# Different sowing dates and their effects on flax (*Linum usitatissimum* L.) growth, yield, and quality in rainfed sulaimany-kurdistan -Iraq.

**Shaee Adeeb Ghareeb* , Solaf Adnan Mahmood , Shilan Hussein Shkur**

**Biotechnology and Crop Science Department, College of Agricultural Engineering Science, University of Sulaimani, Sulamani, Kurdistan, Iraq.**
***Corresponding author email: shaee.gharib@univsul.edu.iq**
**https://doi.org/ 10.59658/jkas.v11i3.2354**

**Received:**
June 30, 2024

**Accepted:**
Aug. 8, 2024

**Published:**
Sept. 15, 2024

## Abstract

The experiment was conducted at the Qlyasan, which was located in the governorate of Sulaimani-Kurdistan in the northeast of Iraq. An investigation was conducted during the 2022-2023 rabi season to assess the impact of planting dates on flax seed yield and oil content. It is required to precisely determine the design, whether it is a split-plot arrangement within a randomized complete block design (RCBD) with three replications was applied. Flax seeds were sown on three different dates: November 25$^{th}$, December 10$^{th}$, and December 25$^{th}$", while the two cultivars Local and Thorshansity 72 (Polish cultivar) were planted. The characteristics studied in this research included plant height (cm), the number of branches/plant, number of capsules/plant, numbers of seeds/capsule,1000 seed weight (g), seed yield (kg ha$^{-1}$), oil content (%).The results indicated that variation in sowing dates had a significant impact on all traits of flax cultivar. The results revealed that the first sowing date 25 November surpassed other sowing dates in all characters and produced the highest seed yield and oil content (1.575kg ha$^{-1}$, 22.89%) respectively and the lowest seed yield and oil content obtained by the last sowing dates. Results showed significant differences among the flax cultivars. the Thorshansity 72 cultivar surpassed to the Local cultivar. Thorshansity 72 cultivar produced the maximum seed yield and oil content (1.520 kg ha$^{-1}$, 23.03%). The interaction between the two factors under study significantly affected all characters except plant height. The highest seed yields and oil content were (1.637t/ha,24.67%) obtained by Thorsanisity72 cultivar, when sowing in 25 November. To summarize, initiating cultivation early in the season under cond0ucive environmental circumstances emerges as a viable tactic for flax production, leading to elevated yield and oil%.
**Keywords**: Flax, Planting Date, Genotypes, Seed Yield, Oil Content%.

## Introduction

Flax (*Linum usitatissimum* L.) is a significant player in the trade and industrial crop sector, contributing to regional development through both local production and export activities [1]. Flax occupies a prominent position in the agricultural industry, ranking as the third-largest fiber crop and one source among the five major oilseed crops globally. Notably, the oil content within flax seeds can vary between 30-45% [2]. Beyond its industrial significance, flax holds value as a medicinal plant, leading to a rapid rise in human consumption for both food and industrial applications [3]. This versatility extends to its ability to be cultivated for both oil extraction from seeds and fiber production from stems [4]. Linseed oil, derived from flax seeds, has even found substitutes in paint formulations. The health benefits associated with flaxseeds have further bolstered the crop's market value. Moreover, the oil extracted from the seeds is recognized as a significant source of essential polyunsaturated fatty acids (PUFAs) for human nutrition. These fatty acids, constituting roughly 30-40% of the seed content, include esters of linoleic acid, linolenic acid, stearic acid, and oleic acid, with alpha-linolenic acid being the most prominent fatty acid present [5].

Climate change is exerting a significant influence on agricultural production, with impacts felt across various practices, including sowing time. Notably, sowing time is recognized as a critical factor influencing crop yield. This importance is reflected in the research focus of numerous scientists worldwide who have identified sowing time as a key factor for flax cultivars. For example, research by [6] highlights the substantial role that sowing date plays in determining flax crop growth, quantity, and quality.

While flax exhibits adaptability to a wide range of environments, it thrives primarily in temperate climates [7,8]. Research has shown that temperature during plant development exerts a dominant influence on various flax characteristics. These characteristics include seed yield and its components, plant height, time to maturity, oil content, and oil composition [7, 9]. Additionally, seed moisture content at harvest may also play a role in determining the final oil content and composition of the seeds [8]. Crop cultivar are a critical factor influencing yield. However, a variety's inherent yield potential, established by its genetic limitations, is ultimately determined by the surrounding environment [10].

