seed yield, which amounted to 2.402 ton h⁻¹ and did not differ significantly from the dates 1st November and 15th October (2.393 and 2.343 ton h⁻¹). In comparison with the plants of the 1st December date, which gave the lowest average of 1.451 ton ha⁻¹. This is reflected in the increase number of capsules per plant (Table 3) and the weight of 1000 seeds Table (4). These results are in agreement with the findings of both [9]; [23];
[20]; [17]; [15]; [6]; [24], who found a significant difference in sowing dates in the yield, of Also, the interaction between cultivars and sowing dates had a significant effect on seed yield, as the Sakha6 cultivar plants sown on 15th November gave the highest value of the interaction, which amounted to 2.662 tons ha⁻¹, and did not differ significantly from the same variety that was sown on 1st November and 15th October (2.655 and 2.552 ton ha⁻¹), while the local variety achieved when sowing at the last date had the lowest value of the interference, amounted to 1.233 ton ha⁻¹.

Table 6. Effect of cultivars and sowing dates on seed yield (ton ha⁻¹) of flax crop for the season (2020-2021)

| Sowing Dates | Cultivars |
|--------------|-----------|
|              | Sakha 1   | Sakha 4 | Sakha 5 | Sakha 6 | Local     | Mean      |
| 15th October | 2.360     | 2.398   | 2.508   | 2.552   | 1.897     | 2.343     |
| 1st November | 2.426     | 2.416   | 2.557   | 2.655   | 1.911     | 2.393     |
| 15th November| 2.400     | 2.415   | 2.524   | 2.662   | 2.009     | 2.402     |
| 1st December | 1.417     | 1.377   | 1.589   | 1.640   | 1.233     | 1.451     |
| Mean         | 2.150     | 2.151   | 2.295   | 2.377   | 1.762     | 0.081     |

4. Conclusion
It could be concluded that was sowing of flax cultivars Sakha6 on 1st November (second date) to give maximum seed yield in Anbar governorate, Iraq.

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