Moroccan Journal of Agricultural Sciences
Vol 5 No 1 (2024): (March 2024), 25-31
Crop Production and Environment

Response of some flax (Linum usitatissimum L.) genotypes to different soil application levels of humic acid

William K.L. ABDELMASIEH Fiber Crops Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt
Gelan S.A. EL-YAMANEE Fiber Crops Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt
Ibrahim H.M. TALHA Fiber Crops Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt

Two field trials were established during 2021/2022 and 2022/2023 seasons at the Experimental Farm of Sakha Agricultural Research Station, Egypt, to evaluate the response of some flax genotypes (Strain 651, Sakha 3, Sakha 5 and Giza 12) to different fertilization levels of humic acid (HA) (0, 1000, 1500 and 2000 g/fed[1]) as a soil application. Split-plot design was used for the experiment with four replicates. The main-plots were assigned to the four fertilization levels of HA and the sub-plots were allocated to the four flax genotypes. The results pointed out that using 2000 g/fed of HA treatment significantly attained the highest values of all studied characters followed by 1500, 1000 and 0 g/fed during both seasons. The results also, referred that S.651 was significantly superior to the rest of the other genotypes in technical length, fiber length, fiber percentage and fiber yield/fed within both seasons. Giza 12 recorded significantly the most beneficial results for stem diameter, straw yield/plant, straw yield/fed, fruiting zone length, seed index and seed yield/plant in both seasons. Also, Sakha 5 significantly surpassed the other genotypes in number of capsules /plant, seed yield/fed, oil percentage and oil yield/fed in the 1st and 2nd seasons. Thus, this research recommended the use of 2000 g/fed of HA with the promising strain (S.651) to obtain the highest fiber yield/fed, or with Sakha 5 to gain the highest seed and oil yield/fed in Northern Delta region of Egypt.

Keywords: Flax genotypes, humic acid, straw yield, seed yield, oil yield, fiber yield

[1] *fed = feddan = 4200 m^2*

INTRODUCTION

Flax (Linum usitatissimum L.) is an annual plant from Linacaea family. It is one of the oldest cultivated crops to be widely grown for oil and fibers. In Egypt, flax has been sown by the ancient Egyptians for its fiber and seeds for thousands of years. Flax is grown as an annual winter crop in Egypt and is currently a crop of industrial importance grown worldwide. Consequently, it is considered a crucial crop in our economic plan because of its significance and the fact that it is produced locally and exported (El Harriri et al., 1998). Towels, clothes, and other textiles are made from the long fibers spun into linen yarns. While, paper, twin and packaging are all made from the short fibers (tow). Flax seeds are crushed and used to make linseed oil and linseed meal. Oil is used to make paints, varnishes, printing ink, oil cloth, and soap because it dries quickly in the air (Abdelmasieh et al., 2023). Egypt's total area under cultivation for flax crop was approximately 8609 hectares in the 2021 season, yielding 7600.74 tonnes of fiber (FAO, 2023).

Optimizing flax cultivation and its qualitative and quantitative properties requires a proper fertilization program (Dordas, 2010). Humic acid is a bio-stimulant with an organic charge that significantly affects plant growth, development and boosts crop yield. Numerous studies have been conducted on it (Nardi et al., 2004). Humic acid improves physical, chemical and biological properties of soil (Keeling et al., 2003 and Mikkelson, 2005). Humic acid is well known for its ability to reduce soil-borne infections, enhance soil health, help plants absorb nutrients, and increase the availability of minerals (Mouromical et al., 2011). Humic acid (HA) is one of the primary organic fertilizers that could be utilized, which is a crucial part of humic substances. Humic acid is considered the most prevalent organic matter component in soils and compost made from municipal waste, which is crucial for both the ecological processes of soil and the environment's elemental cycling (Senesi et al., 1996). Humates appear to have an especially positive impact on the availability of nutrients. Consequently, the application of humates was investigated as a strategy to enhance plant vitality and the balance of nutrients. Furthermore, humates have an impact on the quantity of sugars, amino acids and nitrate that accumulate and additionally the respiration process (Boehme et al., 2005). Humic substances also promote growth, yield, and quality by increasing nutrient uptake, acting as a source of mineral plant nutrients in addition a regulator of their release (Atiyeh et al., 2002).