The introduction of new linseed cultivars represents a significant advancement in efforts to enhance production per unit area. Optimizing agronomic practices to create ideal environmental conditions can further elevate the yield potential of these new cultivars [10]. A well-established principle in genetics is that a specific genotype will not necessarily exhibit the same phenotypic characteristics across all environmental conditions. Furthermore, different genotypes respond in varying ways to a particular environment, and their relative performance can differ significantly [11]. This genotype-environment interaction ultimately determines the selection of genotypes for specific sowing dates. Through this selection process, growers aim to achieve either yield stability or maximization, depending on their goals [12].

The aim of this study to investigated the influence of sowing time and varietal selection on specific growth and yield parameters of flax. Furthermore, the research aimed to assess the potential impact of climate change on optimal sowing time for the crop.

## Materials and Methods

This present study was done in the Qlyasan, which was located in the governorate of Sulaimani in the northeast of Iraq, on the border with Iran. Qlyasan is the Research Station of the Biotechnology and Crop Science Department, College of Agricultural Engineering Sciences, University of Sulaimani, located at (Latitude: 35° 34´ 17″ N, Longitude: 45° 22´ 00″ E, and altitude of 757 masL), 2 km northwest of Sulaimani city. “Garmin, GPS map 60 Cx.”.

It is required to precisely determine the design, whether it is a split-plot arrangement within a randomized complete block design (RCBD) with three replicates. Each replicate consists of 6 experimental units. The experimental unit was (1 m × 1 m), and within each experimental unit there will be five lines, the length of the planted line will be 1 meter, and the distance from one line to the next 20 cm and 6 cm between plant to plant in the same line [13]. The represented soil samples were taken from fields after tillage at depth of (0-30) cm depth, these samples were air dried then sieved by using 2 mm sieves, then packed for analysis, as show in Table (1). 2-3 seeds will be planted in each bed, and it will be thinned to one plant two weeks after germination. A fertilizer regimen incorporating 100 kg N/ha was implemented using urea (46% N) with a split application strategy. Half of the total nitrogen fertilizer was applied at planting, and the remaining half was administered during the flowering stage [14]. Additionally, at planting, 200 kg $P_2O_5$ $ha^{-1}$ of triple superphosphate (46% $P_2O_5$) was applied near the rows in a band and subsequently covered for optimal plant uptake [15]. 1-meter distance between experimental units will be left and 1-meters between blocks. The sowing dates will be (25 November, 10 December and 25 December), while the two cultivars cultivars Local and Thorshansity 72 (Polish cultivar) used. Five plants from each plot were randomly chosen to measure things like their growth, yield and quality characters. These characters were plant height (cm), the number of branches/plants, the number of capsules/plants, numbers of seeds/capsule,1000 seed weight (g), seed yield (kg $ha^{-1}$), oil content (%). Manual harvesting occurred when the plants reached full maturity. Digital Soxhlet instrument was used for measured oil content %, with n-hexane solvent (BDH, UK), [16].

**Table (1): Physicochemical properties of the soil samples from the study sit**

| Physicochemical Properties | | | |
|---|---|---|---|
| **Physical properties** | Sand | 87 | |
| | Silt | 435 | (g $kg^{-1}$) |
| | Clay | 458 | |
| | Texture | Silty Clay (SiC) | |
| | pH | 7.59 | |
| | ECe | 490 | (µS $cm^{-1}$) |
| **Chemical properties** | O.M. | 22.4 | (g $kg^{-1}$) |
| | $CaCO_3$ | 304.3 | |

