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# EFFECT OF SEEDING RATES, PHOSPHORUS AND POTASSIUM FERTILIZERS ON GROWTH, YIELD AND QUALITY OF FLAX

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## ABSTRACT

Two field experiments were carried out at Sakha Agric. Research Station Kafr El-Sheikh, Egypt during the two successive seasons of 2002/2003 and 2003/2004 to study the effect of three seeding rates (70, 80 and 90 kg/fed), three levels of phosphorus fertilizer (zero, 15 and 30 kg $P_2O_5$/fed) and three levels of potassium fertilizer (zero, 12 and 24 kg $K_2O$/fed) in addition to their interactions on yield, yield components and fiber quality of flax (Sakha 1 variety). Results could be summarized as follows:

Increasing seeding rates up to 90 kg/fed caused significant increase in crop growth rate (CGR), seed and oil yields/fed as well as straw with capsules and fiber yields/fed. fiber elongation, fibers strength and fineness, which did not reach the level of significance. On the other hand, increasing seeding rates led to significant reduction in dry weight/plant at the first and second ages of (60 and 81 days after sowing "DAS"), plant height at the second age of (81 DAS), relative growth rate (RGR), straw yield/fed. Number of seeds/plant as well as dry weight/plant at the third and fourth age of (102 and 123 DAS), plant height at first, third and fourth ages of (60 and 102 and 123 DAS), technical length, top capsules zone length, stem diameter, straw and fiber yields/plant, fiber percentage, fiber length, Number of capsules/plant, Number of seeds/capsule. seed yield/plant and oil percentage, but the reduction did not reach the level of significant in both seasons.

Increasing phosphorus fertilizer levels from zero up to 30 kg $P_2O_5$/fed significantly increased dry weight/plant at the third age (102 DAS), plant height at the second age of (81 DAS), CGR and RGR at first period of (60-81 DAS), straw, seeds and oil yields/fed and oil percentage in both seasons. On the contrary, increasing phosphorus levels up to 30 kg $P_2O_5$/fed increased dry weight/plant at first, second and fourth ages of (60, 81 and 123 DAS), plant height at first, third and fourth ages of (60, 102 and 123 DAS), RGR at second and third periods of (81-102 and 102-123 DAS), technical length, top capsules zone length, stem diameter, straw yield/plant, straw with capsules yield/fed, fiber yield/plant as well as per feddan, fiber percentage, fiber length. fiber elongation. fiber strength. fiber fineness. Number of capsules/plant. Number of seeds/capsules, Number of seeds/plant, seed index and seed yield/plant. But did not reach the level of significant in both seasons.

Increasing potassium levels from zero up to 24 kg $K_2O$/fed significantly increased RGR at $1^{st}$ and $2^{nd}$ stages of (60-81 and 81-102 DAS), technical length, straw, fiber, seed and oil yields/fed, fiber yield/plant, fiber strength, Number of seeds/plant and oil% in both seasons. On the other side, dry weight/plant, plant height, CGR, RGR at third growth stage of (102-123 DAS), top capsule zone length, stem diameter, straw yield/plant, straw with capsules yield/fed, fiber percentage, fiber length, fiber elongation, fiber fineness, Number of capsules/plant, Number of seeds/capsule, seed index and seed yield/plant, but differences did not reach the level of significance in both seasons.

The interaction was significant among seeding rates, phosphorus and potassium levels for the most studied characters.

**Keywords**: Flax, linseed, *Linum usitatissimum* L., seeding rates, phosphorus. potassium fertilizer rates, growth yield, quality

## INTRODUCTION

Flax (*Linum usitatissimum*, L.) internationally ranks third after cotton and jute in the cultivated area and the second after cotton in fiber production. Flax also consider the most important bast fiber crop and ranked first between the other ones in Egypt, the flax cultivating area in last few years become limited due to of the great competition with the other winter crops. Increasing the flax yield and improving its fiber and seed quality could be achieved through the agriculture treatments and over-come such shortage in flax production, such as seeding rate, phosphorus and potassium fertilizer levels. Differences among seeding rates on yield and yield components have been demonstrated by many workers such as El-Gazzar (1990), El-Shimy *et al.* (1993), Juric *et al.* (1994), Abo Shetaia *et al.* (1996), Mohamed (1996). El-Gazzar and Abou-Zaied (2001), Gyanendra *et al.* (2001a), Gyanendra *et al.* (2001b), Kineber (2003), Mostafa and El-Deeb (2003) and Zedan (2004). They indicated significantly effects of increasing sowing rates on quantity and quality of flax. While, Marras and Scarpa (1997) and Zubal (2001) reported that, there were no significant differences among plant population per unit area on flax. Effect of phosphorus fertilization on flax yield and quality of flax has been studied by many workers, Mukherjee *et al.* (1987), Jain *et al.* (1989), Yadav *et al.* (1990), Sarode and Naphade (1993), Dwivedi *et al.* (1994), Shrivastava *et al.* (1994), Pali *et al.* (1995), Dubey *et al.* (1997). Kineber *et al.* (1997), Mostafa *et al.* (1998), Sarode *et al.* (1998), Gyanendra *et al.* (2001a), Gyanendra *et al.* (2001b), Jankauskiene (2001) and Zubal (2001) found that phosphorus significantly affected the yield and oil percentage.