The total area of land used for agriculture is limited in Egypt, so there is no way to compensate for this except by sowing new, high yielding cultivars. The potential yield of flax genotypes differed significantly depending on a range of physiological processes that are impacted by both genetics and environment. There is an urgent need to replace the old varieties from the farmers' field with new improved high yielding and disease resistant varieties (Singh, 2013). In this concern, Mahmoud et al. (2022) showed that the new promising Strain (S.651) had the highest percentage of total fiber. According to Leilah et al. (2018), Sakha 3 performed better than the other genotypes of flax in the trial, yielding the highest values for technical length, fiber yield per plant and feddan (4200 m2), fiber length, total fiber percentage, and fiber fineness within both growing seasons. However, the highest levels of seed oil content were produced by Sakha 5. The top values for plant height, technical stem length, fiber length, fiber fineness, total fiber percentage and fiber yield per hectare were obtained by Sakha 3 cultivar, according to Rashwan et al., 2020. In contrast, Giza 11 and Giza 12 attained the highest values for main stem diameter and straw yield per hectare. Sakha 5 also, had the greatest percentage of oil, seed and oil yields per hectare, and number of capsules per plant.

Therefore, this study was conducted with the aim of finding a good and cheap fertilizer source with the aim of increasing productivity and reducing expenses, as well as obtaining new, high-yielding varieties to replace the old ones at Sakha, Kafr El-Sheikh Governorate, Egypt.

MATERIALS AND METHODS

A field trial was carried out at the Experimental Farm of Sakha Agricultural Research Station, Agricultural Research Center (ARC), Egypt, over the two succeeding winter seasons of 2021/22 and 2022/23. The main purpose for this experiment is to find out a good and cheap fertilizer source with the aim of increasing productivity and reducing expenses, as well as obtaining new, high-yielding varieties to replace the old ones for the best flax yield and its features.

The experimental design was a split-plot design with four replicates, where each experimental sub-plot area was 6 m2 (2 x 3 m). The main-plots were assigned to the four levels of humic acid (HA) fertilization as a soil application (0, 1000, 1500 and 2000 g/fed), where the sub-plots were allocated to the four flax genotypes; Strain 651 (S.651) (fiber type), Sakha 3 (fiber type), Sakha 5 (oil type) and Giza 12 (dual type). Table 1 consists of the pedigree of the different flax genotypes.

The experimental location has a clay soil texture. In both study seasons, the summer crop that came before was maize. Mechanical and chemical analysis for the experimental sites in the first and second seasons were carried out by following the method described by Page (1982) and are tabulated in table 2.

Humic acid treatments in the form of potassium humate granule (85% potassium humate) were applied as a soil application twice, 30 and 45 days from planting with (0, 1000, 1500 and 2000 g/fed) for each soil application. While preparing the soil, all the phosphorus-requiring fertilizer, as calcium super phosphate (15.5% P_2O_5) was added at the rate of 100 kg/fed, in addition the nitrogen fertilizer at the rate of 45 kg N/fed as ammonium nitrate (33.5% N) was added in two doses of equal size, the first half of nitrogen before the second irrigation, while the second one was applied before the third irrigation.

In both seasons, the recommended seed rate for each genotype was sown on November 2nd and November 1st, respectively, using the broadcast sowing method. The Ministry of Agriculture and Land Reclamation’s guidelines were followed for the other flax agricultural techniques, which were maintained as usual.

The studied characters

In order to record the yield attributes at harvest time, ten protected plants were selected at random from each sub-plot. Straw yield/fed (ton), seed yield/fed (kg), oil yield/fed (kg) and fiber yield/fed (kg) were calculated from the whole sub-plot area basis. Seed oil percentage was determined according to the method described by A.O.A.C. (1990), using petroleum ether at (40–50°C) in a Soxhlet apparatus. Oil yield/fed (kg) was determined by multiplying seed oil percentage and seed yield/fed. Fiber percentage was calculated by (weight of fiber yield/weight of straw yield after retting) x 100.