**Table (2): Monthly mean values of temperature and rainfall for Qlyasan[1] location in (2022-2023)**

| Month | Average Temperature ($C^O$) | | Rainfall (mm) | |
|---|---|---|---|---|
| 2022 | Max | Min | Max | Min |
| November | 22.5 | 7.4 | 110.2 | 17 |
| December | 18.5 | 1 | 143.8 | 117.4 |
| 2023 | Max | Min | Max | Min |
| January | 14.5 | -0.4 | 1147.8 | 17.2 |
| February | 21.7 | -2 | 323.6 | 290.6 |
| March | 24.4 | 2.4 | 565.8 | 324.2 |
| April | 27.1 | 4.6 | 670.2 | 565.8 |
| May | 33.6 | 11.6 | 718.8 | 679.2 |
| June | 41 | 18.9 | 0.4 | 0 |
| July | 44.2 | 25 | 0 | 0 |
| August | 45.3 | 23.9 | 0.2 | 0 |

Unit of Meteorology of College of Agricultural Engineering Sciences, University of Sulaimani

## Results and Discussion

### Plant height (cm)

Table (3) reveals statistically significant differences in plant height attributable to planting date. The earliest planting date November 25th resulted in the greatest plant height (60.30 cm), whereas the latest sowing date December 25th produced plants with the shortest stature (50.41 cm). This variation may be attributed to the extended vegetative growth period associated with the earlier planting date, potentially benefiting from more favorable temperature and rainfall patterns during this critical stage. These observations align with previous research documented in [17, 18, 19].

The plant heights were significantly affected by cultivars Table (4). The highest means of plant height was (56.76 cm) acquired by (Thorsanisity72), cultivars while the lowest means of plant height was (52.31 cm) acquired by Local cultivar, this trial investigated the variation observed among different genotypes. While genetic makeup played a primary role in determining these variations, the influence of environmental factors, such as temperature, rainfall, humidity, and sunshine duration, was also acknowledged [10,20]. Analysis of Table (5) reveals no statistically significant interaction effect between sowing dates and cultivars on plant height.

### Number of branches/plants

Data from Table (3) reveal statistically significant variations in the number of branches per plant across different planting dates. The earliest planting date, on November 25th, yielded the greatest average number of branches per plant (7.20), whereas the latest planting date, on December 25th, resulted in the lowest average number of branches per plant (5.80).

This might be due to the concurrence of growth stages with congenial temperature during early sowing which had affected all elementary physiological processes in plants which resulted similar trend observed by [21,22]. The number of branches per plant was significantly affected by both cultivars. The maximum number of branches was (6.78) obtained by Thorsanisity72 cultivar, it was also found from the Table (4). The observed variation in branch number per plant could be attributed to two key factors: inherent genetic predisposition and the plants' adaptation to the prevailing environmental conditions during the experiment [10].

That the interaction of sowing dates and cultivars Table (5) had significant effects on number of branches/plants. The maximum number of branches was (7.50) obtained by Thorsanisity72 cultivar when sowing on first planting date and the minimum number of branches/plants was (5.71) obtained by Local cultivar when sowing on last planting date.

## Number of capsules/plants

The experiment's results demonstrated a significant influence of sowing date on the number of capsules per plant. The first sowing date November 25$^{th}$ produced the highest number of capsules per plant (44.21). This might be attributed to the exposure of the flax sown on this date to lower temperatures, increased dew formation, and greater coldness, which in turn, could have promoted enhanced growth characteristics like plant height and capsule number. These findings align with previous research conducted by [23, 24]. Conversely, the last sowing date December 25$^{th}$ resulted in the lowest number of capsules per plant (36.02) as shown in Table (3). The lower capsule numbers observed with later flowering could be due to the impact of temperature on pollination success and ovary survival during delayed sowing periods, as suggested by [25].

The data presented in Table (4) reveal a statistically significant influence of linseed cultivar on the number of capsules per plant. The highest number of capsules/plant (41.26 capsules) was obtained from the Thorsanisity72 cultivar, the observed significant difference can likely be attributed to both inherent genotypic variation and the differential adaptation of these genotypes to the experimental environment. These findings are consistent with previous research by [26,27].

Table (5) demonstrates a significant interaction effect between sowing dates and flax cultivars on the number of capsules produced per plant. The maximum number of capsules/plants was (45.11) obtained by Thorsanisity72 cultivar when sowing on first planting dates.

## Number of seeds/capsules

Based on the information in Table (3), there are statistically significant differences in the number of seeds per capsule across the sowing dates. The sowing date of November 25$^{th}$ resulted in the highest average number of seeds per capsule (6.49), whereas December 25$^{th}$, the latest sowing date, yielded the lowest average number of seeds per capsule (4.45).