Many workers have studied the effect of potassium levels on yield. yield components and quality of flax such as Hella *et al.* (1998), Dixit and Sharma (1993), Suratman and Mouludi (1993), El-Sweify and Mostafa (1996) and Zedan *et al.* (1999). They reported that potassium caused an increase in flax yield and its components in addition to fiber and seed quality.

This investigation was conducted to estimate the effect of seeding rates, phosphorus and potassium fertilization on growth, yield and its components and quality of Sakha 1 flax variety.

## MATERIALS AND METHODS

The present investigation was carried out at Sakha Experimental Station of Sakha Agriculture Research Station, Kafr El-Sheikh Governorate, Egypt, during the two successive seasons of 2002/2003 and 2003/2004. This work was undertaken to study the effect of seeding rates, phosphorus and potassium fertilizer levels on growth, yield, yield attributes and quality of flax variety Sakha 1. Each experiment included 27 treatments which were the combinations of three seeding rates (70, 80 and 90 kg/fed), phosphorus levels (0, 15 and 30 kg $P_2O_5$/fed) and potassium levels (0, 12 and 24 kg $K_2O$/fed). The seeds were sown by manual broadcasting at the first week of Nov. in the two seasons. A split-split plot design with four replications was used and allocated at main i.e. seeding rates, phosphorus fertilizer levels at sub plots and potassium fertilizer levels at sub-sub plots, respectively. The area of the experimental unit was 6m$^2$ (1.5x4m) the soil of the experimental field were clay in texture. The mechanical and chemical analyses for the experimental sites are given in Table 1. The preceding crop was maize (*Zea maize*, L.) in both seasons. The soil of experimentation was well prepared i.e. two ploughing and well leveled was done. Nitrogen was added at the rate of 45 kg N/fed in the form of urea (46.5%) at two equal doses half of N amount before the 1$^{st}$ irrigation and the other half before the 2$^{nd}$ irrigation. Phosphorus was added in the form superphosphate (15.5%$P_2O_5$) before sowing and potassium sulphate (48% $K_2O$) was applied before sowing at one dose.

**Table 1: Mechanical and chemical analyses of experimental soil (10-30 cm) in the two growing seasons (2002/2003 and 2003/204).**

| Mechanical analyses | | | Chemical analyses | | |
|---|---|---|---|---|---|
| | 2002/2003 | 2003/2004 | | 2002/2003 | 2003/2004 |
| Clay% | 42.0 | 43.0 | pH | 8.10 | 8.05 |
| Silt% | 32.0 | 31.2 | Available N (PPm) | 17.8 | 19.0 |
| Sand% | 26.0 | 25.8 | Available P (PPm) | 8.40 | 8.11 |
| Soil texture | Clayey | Clayey | Soluble cations of K meq/l | 0.35 | 0.36 |

All agronomic practices were applied at the proper stage of development. At harvest, ten plants were randomly taken from each sub-sub plot to determine yield components while, straw, seed and fiber yields per feddan were estimated from the area of sub-sub plot.

**The characters studied were as follows:**

**A: Growth parameters and attributes:**

1. Dry weight/plant (g) 2. Plant height (cm)
3. Crop growth rate (CGR) 4. Relative growth rate (RGR)

**B: Straw yield and its components:**

1: Technical stem length (cm) 2: Top capsule zone length
3: Stem diameter (mm) 4: Straw yield/plant (g)
5: Straw yield/fed. (ton) 6: Straw with capsules yield/fed

**C. Fiber yield and its related characters:**

1: Fiber yield/plant (g) 2: Fiber yield/fed. (kg)
3: Fiber percentage 4: Fiber length (cm)
5: Fiber fineness (N.m) 6: Fiber strength (R.K.M.)
7. Fiber elongation at Stelometer apparatus

**D. Seed yield and its related characters:**

1: Number of capsules/plant 2: Number of seeds/capsule
3: Number of seeds/plant 4: Seed index (g/1000 seed)
5: Seed yield (g/plant) 6: Seed yield (kg/fed)
7. Oil percentage 7. Oil yield (kg/fed)

All data were subjected to the analysis of variance according to the procedures outlined by Snedecor and Cochran (1967). The mean value of treatments were compared according to Duncan Multiple Range Test (Duncan, 1955). All statistical analysis was performed using analysis of variance technique by means of MSTATC computer software package.

# RESULTS AND DISCUSSION

## A. Growth parameters and attributes

Table 2 shows that dry weight/plant and plant height were not significantly affected by seeding rates, except at plant age of 60 and 81 days for dry weight/plant and age of 81 days for plant height in both seasons. There were gradual reduction for dry weight/plant and plant height with increasing seed rate up to 90 kg/fed at all growth ages, such differences did not reach the level of significance in both seasons. The highest amount of light energy, intercepted by level/plant with the low seeding rate, account much for this results and, in turn, caused an increase in the amount of metabolites synthesized by flax plants. Consequently, the dry weights of different parts of plants become heavy. The reduction in dry weight/plant at the highest seeding rate might be due to the height competition between plants for water light and nutrients. These results are in harmony with those obtained by El-Gazzar (1990), Ggyanendra *et al.* (2001a) and Mostafa and El-Deeb (2003).

Increasing phosphorus levels from zero up to 30 kg $P_2O_5$/fed increased dry weight/plant and plant height at all growth ages but increases did not reach the level of significance except at plant age of 81 days for plant height were significant in both seasons. It could be reported that the application of phosphorus encouraged the physiological reactions which was reflected in dry weight/plant and plant height. Similar findings were reported by El-Gazzar (1997) and Gyanendra *et al.* (2001a).