Yield and its components

• Straw yield and its features were: technical length (cm), stem diameter (mm), straw yield/plant (g) and straw yield/fed (ton).

• Seed yield and its features were: fruiting zone length (cm), number of capsules/plant, seed index (weight of 1000 seeds) (g), seed yield/plant (g) and seed yield/fed (kg).

• Oil yield and its features were: oil percentage and oil yield/fed (kg).

• Fiber yield and its features were: fiber length (cm), fiber percentage and fiber yield/fed (kg).

Statistical analysis

The data was statistically analysed using the method of analysis of variance (ANOVA) for the split-plot design as published by Gomez and Gomez (1984) using the “MSTAT-C” software package. In addition, treatment means were compared by using the least significant difference (LSD) method at 5% level probability as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Straw yield and its features

Data shown in table 3 indicated that humic acid (HA) fertilization levels have a significant impact on straw yield and its features; technical length, stem diameter, straw yield/plant and straw yield/fed, in the first and second seasons. The obtained results explained that the application of 2000 g HA/fed significantly exceeded other levels in technical length, stem diameter, straw yield/plant and straw yield/fed in both growing seasons. The application level of 1500 g HA/fed came in the second rank after application of 2000 g HA/fed. While, the minimum values for the aforementioned studied characters were obtained from the control treatment (0 g HA/fed) in each season. These findings are mainly attributed to the good positive effect of humic acid in improving physical, chemical and biological properties of soil, and thus the ease of availability of nutrients to improve vegetative growth. Also, the plants grown in soil containing sufficient amount of humic substances are less subjected to stresses, give higher yields and quality. These results are in accordance with those obtained by Senesi et al. (1996), Atiyeh et al. (2002), Keeling et al. (2003), Nardi et al. (2004), Boehme et al. (2005), Mikkelson (2005), Dordas (2010) and Mouromical et al. (2011).

It was observed that the flax genotype Giza 12 (dual purpose type) significantly exceeded the other studied genotypes; S.651 (fiber type), Sakha 3 (fiber type) and Sakha 5 (oil type) and resulted in the best values for stem diameter, straw yield/plant and straw yield/fed throughout both growing seasons (Table 3). However, S.651 achieved the highest values concerning technical length only in both agronomic seasons. At the same time, the strain 651 achieved the lowest values for the other aforementioned studied traits. These results are mainly due to differences in the genetical factors of the four tested genotypes and potentiality between the fiber, oil and dual-purpose types of flax. These outcomes are consistent with those obtained by Leilah et al. (2018), Kushwaha et al. (2019), Omar et al. (2020), Rashwan et al. (2020), Omar et al. (2021), Mahmoud et al. (2022) and Abdelmasieh et al. (2023).

Straw yield (ton/fed) in each season was significantly impacted by the interaction between humic acid (HA) fertilization levels and flax genotypes (Table 3). Furthermore, the showed data revealed that the maximum values of the aforementioned character belonged to the highest application level of humic acid (2000 g HA/fed) with Giza 12 flax genotype, while the lowest one obtained by 0 g HA/fed (control) with Sakha 5 flax genotype in both seasons, respectively.

Seed yield and its features

Significant differences were observed among humic acid fertilization levels treatments on fruiting zone length, seed yield/plant and seed yield/fed, in both seasons of the experiment and on number of capsules/plant in the second season only (Tables 4 and 5). It could be noticed that the application of 2000 g HA/fed gained the best results for the mentioned characteristics; fruiting zone length, number of capsules/plant, seed yield/plant and seed yield/fed. While, the control treatment (without HA) recorded the lowest values for the mentioned characters in the 1st and 2nd seasons. This increment in seed yield and its features might be attributed to the fact that humates influence the respiration process and the amount of sugars, amino acids and nitrate accumulated. Also, humic substances also promote growth, yield, and quality by increasing nutrient uptake, acting as a source of mineral plant nutrients as well as a regulator of their release, consequently enhancing the reproductive organs growth and the proportion of the reproductive tissue. These results are matching with those reported by Senesi et al. (1996), Atiyeh et al. (2002), Keeling et al. (2003), Nardi et al. (2004), Boehme et al. (2005), Mikkelson (2005), Dordas (2010) and Mouromical et al. (2011).