The reduction in seeds per capsule observed with later sowing dates in Table (3) can be attributed to two interrelated factors. Firstly, delayed sowing exposes the crop to a rise in temperature during the flowering and seed-filling stages Table (2). This is corroborated by research from [19, 28, 29]. Secondly, later sowing shortens the period between flowering and harvest, potentially limiting seed development. Furthermore, varying sowing dates can expose the linseed crop to different climatic conditions (not just temperature). This variation in climate may hinder seed filling within the capsules of different linseed cultivars, ultimately resulting in fewer seeds per capsule. This finding aligns with the observations reported by [23, 30].

In Table (4) was significantly affected by cultivar. The maximum values were (5.72) seed acquired by Thorsanisity72 cultivar, while the minimum values were (5.07) seed obtained by Local cultivar. The superior performance of the Thorsanis72 cultivar can be attributed to its inherent characteristics, which include some characteristics like increase of height and number of branches/plant and number of capsule/plants which led to increase number of seeds/capsules. This result agreement with [31]. It was also found from Table (5) that the interaction between planting dates and cultivars had significant effect on number of seeds/capsule.the maximum values was (6.94) seeds per capsule obtained by Thorsanisity72 cultivar when planted on 25 November.

**1000 seed weight**

Environmental factors, particularly temperature during vegetative and reproductive stages, significantly impacted 1000-seed weight Table (3). The sowing date of November 25$^{th}$ resulted in the highest 1000-seed weight (6.79 g), with a subsequent decrease observed in plots sown later. This decline might be attributed to the pressure placed on later-sown crops to mature and dry rapidly due to a sudden rise in temperature. In contrast, timely sown crops experience an advantage. After completing a satisfactory vegetative growth period, they reach the seed filling stage when temperatures are more favorable [32, 33, 34]. These findings align with previous research, which reported that early sowing resulted in higher test weight compared to delay sowing. While the current study's findings diverge from those reported in [24, 35], where sowing dates were found to have no statistically relevant effect on test mass. The data presented here Table (4) demonstrates a statistically significant difference in 1000-seed weight between the cultivars examined. Thorsanisity72 exhibited the highest 1000-seed weight (6.36 g), which was substantially greater than that of Local (5.36 g). The success of the Thorsanis72 cultivar likely stems from its combined strengths: broad environmental adaptability, high resource use efficiency, and favorable genotypic characteristics. In contrast, the local cultivar exhibits a shorter lifecycle compared to other cultivars. However, this potentially advantageous trait might be limited by a less extensive root system, which could restrict membrane development and contribute to smaller seed size. These findings align with previous research by [36, 37] who demonstrated a significant influence of linseed cultivar on thousand seedweight.

The interaction effects of planting dates with cultivar had significant effect on 1000-seed weight of flax plants. The highest values were (7.29g) procure by Thorsanisity72 cultivar when planted on 25 November, while the lowest values were (4.98g) obtained by Local cultivar when planted on last planting.

**Seed yield (Kg ha-$^{1}$)**

The data in Table (3) shows that planting flax seeds on the earliest date (November 25$^{th}$) resulted in the greatest yield of seeds per hectare (1.575 kg/ha). Seed yield decreased with later planting dates, with the December 25$^{th}$ planting producing the lowest yield (1.382 kg/ha). The increased seed yield observed for the November 25$^{th}$ sowing date can be attributed to a combination of factors. These factors include a greater number of capsules per plant, more seeds per capsule, and a higher 1000-seed weight. Our findings are consistent with previous research documented by [17, 38, 39]. Furthermore, our results corroborate the findings of [40], who also reported a significant influence of sowing date on various growth characteristics and yield components of linseed.

This paraphrase clarifies the contrasting viewpoint and emphasizes the positive impact of early sowing on growth and yield. It also acknowledges the supporting evidence from previous research by [41]. Results showed significant differences among the flax cultivars. Where Thorsanisity72 surpassed to the Local cultivar. The superior performance of this particular cultivar can likely be attributed to its exceptional yield metrics, including a greater number of capsules per plant, branches per plant, and seeds per capsule. These findings are consistent with prior research by [42, 43] who reported variations in seed yield observed among different flax cultivars. Furthermore.