Increasing potassium levels from zero up to 24 kg $K_2O$/fed increased dry weight/plant and plant height at all growth ages but differences did not reach the level of significance in both seasons. Similar results were reported by Hella *et al.* (1988), Dixit and Sharma (1993), Suratman and Mouludi (1993), El-Sweify and Mostafa (1996) and Zedan *et al.* (1999).

The interaction most effect was not significant among the three factors under study for all growth characters.

Table 3 shows that the means of crop growth rate (CGR) and relative growth rate (RGR) were significantly affected by seeding rate at all growth periods in both seasons. It is clear that significant positive effect for seeding rate on CGR where heavy density gave higher values for this traits than light ones. Such effect could be attributed to Number of plants/$m^2$ (field emergence %). Also, there were negative relationship between RGR values and seeding rate where light density increased this values and vice-versa. Furthermore, the trend of results is similar to those of dry matter accumulation and similar discussion could be cited. These results are in harmony with those obtained by El-Gazzar (1990), Gyanendra *et al.* (2001a) and Mostafa and El-Deeb (2003).

In respect to phosphorus fertilizer effect, results demonstrated that phosphorus levels significantly affected CGR at all growth periods and the first period for RGR. Results indicated that there were gradual increase in each of the mean values of all stages with increasing phosphorus fertilizer levels from zero up to 30 kg $P_2O_5$/fed in both seasons. These results are similar to those of dry weight/plan and plant height and similar discussion could be cited. These results agree with those obtained by El-Gazzar (1997) and Gyanendra *et al.* (2001).

Data showed that, increasing potassium level from zero up to 24 kg/fed gradually increases detected on CGR and RGR at all growth periods but differences did not reach the level of significance except at the first and second periods for RGR in both seasons. These results are similar to those of dry weight/plant and plant height and similar discussion could be cited.

Similar results were reported by Hella *et al.* (1988), Dixit and Sharma (1993), Surtman and Mouludi (1993), El-Sweify and mostafa (1996) and Zedan *et al.* (1999).

The interaction effect was significant for all growth stages except for RGR at the third stage (102-123) days after sowing.

**B. Straw yield and its related characters:**

Data on seeding rates indicated significant differences in straw yield per feddan. Meanwhile, results indicated that there were gradual decrease in each of the mean values of technical length, top capsule zone length, stem diameter and straw yield/plant with increasing seeding rate levels from 70 up to 90 kg/fed except with straw with capsules yield./fed trait which increased in its mean values with increasing seeding rate levels from 70 up to 90 kg/fed such differences did not reach the level of significance in both seasons. In general, the trend of results is similar to those of dry weight/plant and plant height. This fact might be due to low competition between flax plants for environmental factors. These results in harmony with those of Juric *et al.* (1994), Abo-Shetaia *et al.* (1996), Marras and Scarpa (1997), El-Gazzar and Abou Zaied (2001) and Zubal (2001).

Regarding phosphorus fertilizer effect, data showed not significant differences in technical length, top capsules zone length, stem diameter, straw yield/plant and straw with capsules yield/fed except straw yield/fed in both seasons. The differences did not reach the level of significant in the two seasons. It is clear that there were gradual increments towards the highest phosphorus levels in all six previous characters in both seasons. These results suggest that the increase in straw yield and its related characters may be due to physiological activities stimulation in flax plants. The results reported in this work are in agreement with those obtained by Mostafa *et al.* (1998), Sarode *et al.* (1998), El-Shimy *et al.* (2001) and Gyanendra *et al.* (2001a).

Results showed that there were significant differences among means of potassium levels for technical length and straw yield/feddan. While, the differences on each of top capsule zone length, stem diameter, straw yield/plant and straw with capsules yield/fed did not reach the level of significance.

Table 2: Means of dry matter accumulation and plant height of flax as affected by seeding rates, phosphorus and potassium levels in 2002/2003 and 2003/2004 seasons.