The studied flax genotypes (S.651, Sakha 3, Sakha 5 and Giza 12) significantly affected in fruiting zone length, number of capsules/plant, seed index, seed yield/plant and seed yield/fed, in each season, as shown in Tables 4 and 5. The achieved data exposed that Giza 12 dual type genotype produced the greatest values of fruiting zone length, seed index and seed yield/plant, followed by Sakha 5 oil type genotype. However, Sakha 5 genotype attained the best values for number of capsules/plant and seed yield/fed in both agronomic seasons. At the same time, the lowest values of seed yield and its attributes resulted from the fiber type strain (S.651) in each season (Tables 4 and 5). The genetic composition and genetic variables of the examined flax cultivars may responsible for the majority of the variation observed amongst the genotypes of flax. These outcomes concur with those reported by Singh (2013), Leilah et al. (2018), Kushwaha et al. (2019), Omar et al. (2020), Rashwan et al. (2020), Omar et al. (2021), Mahmoud et al. (2022) and Abdelmasieh et al. (2023).

As for the interaction effect between humic acid (HA) fertilization levels and flax genotypes, Table 5 reflected that the interaction exhibited a significant impact on seed yield/plant on the first season only and on seed yield/fed in both seasons, respectively. Data showed that the highest values of seed yield/plant and seed yield/fed characters were achieved by the application level of 2000 g HA/fed with Giza 12 and Sakha 5 flax genotypes, in order. Whilst, applying 0 g HA/fed (control) with S.651 flax strain resulted in the lowest seed yield/plant and seed yield/fed, respectively in both seasons of study (Table 5).

Oil yield and its features

The studied humic acid fertilization levels treatments proved a significant effect on oil percentage and oil yield/fed (Table 5). Humic acid application level of 2000 g HA/fed attained the best results for the aforementioned studied characters in the 1st and 2nd seasons. With the decrease in the level of humic acid fertilization, a decrease in these characteristics began to occur, and this may occur due to a decrease in the supply of nutrients available to the plant, including the fruiting parts, compared to the higher rate of humic acid fertilization, which leads to a gradual decrease in seed yield and thus oil content. And of course, the lowest values obtained from those traits mentioned belonged to the fertilization level of 0 kg ha/fed (control) in both seasons of the study. These findings are matched with those obtained by Atiyeh et al. (2002), Keeling et al. (2003), Nardi et al. (2004), Boehme et al. (2005), Mikkelson (2005), Dordas (2010) and Mouromical et al. (2011).

Statistical analysis showed highly significant differences for oil percentage and oil yield/fed between the four flax genotypes (Table 5). Data presented in Table 5 indicated that Sakha 5 the oil type cultivar gave the highest oil percentage and oil yield/fed values followed by Giza 12 the dual type cultivar. On the other hand, the lowest values of oil percentage and oil yield/fed were obtained by Sakha 3 genotype the fiber type cultivar in both seasons. These findings might be explained by the fact that, oil types generally surpassed dual and fiber types in oil yield per feddan due to its genetic potential and higher percentage of oil. These results are in accordance with those obtained by Kineber et al. (2015), Leilah et al. (2018), Kushwaha et al. (2019), Omar et al. (2020), Rashwan et al. (2020), Omar et al. (2021), Mahmoud et al. (2022) and Abdelmasieh et al. (2023).

As for the interaction effect between fertilization levels of humic acid and flax genotyped, Table 5 reflected that the interaction had no significant impact on oil percentage and oil yield/fed throughout the first and second seasons of study.