The result of Table (5) showed that the interaction effect between sowing date and cultivars significantly affected the seed yield. The highest yields were (1.637t/ha) obtained by Thorsanisity72 cultivar, when sowing in 25 November, however, the minimum seed yields were (1.347t/ha) procured by Local cultivar when sowing on last planting date.

**Oil content**

As shown in Table (3) there was significant difference among sowing dates in percentage of oil. The highest percentage was (22.89%) obtained by sowing on 25 November, while the lowest percentage was (19.60%) occurred at sowing date 25 December. The oil percentage reduced with delay in sowing dates, the study observed a decrease in seed oil percentage with delayed sowing dates. This decline is attributed to unfavorable weather conditions, particularly high temperatures during the seed filling period. These high temperatures likely hinder the efficient translocation of nutrients from leaves to developing seeds. This reduced nutrient mobility consequently leads to a decrease in seed oil content. These findings are consistent with previous research reported in [18, 28, 29].The result disagrees with [44] observed an increase in oil content as temperatures rose during the flowering to maturity stages, they reported that a 1°C rise in temperature corresponded to a 1% increase in oil content. Concerning the percentage of oil genotypes, the significant differences.

**Table (3): The effect of planting date on some traits of flax plant**

| Planting dates | Plant height (cm) | No. of branch /plant | No. of capsule/plant | No. of seed/capsule | 1000 seed weight(g) | Seed yield (kg-ha) | Oil content% |
|---|---|---|---|---|---|---|---|
| **25-Nov** | 60.30 | 7.20 | 44.21 | 6.49 | 6.79 | 1.575 | 22.89 |
| **10-Dec** | 52.90 | 6.45 | 40.57 | 5.24 | 5.96 | 1.482 | 21.53 |
| **25-Dec** | 50.41 | 5.89 | 36.02 | 4.45 | 5.23 | 1.382 | 19.60 |
| **LSD (p≤0.05)** | 0.192 | 0.068 | 0.171 | 0.064 | 0.064 | 0.010 | 0.082 |

Table (4) the highest percentages were (23.03%) gained by Thorsanisity72 cultivar. Flax seed composition is primarily defined by two key constituents: oil content and fatty acid profile. While genetics play a fundamental role in determining these constituents, environmental factors such as growing season, geographic location, and agronomic practices are also recognized to exert a significant influence [45].

**Table (4): The effect of cultivars on some traits of flax plant**

| Cultivars | Plant height (cm) | No. of branch /plant | No. of capsule/plant | No. of seed/capsule | 1000 seed weight(g) | Seed yield (kg-ha) | Oil content% |
|---|---|---|---|---|---|---|---|
| **Thorsanisity 72** | 56.76 | 6.78 | 41.26 | 5.72 | 6.36 | 1.520 | 23.03 |
| **Local** | 52.31 | 6.24 | 39.27 | 5.07 | 5.63 | 1.439 | 19.65 |
| **LSD (p≤0.05)** | 0.156 | 0.056 | 0.139 | 0.052 | 0.052 | 0.008 | 0.067 |

The effect of sowing dates and cultivars interaction on oil content displayed in Table (5) they showed significant differences, the highest percentage was (24.67%) procure by the Thorsanisity72 cultivar when sowed on 25 November, however the lowest percentages was (18.16%) obtained by Local cultivar when sowing on the last planting date.

**Table (5): The effect of interaction between planting date and cultivars on some flax traits**

| Planting dates x Cultivars | | Plant height (cm) | No. of branch /plant | No. of capsule/plant | No. of seed/capsule | 1000 seed weight(g) | Seed yield (kg-ha) | Oil content% |
|---|---|---|---|---|---|---|---|---|
| **25-Nov** | **Thorsanisity 72** | 62.26 | 7.50 | 45.11 | 6.94 | 7.29 | 1.637 | 24.67 |
| | **Local** | 58.33 | 6.89 | 43.32 | 6.05 | 6.31 | 1.513 | 23.36 |
| **10-Dec** | **Thorsanisity 72** | 56.81 | 6.77 | 41.80 | 5.39 | 6.29 | 1.507 | 21.10 |
| | **Local** | 48.98 | 6.13 | 39.33 | 5.09 | 5.62 | 1.457 | 21.05 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 25-Dec | Thorsanisity 72 | 51.21 | 6.06 | 36.86 | 4.82 | 5.48 | 1.417 | 19.17 |
| | Local | 49.61 | 5.71 | 35.17 | 4.07 | 4.98 | 1.347 | 18.16 |
| LSD (p≤0.05) | | n.s | 0.1915 | 0.097 | 0.242 | 0.091 | 0.014 | 0.116 |