| Characters | Season | Days after sowing | Seeding rate kg/fed (S) | | | | $P_2O_5$ kg/fed (P) | | | | $K_2O$/fed (K) | | | | Interaction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sig. | 70 | 80 | 90 | Sig. | 0 | 15 | 30 | Sig. | 0 | 12 | 24 | SxP | SxK | PxK | SPK |
| Dry wt. (g/plant) | 2002/3 | 60 | ** | 0.12a | 0.10ab | 0.09b | NS | 0.10 | 0.11 | 0.11 | NS | 0.10 | 0.10 | 0.11 | ** | * | NS | NS |
| | 2003/4 | | * | 0.13a | 0.11ab | 0.09b | NS | 0.11 | 0.12 | 0.12 | NS | 0.11 | 0.11 | 0.12 | * | * | NS | NS |
| Plant height (cm) | 2002/3 | | NS | 21.40 | 19.40 | 19.10 | NS | 19.70 | 19.80 | 20.30 | NS | 19.40 | 20.10 | 20.40 | NS | * | NS | NS |
| | 2003/4 | | NS | 22.50 | 20.40 | 20.10 | NS | 20.70 | 20.80 | 21.30 | NS | 20.40 | 21.10 | 21.40 | NS | NS | NS | NS |
| Dry wt. (g/plant) | 2002/3 | 81 | ** | 0.42a | 0.34b | 0.32b | NS | 0.33 | 0.37 | 0.38 | NS | 0.34 | 0.37 | 0.38 | NS | ** | NS | NS |
| | 2003/4 | | ** | 0.44a | 0.35b | 0.34b | NS | 0.35 | 0.39 | 0.39 | NS | 0.36 | 0.39 | 0.40 | NS | ** | NS | NS |
| Plant height (cm) | 2002/3 | | * | 44.90a | 44.10a | 40.90b | * | 41.80b | 42.60ab | 45.50a | NS | 42.50 | 42.60 | 44.90 | NS | ** | NS | NS |
| | 2003/4 | | * | 47.60a | 46.30a | 42.50b | * | 43.50b | 44.70b | 48.20a | NS | 44.60 | 44.70 | 47.10 | NS | * | NS | NS |
| Dry wt. (g/plant) | 2002/3 | 102 | NS | 1.50 | 1.40 | 1.36 | * | 1.32b | 1.38ab | 1.55a | NS | 1.36 | 1.43 | 1.47 | ** | NS | NS | NS |
| | 2003/4 | | NS | 1.59 | 1.46 | 1.43 | * | 1.37c | 1.45b | 1.64a | NS | 1.43 | 1.50 | 1.54 | * | NS | NS | NS |
| Plant height (cm) | 2002/3 | | NS | 76.90 | 74.70 | 74.20 | NS | 74.50 | 75.60 | 75.60 | NS | 74.70 | 74.90 | 76.20 | NS | NS | NS | NS |
| | 2003/4 | | NS | 80.70 | 78.40 | 77.90 | NS | 78.20 | 79.40 | 79.40 | NS | 78.40 | 78.60 | 80.00 | NS | NS | NS | NS |
| Dry wt. (g/plant) | 2002/3 | 123 | NS | 0.99 | 0.87 | 0.85 | NS | 0.82 | 0.92 | 0.97 | NS | 0.89 | 0.90 | 0.92 | ** | NS | NS | NS |
| | 2003/4 | | NS | 1.04 | 0.91 | 0.89 | NS | 0.86 | 0.97 | 1.02 | NS | 0.93 | 0.94 | 0.97 | * | NS | NS | NS |
| Plant height (cm) | 2002/3 | | NS | 89.80 | 89.80 | 89.30 | NS | 88.60 | 89.40 | 90.90 | NS | 88.70 | 89.90 | 90.30 | NS | NS | NS | ** |
| | 2003/4 | | NS | 94.30 | 94.30 | 93.80 | NS | 93.00 | 93.90 | 95.40 | NS | 93.10 | 94.40 | 94.80 | NS | NS | NS | * |

*, ** and NS indicate $P<0.05$, $P<0.01$ and not significant, respectively.

Means followed by the same letter within rows are not significantly different at the 5% level using Duncan's Multiple Range test.

Table 3: Means of crop growth rate (CGR) and relative growth rate (RGR) of flax as affected by seeding rates, phosphorus and potassium levels in 2002/2003 and 2003/2004 seasons.

| Chara-cters | Season | Days after sowing | Seeding rate kg/fed (S) | | | | $P_2O_5$ kg/fed (P) | | | | $K_2O$/fed (K) | | | | Interaction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sig. | 70 | 80 | 90 | Sig. | 0 | 15 | 30 | Sig. | 0 | 12 | 24 | SxP | SxK | PxK | SPK |
| CGR ($g/m^2$/ week) | 2002/3 | 60-81 | * | 152.4b | 166.2ab | 177.2a | ** | 147.9b | 159.8b | 188.1a | NS | 154.1 | 168.0 | 173.6 | * | ** | ** | NS |
| | 2003/4 | | * | 160.0c | 172.8b | 187.8a | ** | 153.8c | 167.8b | 199.4a | NS | 160.3 | 178.6 | 181.7 | * | ** | ** | NS |
| | 2002/3 | 81-102 | ** | 299.9c | 336.9b | 376.1a | ** | 313.3c | 347.8b | 351.8a | NS | 326.9 | 341.6 | 344.3 | ** | NS | ** | ** |
| | 2003/4 | | ** | 311.9c | 353.7b | 398.7a | ** | 325.8c | 365.2b | 372.9a | NS | 343.2 | 358.7 | 361.5 | * | NS | * | ** |
| | 2002/3 | 102-123 | ** | 301.7b | 343.6a | 345.3a | * | 319.7b | 325.7b | 345.2a | NS | 318.4 | 329.9 | 342.3 | ** | * | ** | ** |
| | 2003/4 | | ** | 313.8c | 360.8b | 366.5a | ** | 332.5c | 341.9b | 365.9a | NS | 334.3 | 346.4 | 359.4 | ** | * | * | * |
| RGR ($g/g/m^2$/ week) | 2002/3 | 60-81 | ** | 0.420a | 0.417a | 0.374b | * | 0.387b | 0.395b | 0.428a | ** | 0.376b | 0.394b | 0.440a | ** | ** | ** | ** |
| | 2003/4 | | * | 0.441a | 0.438a | 0.393b | * | 0.406b | 0.415b | 0.449a | * | 0.395b | 0.414b | 0.462a | ** | ** | ** | ** |
| | 2002/3 | 81-102 | ** | 0.331a | 0.304ab | 0.279ab | NS | 0.295 | 0.307 | 0.311 | * | 0.290b | 0.295b | 0.329a | NS | * | ** | * |
| | 2003/4 | | ** | 0.351a | 0.319ab | 0.290b | NS | 0.309 | 0.322 | 0.326 | * | 0.302b | 0.309b | 0.349a | NS | * | * | * |
| | 2002/3 | 102-123 | NS | 0.164 | 0.158 | 0.145 | NS | 0.150 | 0.153 | 0.165 | NS | 0.147 | 0.155 | 0.163 | NS | * | NS | NS |
| | 2003/4 | | NS | 0.172 | 0.166 | 0.152 | NS | 0.158 | 0.160 | 0.173 | NS | 0.154 | 0.163 | 0.171 | NS | NS | NS | NS |

*, ** and NS indicate $P<0.05$, $P<0.01$ and not significant, respectively.