Fiber yield and its features

The influence of various studied treatments of humic acid fertilization levels on fiber yield and its features of flax were presented in Table (6). Application of 2000 g HA/fed resulted in significant increases for fiber length, fiber percentage and fiber yield/fed followed by 1500 and 1000 g HA/fed in each season. Table (6) also showed that the application of 0 g HA/fed (control) gave the lowest values for mentioned characters; fiber length, fiber percentage and fiber yield/fed in both seasons of study. These findings are mainly due to the reason that humic substances have a bio-stimulators positive effect on flax through their effect on the biosynthesis of cellulose, which results in increasing cellulose concentration in fiber, leading to an increase in fiber yield. Such results are reported by Senesi et al. (1996), Atiyeh et al. (2002), Keeling et al. (2003), Nardi et al. (2004), Boehme et al. (2005), Mikkelson (2005), Dordas (2010), Mouromical et al. (2011) and Ponazhev (2013).

Fiber length, fiber percentage and fiber yield/fed significantly affected by the flax genotypes in both seasons, as shown in table 6. The presented data indicated that the new promising fiber Strain (S.651) achieved significantly the highest values for aforementioned characters compared with the other cultivars through both seasons of study. While, the oil type Sakha 5 occupied the last place in those studied characteristics. These findings are primarily attributable to the fiber genotypes' genetic potential, which generally outperformed dual and oil types in terms of fiber length, fineness, percentage, and yield per feddan. These results align with those obtained by Kushwaha et al. (2019), Omar et al. (2020), Rashwan et al. (2020), Omar et al. (2021), Mahmoud et al. (2022) and Abdelmasieh et al. (2023).

With respect to the interaction effect between humic acid fertilization levels and flax genotypes, the obtained data tabulated in Table 6 showed that the interaction had no significant impact on fiber length, fiber percentage and fiber yield/fed during both seasons of study.

CONCLUSION

Finally, this experiment recommends using the effective and cheap fertilizer source (humic acid) at the rate of 2000 g HA/fed with the new promising fiber type strain (S.651) for the best fiber yield/fed, or with the oil type Sakha 5 cultivar for the best seed and oil yield/fed under the environmental conditions of the Northern Delta of Egypt.

REFERENCES

A.O.A.C. (1990). Official Methods of the Analysis. Association of Official Analytical Chemists. 15th Edition, Published by Association of Official Analytical Chemists, Arilnglon, Virginia, U.S.A.

Abdelmasieh W.K.L., Sabah M. Abo El-Komsan, Sallam I.M. (2023). Maximising the Yield and its Components of Two New Flax Cultivars by using Combinations of Mineral and Bio-Fertilizer. J. of Plant Production, 14: 275-281.

Atiyeh R.M., Edwards C.A., Metzger J.D., Lee S., Arancon N.Q. (2002). The influence of humic acids derived from earthworm-processed organic wastes on plant growth. Bioresource Technology, 84: 7-14.

Boehme M., Schevtschenko J., Pinker I. (2005). Iron Supply of Cucumbers in Substrate Culture with Humate. Acta Horticulturae, 41: 329-335.

Dordas C.A. (2010). Variation of physiological determinants of yield in linseed in response to nitrogen fertilization. Ind. Crop Prod., 31: 455-465.

El Harriri D.M., Mostafa S.H., El Sweify A.H. (1998). Effect of potassic fertilizer and phytohormone levels on yield attributes, yield and yield quality of flax in sandy soils. The first Nordic Conference on Flax and Hemp Processing. 10-12 Aug., Tampere. Finland.

FAO (2023). Food and Agriculture Organization. Faostat, FAO Statistics Division, December, 2022. http://www.fao.org/ faostat/en/#data /QC.

Gomez K.N., Gomez A.A. (1984).Statistical procedures for agricultural research. John Wiley and Sons, New York, USA.2nd ed., 68 p.

Keeling A.A., McCallum K.R., Bekwith C.P. (2003). Crop and Environment Research Center, Harper Adans University College, Newport, Shropshire, UK. Bioresource Technology, 90: 127-137.