This field study in Sulaimani-Kurdistan, Iraq, during the rabi season demonstrates the potential for flax cultivation. Sowing date emerged as a critical factor for optimizing flax productivity. Planting the appropriate cultivar significantly impacted growth parameters, yield, and yield components. Additionally, environmental conditions demonstrably influenced yield and oil content, with the effect dependent on the specific flax cultivars. In conclusion, early sowing under favourable ecological conditions represents a successful strategy for flax cultivation. Early planting resulted in increased seed yield and oil content. Therefore, prioritizing early sowing, while considering optimal soil temperatures, is recommended to maximize both seed and oil content.

## References


**1)** Khalifa, R. Kh. M., Manal, F. M., Bakry, A. B., & Zeidan, M. S. (2011). Response of some flax varieties to micronutrients foliar application under newly reclaimed sandy soil. *Australian Journal of Basic and Applied Sciences*, *5*(8), 1328-1334.

2) Mueller, K., Eisner, P., Yoshie-Stark, Y., Nakada, R., & Kirchhoff, E. (2010). Functional properties and chemical composition of fractionated brown and yellow linseed meal (*Linum usitatissimum* L.). *Journal of Food Engineering*, *98*(4), 453-460. https://doi.org/10.1016/j.jfoodeng.2010.01.012

3) Khourang, M., Parissa, B., & Reza, O. (2012). Effect of some chemical and biological fertilizer on productivity of a medicinal flax (*Linum usitatissimum* L.) plant. *International Journal of Agronomy and Plant Production*, *3*(3), 78-83.

4) Martin, J. H., Richard, P. W., & David, L. S. (2006). *Principles of field crop production* (4th ed.). New Jersey: Columbus, Ohio.

5) El-Nagdy, G. A., Nassar, D. M. A., El-Kady, E. A., & ElYamanee, G. S. A. (2010). Response of flax plant (*Linum usitatissium* L.) to treatments with mineral and bio-fertilizers from nitrogen and phosphorus. *Journal of American Science*, *6*(10), 207-217.

6) Salih, R. F. (2019). Effect of sowing dates and varieties of cotton (*Gossypium hirsutum* L.) on growth and yield parameters. *ZANCO Journal of Pure and Applied Sciences*, *31*(3), 64-70. https://doi.org/10.21271/ZJPAS.31.3.6

7) Casa, R., Russell, G., Lo Cascio, B., & Rossini, F. (1999). Environmental effects on linseed (*Linum usitatissimum* L.) yield and growth of flax at different stand densi-