Means followed by the same letter within rows are not significantly different at the 5% level using Duncan's Multiple Range test.

Moreover, there were gradual increment towards the highest potassium level (24 kg $K_2O$/fed) in all straw characters. It could be reported that the application of potassium encouraged the physiological reactions to produce more seed components. This trend was in connection with that obtained by Hella *et al.* (1988), Dixit and Sharma (1993), El-Sweify and Mostafa (1996) and Zedan *et al.* (1999). Summary of the significant interaction effects of the three experimental factors are given in Table 4. In general, combinations among seeding rates, phosphorus and potassium levels increased and improved straw yield and its related characters.

**C. Fiber yield and its related characters:**

Data in Table 5 indicated that fiber yield per fed and its related characters tended to significantly increases with increasing seeding rates from 70 up to 90 kg/fed. However, gradual decrease detected by increasing seeding rates up to 90 kg/fed on fiber yield/plant, fiber percentage and fiber length. Moreover, fiber yield/fed, fiber elongation and fibers strength and fineness there were gradual increase in each of the mean values of all characters with increasing seeding rates from 70 to 90 kg/fed. It is clear that the increases in fiber yield/fed and fiber quality might be due to the increases in number of plants per unit area beside increasing growth characters at the early stage of growth. In contrast, fiber yield/plant, fiber percentage and fiber length recorded the highest mean values with decreasing the seeding rate. This fact might be due to low competition between flax plants for environmental factors. Similar results were obtained by Mohamed (1996), Abo-Shetaia *et al.* (1996), El-Gazzar and Abou-Zaied (2001) and Mostafa and El-Deeb (2003).

Results indicated that phosphorus fertilizer levels showed differences in fiber yield and its components and quality, such differences did not reach the level of significance in both seasons. Results indicated that there were gradual increase in each of the mean values of all characters with increasing phosphorus levels from zero up to 30 kg $P_2O_5$/fed. These results suggested that the increases in fiber yield and its related characters may be due to physiological activities stimulation in flax plants. The results reported in this work are in agreement with those obtained by Kineber *et al.* (1997), Mostafa *et al.* (1998) and El-Shimy *et al.* (2001).

Results showed that there were significant differences among means of potassium levels for fiber yield/plant as well as per feddan and fiber tenacity. While, the differences on each of fiber percentage, fiber length, fiber elongation and fiber fineness did not reach the level of significance. Moreover, there were gradual increment towards the highest potassium level (24 kg $K_2O$/fed) in all fiber characters. It could be reported that the application of potassium encouraged the physiological reaction to produce more seed components. This trend was in connection with that obtained by Zedan *et al.* (1999), Jankauskiene (2001) and Zubal (2001). The interaction among the factors under the study were significantly affected in fiber yield and its components and quality except at fiber elongation in both seasons, fiber length in second season and fiber fineness in first season. This indicates that

Table 4: Straw yield and its related characters on flax as affected by seeding rates, phosphorus and potassium levels in 2002/2003 and 2003/2004 seasons.

| Characters | Season | Seeding rate kg/fed (S) | | | | $P_2O_5$ kg/fed (P) | | | | $K_2O$/fed (K) | | | | Interaction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sig. | 70 | 80 | 90 | Sig. | 0 | 15 | 30 | Sig. | 0 | 12 | 24 | SxP | SxK | PxK | SPK |
| Technical length (cm) | 2002/3 | NS | 84.3 | 84.2 | 83.7 | NS | 82.9 | 84.6 | 84.7 | ** | 82.5b | 84.7a | 85.0a | NS | ** | NS | ** |
| | 2003/4 | NS | 89.3 | 88.4 | 87.1 | NS | 86.1 | 88.3 | 89.8 | ** | 85.8b | 88.9a | 90.1a | NS | ** | NS | ** |
| Top capsule zone length (cm) | 2002/3 | NS | 11.96 | 11.22 | 10.76 | NS | 11.14 | 11.39 | 11.41 | NS | 10.88 | 11.33 | 11.74 | NS | * | NS | NS |
| | 2003/4 | NS | 12.56 | 11.78 | 11.30 | NS | 11.70 | 11.96 | 11.98 | NS | 11.42 | 11.90 | 12.33 | NS | * | NS | NS |
| Stem diameter (mm) | 2002/3 | NS | 2.00 | 1.92 | 1.90 | NS | 1.88 | 1.93 | 1.99 | NS | 1.90 | 1.92 | 2.00 | NS | * | NS | NS |
| | 2003/4 | NS | 2.12 | 2.10 | 1.99 | NS | 1.97 | 2.03 | 2.09 | NS | 1.99 | 2.02 | 2.10 | NS | * | NS | NS |
| Straw yield (g/plant) | 2002/3 | NS | 1.506 | 1.413 | 1.393 | NS | 1.383 | 1.439 | 1.489 | NS | 1.395 | 1.447 | 1.470 | NS | NS | ** | * |
| | 2003/4 | NS | 1.580 | 1.480 | 1.460 | NS | 1.450 | 1.510 | 1.550 | NS | 1.460 | 1.510 | 1.540 | NS | NS | ** | * |
| Straw yield (t./fed) | 2002/3 | ** | 4.496a | 4.401b | 4.319c | ** | 4.289b | 4.458a | 4.466a | * | 4.333b | 4.436a | 4.444a | ** | ** | ** | ** |
| | 2003/4 | ** | 4.766a | 4.621b | 4.489c | ** | 4.460b | 4.681a | 4.734a | * | 4.506b | 4.658a | 4.711a | ** | ** | ** | ** |
| Straw with capsules yield (t./fed) | 2002/3 | NS | 5.992 | 6.018 | 6.175 | NS | 5.962 | 6.073 | 6.149 | NS | 6.028 | 6.045 | 6.112 | NS | * | * | NS |
| | 2003/4 | NS | 6.292 | 6.319 | 6.484 | NS | 6.260 | 6.377 | 6.456 | NS | 6.329 | 6.347 | 6.417 | NS | * | * | NS |