Kineber M.E.A., El-Kady E.A.F., El-Kady E.A., Mostafa S.H.A., Hella A.M.A., Zedan S.Z.A., Mourad N.K.M., El-Azzouni A.M.A., El-Refaie A.M.M., Abd El-Sadek M.S., El-Gazzar A.A., Zahan A.E.A., Lotfy E.E., Abo-Kaied H.M.H., El-Shimy G.H., Hussein M.M., El-Deeb E.I., Mousa A.M., Abo El-Komsan S.M., Omar T.A., Hassan S.S., Abd El-Haleem R.A., Abd El-Daiem M.A.M., El-Borhamy A.M.A., ElSwiefy A.H. (2015). Sakha 5 and Sakha 6 two new high yielding varieties of flax. J. Agric. Res., Kafrelsheikh Univ., 41: 1367-1379.

Kushwaha S., Shrivastava A., Namdeo K. (2019). Effect of sulphur on utilization of nutrients in linseed (Linum usitatissimum L.) genotypes. Annals of Plant and Soil Research, 21: 364-366.

Leilah A.A., Ghonema M.H., Kineber M.E., Talha I.H.M. (2018). Effect of nitrogen and phosphorus fertilizers levels on yields and technological characters of three flax cultivars under saline soil conditions. J. Plant Production, Mansoura Univ., 9: 689-693.

Mahmoud I. Doaa, Abd AL-Sadek S. Maysa, Ghonaim M. Marwa, Morsi A.A. (2022). Genetic Diversity Assessment of some Flax Genotypes Using Morphological and Molecular Markers. Direct Res. J. Agric. Food Sci., 10: 289-300.

Mikkelson R.L. (2005). Humic Materials for Agriculture, Davis, California, USA. Better Crops with Plant Food. Better Crops with Plant Food, 89: 6-7.

Mouromical G.M., Angela G.L., Monaco A.L. (2011). The Effect of Organic Supplementation of Solarized Soil on the Quality of Tomato. Scientific Horticulture, 129: 189-196.

Nardi S.D., Zzeghello P., Pandalai S.G. (2004). Rhizoshere a Communication between Plant and Soil. Recent Research Development in Crop Science, 1: 349-360.

Omar T.A., Amal M.A. El-Borhamy and Doaa I. Mahmoud (2021). Effect of Mineral and Bio-Nitrogen Fertilization on Yield and its Components of Some Flax Varieties. Journal of Plant Production, 12: 105-108.

Omar T.A., Amal M.A. El-Borhamy and Maysa S. Abd ElSadek (2020). Effect of harvesting dates and seeding rates on yield and yield components of some flax varieties. J. of Plant Production, Mansoura Univ., 11: 1501 - 1505

Page A.L. (1982). Methods of soil analysis, Part 2, chemical and microbical properties (2nd Ed.). American Society of Agronomy. In Soil Sci. of Amer. Inc. Madison Wisconsin, USA.

Ponazhev V.P. (2013). Production of flax-the level of modern requirements. Plant protection and quarantine, 2: 6-9.

Rashwan E., Alsohim A.S., El-Gammaal A., Hafez Y., Abdelaal K. (2020). Foliar application of nano zinc-oxide can alleviate the harmful effects of water deficit on some flax cultivars under drought conditions. Fresenius Environ. Bull., 29: 8889–8904.

Senesi N., Miano T.M., Brunetti G. (1996). Humic-like substances in organic amendments and effects on native soil humic substances. In: Piccolo, A., Ed., Humic Substances in Terrestrial Ecosystems, Elsevier, New York, 531-593.

Singh R.K. (2013). Effect of Dates of Sowing on Growth, Yield and Quality of Linseed (Linum usitatissimum L.) Varieties. Ph.D. Thesis, Banaras Hindu University Varanasi.

Snedecor G.W., Cochran W.G. (1980). Statistical Methods, 7th Ed., Ames, IA: The Iowa State University Press, USA.

References