ties. *European Journal of Agronomy, 11*(3-4), 267-278. https://doi.org/10.1016/S1161-0301(99)00029-4
8) Adugna, W., & Labuschagne, M. T. (2003). Association of linseed characters and its variability in different environments. *Journal of Agricultural Science, 140*(3), 285-296. https://doi.org/10.1017/S0021859603003221
9) Dybing, C. D., Evenson, P. D., & Lay, C. (1988). Relationships among daily flower production, length of the flowering period, and seed yield of flax. *Crop Science, 28*(2), 287-292. https://doi.org/10.2135/cropsci1988.0011183X002800020037x
10) Ram, K. S. (2013). Effect of dates of sowing on growth, yield and quality of linseed (*Linum usitatissimum* L.) varieties [Master's thesis, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi].
11) Eberhart, S. A., & Russel, W. A. (1966). Stability parameters for comparing varieties. *Crop Science, 60*, 36-40. https://doi.org/10.2135/cropsci1966.0011183X000600010011x
12) Finlay, K. W., & Wilkinson, G. N. (1963). The analysis of adaptation in a plant breeding program. *Australian Journal of Agricultural Research, 4*(5), 742-754. https://doi.org/10.1071/AR9630742
13) Sarkees, N. A., & Mahmood, B. J. (2018). Effect of plant density on yield and quality of two flax cultivars (*Linum usitatissimum* L.). *Journal of Tikrit University for Agricultural Sciences, 18*(3), 13-20.
14) Hassen, A. Y., & Shaker, A. T. (2013). Effect of nitrogen and iron at two levels of field capacity on the growth and yield of linseed (*Linum usitatissimum* L.). *Diala Journal for Agricultural Sciences, 2*(5), 670-681.
15) Esmail, A. O., Yasin, H. S., & Mahmood, B. J. (2014). Effect of levels of phosphorus and iron on growth, yield, and quality of flax. *Journal of Agriculture and Veterinary Science (IOSR-JAVS), 7*(5), 7-11.
16) Ferreira-Dias, S., Valente, D. G., & Abreu, J. M. F. (2003). Comparison between ethanol and hexane for oil extraction from *Quercus suber* L. fruits. *Grasas y Aceites, 54*(4), 378-383.
17) Rahimi, M. M. (2014). Effect of sowing date and nitrogen on yield and yield components of medicinal flax. *International Journal of Biosciences (IJB), 5*(12), 160-165.
18) Emam, S. M. (2019). Effectiveness of sowing dates and rates on productivity of two flax (*Linum usitatissimum* L.) cultivars. *Egyptian Journal of Agronomy, 41*(3), 261-274.
19) Al-Juheishy, W. K. S. (2020). Effect of sowing dates and zinc spraying on growth and yield of flax (*Linum usitatissimum* L.). *International Journal of Agriculture, State Science, 16*(Supplement 1), 1875-1882.
20) Salih, R. F., Qader, A. T., & Bakr, Z. S. (2021). Row spacing and seeding rate effect on growth parameters of flax (*Linum usitatissimum* L.). *ZANCO Journal of Pure and Applied Sciences, 33*(S1), 72-75.

21) Verma, K. P., & Pathak, R. K. (1993). Response of linseed (*Linum usitatissimum* L.) varieties to different dates of sowing. *Indian Journal of Agronomy, 38,* 60-63.

22) Mevada, K. D., Parmar, B. G., Patel, H. K., & Patel, P. D. (2017). Response of linseed (*Linum usitatissimum* L.) to different sowing dates and seed rates under middle Gujarat conditions. *Crop Research, 52*(4 & 5), 150-154.

23) Abdul El-Dayem, M. A., Shams, S. A. A., & Abdo Kaied, H. M. H. (1998). Effect of planting dates and seeding rates on yield and its components of flax (*Linum usitatissimum* L.) grown under newly reclaimed land. *Annals of Agricultural Science, Moshtohor*, *40*(2), 741-749.

24) Jana, K., Das, S. K., Roy, D. C., Kundu, M. K., Kundu, A., & Sathish, G. (2018). Seed yield of linseed varieties grown as 'paira' crop as influenced by dates of sowing. *Journal of Applied and Natural Science, 10*(1), 17-23.

25) Mirshekari, M., Amiri, R., Iran Nezhad, H., Sadat Noori, S. A., & Zand Vakili, O. R. (2012). Effects of planting date and water deficit on qualitative and quantitative traits of flax seed. *American-Eurasian Journal of Agricultural and Environmental Sciences*, *12*, 901-913.

26) El-Sweify, H. H. (1993). *Evaluation of some promising flax strains in relation to growth*, *yield and quality* (Ph.D. thesis). Faculty of Agriculture, Moshtohor, Zagazig University, Egypt.

27) Omar, T. S. (2002). *Response of some flax strains to row spacing and nitrogen fertilization* (Ph.D. thesis). Faculty of Agriculture, Moshtohor, Banha University, Egypt.

28) Sohair, E. D. E., Amany, M. A., Naguib, A., & Doaa, I. M. (2015). Effect of sowing date on yield, fiber, and seed quality of eight flax genotypes. *American-Eurasian Journal of Agriculture and Environment Sciences*, *15*(5), 886-895.