*, ** and NS indicate $P<0.05$, $P<0.01$ and not significant, respectively.

Means followed by the same letter within rows are not significantly different at the 5% level using Duncan's Multiple Range test.

Table 5: Fiber yield and its related characters on flax as affected by seeding rates, phosphorus and potassium levels in 2002/2003 and 2003/2004 seasons.

| Characters | Season | Seeding rate kg/fed (S) | | | | $P_2O_5$ kg/fed (P) | | | | $K_2O$/fed (K) | | | | Interaction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sig. | 70 | 80 | 90 | Sig. | 0 | 15 | 30 | Sig. | 0 | 12 | 24 | SxP | SxK | PxK | SPK |
| Fiber yield (g/plant) | 2002/3 | NS | 0.156 | 0.145 | 0.144 | NS | 0.146 | 0.147 | 0.153 | * | 0.139b | 0.144a | 0.163a | NS | NS | NS | * |
| | 2003/4 | NS | 0.164 | 0.152 | 0.151 | NS | 0.153 | 0.154 | 0.160 | * | 0.146b | 0.151b | 0.171a | NS | NS | NS | * |
| Fiber yield (kg/fed) | 2002/3 | NS | 582.2 | 598.8 | 600.7 | NS | 583.9 | 591.7 | 606.0 | ** | 584.8b | 587.5b | 609.4a | ** | ** | * | ** |
| | 2003/4 | NS | 611.3 | 628.7 | 630.7 | NS | 613.1 | 621.3 | 636.3 | ** | 614.0b | 616.8b | 639.8a | * | * | * | * |
| Fiber percentage | 2002/3 | NS | 0.21 | 0.21 | 0.20 | NS | 0.20 | 0.20 | 0.21 | NS | 0.20 | 0.20 | 0.21 | ** | NS | NS | NS |
| | 2003/4 | NS | 0.22 | 0.22 | 0.21 | NS | 0.21 | 0.21 | 0.22 | NS | 0.21 | 0.21 | 0.22 | * | NS | NS | NS |
| Fiber length (cm) | 2002/3 | NS | 90.2 | 88.7 | 88.3 | NS | 87.6 | 89.7 | 89.9 | NS | 87.0 | 88.5 | 91.7 | NS | * | NS | NS |
| | 2003/4 | NS | 94.7 | 93.1 | 92.7 | NS | 91.9 | 94.2 | 94.3 | NS | 91.3 | 92.9 | 96.3 | NS | NS | NS | NS |
| Fiber elongation % | 2002/3 | NS | 2.39 | 2.42 | 2.51 | NS | 2.39 | 2.45 | 2.48 | NS | 2.43 | 2.44 | 2.45 | NS | NS | NS | NS |
| | 2003/4 | NS | 2.51 | 2.54 | 2.63 | NS | 2.51 | 2.57 | 2.60 | NS | 2.55 | 2.56 | 2.57 | NS | NS | NS | NS |
| Fiber strength (RKM) | 2002/3 | NS | 27.6 | 27.8 | 27.9 | NS | 27.6 | 27.7 | 27.9 | * | 27.5b | 27.7ab | 28.0a | NS | ** | * | ** |
| | 2003/4 | NS | 28.9 | 29.2 | 29.3 | NS | 28.9 | 29..1 | 29.3 | * | 28.6b | 29.1a | 29.7a | NS | * | * | * |
| Fiber fineness (N.M.) | 2002/3 | NS | 128.2 | 134.8 | 138.2 | NS | 126.9 | 136.0 | 138.2 | NS | 129.4 | 129.9 | 141.9 | NS | NS | NS | NS |
| | 2003/4 | NS | 134.6 | 141.5 | 145.1 | NS | 133.2 | 143.9 | 144.0 | NS | 135.4 | 136.9 | 149.0 | NS | * | NS | NS |

*, ** and NS indicate P<0.05, P<0.01 and not significant, respectively.

Means followed by the same letter within rows are not significantly different at the 5% level using Duncan's Multiple Range test.

the three factors under study (seeding rates, phosphorus and potassium fertilizer levels) were not similar in their effect on those contributions.