29) Al-Obady, R. F. A., & Shaker, A. T. (2022). Effect of sowing dates and compound fertilizer NPK on growth and yield of flax (*Linum usitatissimum* L.). *Basrah Journal of Agricultural Sciences*, *35*(2), 185-198.

30) Dixit, J. P., Chourasia, S. K., Pillani, P. V. A., & Khan, R. A. (1992). Assessment of linseed (*Linum usitatissimum* L.) varieties under double-cropping system in Tawa command. *Indian Journal of Agronomy, 39*(1), 105-109.

31) Ghareeb, A. S. H. (2014). *Response of some genotypes to different sowing dates and its effect on growth, yield and quality of peanut (Arachis hypogaea L.)* (M.Sc. thesis). Salahaddin University, College of Agriculture.

32) Ahmad, A., Hay, A., & Ftah. (2006). Effect of sowing and harvesting dates on yield and its quality for some flax varieties. *Journal of Agricultural Science, Mansoura University, 31*(9), 5557-5566.

33) Mohapatra, S. C., Bishoyi, B. S., & Patra, H. K. (2009). Effect of sowing dates and varieties on production of linseed (*Linum usitatissimum* L.). *Environment and Ecology, 27*(1A), 436-438.

34) Al-Doori, S. A. M. (2012). Influence of sowing dates on growth, yield, and quality of some flax genotypes (*Linum usitatissimum* L.). *College of Basic Education Researchers, 12*(1), 733-746.
35) Farhadi, N., Souri, M. K., Alirezalu, A., & Moghaddam, M. (2013). Effects of sowing dates on quantity and quality of castor bean (*Ricinus communis* L.) under semi-arid conditions in Iran. *Zeitschrift für Arznei- & Gewürzpflanzen, 18*(2), 72-77.
36) Abebe, D., & Adane, C. (2016). Response of linseed (*Linum usitatissimum* L.) to seed rates and seeding methods in South-Eastern Highlands of Ethiopia. *Journal of Biology, Agriculture and Healthcare, 5*(56-62), 13.
37) Barbara, C., Saša, S., Aleš, H., & Anita, K. (2020). Impact of linseed variety, location, and production year on seed yield, oil content, and its composition. *Agronomy Journal, 10*(11), 1770.
38) Jana, K., Das, S. K., Roy, D. C., Kundu, M. K., Kundu, A., & Sathish, G. (2018). Seed yield of linseed varieties grown as 'paira' crop as influenced by dates of sowing. *Journal of Applied and Natural Science, 10*(1), 17-23.
39) Kumari, S. (2020). Effect of sowing dates on yield attributes and yield of linseed (*Linum usitatissimum* L.) varieties. *Journal of Pharmacognosy and Phytochemistry, 9*(1), 791-792.
40) Shaikh, F. G., Gokhale, D. N., Rokade, B. S., & Jadhav, P. J. (2009). Effect of sowing date on some growth characters in linseed. *Journal of Agrometeorology, 11*(2), 203-205.
41) Singh, V. K., Singh, T., & Bohra, J. S. (2006). Comparative performance of sulfur, seed rate, and date of sowing on yield, quality, and nutrient uptake by linseed under rainfed conditions of the Varanasi region. *Crop Research (Hisar), 31*(1), 63-65.
42) El-Hariri, D. M., Mostafa, S. H., & El-Sweify, A. H. (1998). Effect of potassium fertilizer and phytohormone level on yield attributes, yield, and quality of flax in sandy soil. *The 1st Nordic Conference on Flax and Hemp Processing*, Tampere, Finland.
43) Bakry, A. B., Nofal, O. A., & Zeidan, M. S. (2012). Agronomic characteristics of three flax varieties as affected by some sources of potassium fertilization under newly reclaimed sandy soil conditions. *Australian Journal of Basic and Applied Sciences, 6*(4), 77-81.
44) Demurin, Y. A., Skoric, D., Veresbaranji, I., & Jocic, S. (2000). Inheritance of increased oleic acid content in sunflower seed oil. *Helia, 23*(32), 87-92.
45) Wilcox, J. R., & Shibles, R. M. (2001). Interrelationships among seed quality attributes in soybean. *Crop Science, 41*(1), 11-14.