**D: Seed yield and its related characters:**

Mean values of seed yield, yield components of flax, as affected by seeding rates, phosphorus and potassium levels are presented in Table 6. Statistical analysis revealed that three seeding rates significantly differed in there effect on number of seeding rates significantly differed in there effect on number of seeds/plant, seed yield/fed and oil yield/fed. In the mean time, the highest seeding rate (90 kg/fed) recorded the lowest value for number of seeds/plant. Furthermore, increasing seeding rate up to 90 kg/fed caused an increase in seed and oil yields/fed in both seasons. Meanwhile, Number of capsules/plant, Number of seeds/capsule, seed yield/plant and oil percentage were decreased with increasing seeding rate up to 90 kg/fed. Such differences did not reach the level of significance in both seasons, seeding rates had no effects on 1000-seed weight. These increases (in seed characters), which were positively correlated with increasing the seeding rate, might be due to the increase in number of plants per unit area. A like findings were observed by El-Gazzar (1990), Mohamed (1996), El-Gazzar and Abou-Zaied (2001) and Mostafa and El-Deeb (2003).

In respect of phosphorus fertilizer effect, results demonstrated that phosphorus fertilizer levels significantly affected seed yield/fed, oil% and oil yield/fed. On the contrary, Number of capsules/plant, Number of seeds/capsule, Number of seeds/plant and seed yield/plant did not reach the level of significance in the two seasons. Phosphorus levels had no effects on 1000-seed weight. Moreover, there was a progressive increment in all seed characters by increasing phosphorus levels from the untreated control up to 30 kg/ $P_2O_5$/fed in the two seasons. It could be reported that the application of phosphorus encouraged the physiological reactions, which was reflected in higher seed yield and its related characters. Similar findings, were reported by Jain *et al.* (1989), Yadov *et al.* (1990), Shrivastava *et al.* (1994), Mostafa *et al.* (1998), El-Shimy *et al.* (2001), Gyanendra *et al.* (2001a) and Gyanendra *et al.* (2001b).

Results showed that there were significant differences among means of potassium level for Number of seeds/plant, seed yield/fed, oil percentage and oil yield/fed, the differences on each of Number of capsules/plant, Number of seeds/capsule, seed index and seed yield/plant did not reach the level of significance. Moreover, there were gradual increment towards the highest potassium level (24 kg $K_2O$/fed) in all seed characters. It could be reported that the application of potassium encouraged the physiological reactions to produce more seed components. This trend was in connection with that obtained by Hella *et al.* (1998), Dixit and Sharma (1993), El-Sweify and Mostafa (1996)and Zedan *et al.* (1999).

Seeding rates x phosphorus x potassium levels interaction had a significant effect on Number of seeds/plant, seed index, seed yield/fed, oil percentage and oil yield/fed. This indicates that the three factors under study (seeding rate, phosphorus and potassium fertilizer levels) were not similar in their effect on these contributions.

**Table 6: Seed yield and its related characters on flax as affected by seeding rates, phosphorus and potassium levels in 2002/2003 and 2003/2004 seasons.**

| Characters | Season | Seeding rate kg/fed (S) | | | | $P_2O_5$ kg/fed (P) | | | | $K_2O$/fed (K) | | | | Interaction | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sig. | 70 | 80 | 90 | Sig. | 0 | 15 | 30 | Sig. | 0 | 12 | 24 | SxP | SxK | PxK | SPK |
| Number of capsules/plant | 2002/3 | NS | 8.39 | 7.27 | 7.04 | NS | 7.51 | 7.56 | 7.65 | NS | 7.17 | 7.46 | 8.09 | NS | NS | NS | NS |
| | 2003/4 | NS | 8.81 | 7.64 | 7.40 | NS | 7.80 | 7.93 | 83.03 | NS | 7.52 | 7.83 | 8.49 | NS | NS | NS | NS |
| Number of seeds/capsule | 2002/3 | NS | 5.11 | 5.24 | 5.02 | NS | 4.97 | 5.05 | 5.34 | NS | 5.07 | 5.05 | 5.25 | NS | NS | NS | NS |
| | 2003/4 | NS | 5.36 | 5.50 | 5.27 | NS | 5.22 | 5.30 | 5.61 | NS | 5.30 | 5.32 | 5.51 | NS | NS | NS | NS |
| Number of seeds/plant | 2002/3 | ** | 44.1a | 37.1b | 36.5b | NS | 38.6 | 39.5 | 39.5 | * | 36.9b | 39.2a | 41.7a | NS | ** | NS | ** |
| | 2003/4 | ** | 46.7a | 38.9b | 37.9b | NS | 40.5 | 41.5 | 41.5 | * | 38.8b | 40.7b | 44.2a | NS | ** | NS | ** |
| Seed index (g/1000-seed) | 2002/3 | NS | 9.82 | 9.64 | 9.97 | NS | 9.78 | 9.76 | 9.90 | NS | 9.73 | 9.80 | 9.91 | NS | * | NS | NS |
| | 2003/4 | NS | 8.84 | 8.68 | 8.97 | NS | 8.90 | 8.78 | 8.80 | NS | 8.75 | 8.82 | 8.92 | NS | * | NS | NS |
| Seed yield/plant (g) | 2002/3 | NS | 0.43 | 0.38 | 0.34 | NS | 0.38 | 0.38 | 0.40 | NS | 0.37 | 0.37 | 0.42 | NS | NS | NS | NS |
| | 2003/4 | NS | 0.38 | 0.34 | 0.31 | NS | 0.34 | 0.34 | 0.36 | NS | 0.33 | 0.33 | 0.38 | NS | NS | NS | NS |
| Seed yield (t/fed) | 2002/3 | ** | 0.887c | 0.938b | 1.000a | ** | 0.913b | 0.922b | 0.990a | ** | 0.863b | 0.973a | 0.989a | ** | ** | ** | ** |
| | 2003/4 | ** | 0.798c | 0.844b | 0.900a | ** | 0.822b | 0.829b | 0.891a | ** | 0.768b | 0.876a | 0.899a | ** | ** | ** | ** |
| Oil percentage | 2002/3 | NS | 41.6 | 40.3 | 39.9 | * | 39.9b | 40.4b | 41.5a | * | 40.0b | 40.2b | 41.7a | NS | NS | * | NS |
| | 2003/4 | NS | 41.8 | 41.2 | 41.5 | * | 40.8c | 41.3b | 42.4a | * | 40.3c | 41.1b | 42.6a | NS | NS | * | NS |
| Oil yield (t/fed) | 2002/3 | * | 0.273c | 0.383b | 0.405a | * | 0.372c | 0.374b | 0.417a | * | 0.349c | 0.396b | 0.418a | * | * | * | ** |
| | 2003/4 | * | 0.342c | 0.351b | 0.382a | * | 0.340c | 0.342b | 0.382a | * | 0.311c | 0.363b | 0.387a | * | * | * | ** |

*, ** and NS indicate $P<0.05$, $P<0.01$ and not significant, respectively.

Means followed by the same letter within rows are not significantly different at the 5% level using Duncan's Multiple Range test.

It could be concluded that the highest quantity and quality of flax yield were obtained from Sakha 1 variety which occurred from the seeding rates at 90 kg/fed combined with 30 kg P2O5 and 24 kg K2O/fed under Kafr El-Shiekh conditions.

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# تأثير معدلات التقاوى والتسميد الفوسفاتي والبوتاسى على نمو ومحصول وجودة الكتان

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**قسم بحوث الألياف – معهد بحوث المحاصيل الحقلية ، مركز البحوث الزراعية**

أقيمت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بسخا – كفر الشيخ خلال موسمى ٢٠٠٢/٢٠٠٣ و ٢٠٠٣/٢٠٠٤ وذلك لدراسة تأثير معدلات التقاوى (٧٠ ، ٨٠ و ٩٠ كجم/فدان) وثلاثة مستويات من السماد الفوسفاتي (صفر ، ١٥ و ٣٠ كجم فو٢أ٥/فدان) وثلاثة مستويات من السماد البوتاسى (صفر ، ١٢ و ٢٤ كجم بو٢أ/فدان) على نمو ومحصول وجودة الكتان (سخا ١) وأشارت النتائج إلى مايلى :

- أدت زيادة معدلات التقاوى إلى ٩٠ كجم/فدان إلى زيادة معنوية فى معدل نمو المحصول (CGR) ومحصول الفدان من البذرة والزيت ولم تصل الزيادة إلى مستوى المعنوية لكل من محصول الفدان من القش بالكبسول والألياف وإستطالة ومتانة ونعومة الألياف ومن جهة أخرى أدت الزيادة فى معدلات التقاوى لنقص معنوى فى الوزن الجاف للنبات وإرتفاع النبات ومعدل النمو النسبى (RGR) ومحصول القش للفدان وعدد بذور النبات ولم يصل النقص لمستوى المعنوية لكل من الطول الفعال والطول الثمرى وقطر الساق ومحصول النبات من القش والألياف والبذرة والنسبة المئوية للألياف وطول الألياف وعدد كبسولات النبات وعدد بذور الكبسولة والنسبة المئوية للزيت.
- أدت زيادة مستويات التسميد الفوسفاتي من صفر إلى ٣٠ كجم فو٢أ٥/فدان إلى زيادة معنوية فى إرتفاع النبات عند عمر ٨١ يوم والوزن الجاف للنبات عند عمر ١٠٢ يوم ومعدل نمو المحصول ومعدل النمو النسبى فى المرحلة العمرية الأولى من (٦٠–٨١ يوم) ومحصول الفدان من القش والبذرة والزيت والنسبة المئوية للزيت ولم تصل الزيادة إلى مستوى المعنوية لكل من إرتفاع النبات عند الأعمار (٦٠ ، ٨١ ، ١٠٢ و ١٢٣ يوم من الزراعة) والوزن الجاف للنبات عند الأعمار (٦٠،٨١ و ١٢٣ يوم من الزراعة) ومعدل النمو النسبى عند المرحلة العمرية الثانية (٨١–١٠٢) والثالثة (١٠٢–١٢٣ يوم من الزراعة) والطول الفعال والطول الثمرى وقطر الساق ومحصول القش والبذرة للنبات ومحصول الفدان من القش بالكبسول ومحصول الألياف للنبات والفدان وجودة الألياف وعدد بذور وكبسولات النبات وعدد بذور الكبسولة.

أدت زيادة مستوبات السماد البوتاسى من صفر إلى ٢٤ كجم بو٢أ/فدان إلى زيادة معنوية لكل من معدل النمو النسبى عند المرحلة العمرية الأولى والثانية (٦٠–٨١ و ٨١–١٠٢ يوم من الزراعة) والطول الفعال ومحصول الفدان من القش والألياف والبذرة والزيت ومحصول النبات من الألياف ومتانة الألياف وعدد بذور النبات والنسبة المموية للزيت ولم تصل الزيادة لمستوى المعنوية لكل من الوزن الجاف للنبات وإرتفاع النبات ومعدل نمو المحصول ومعدل النمو النسبى فى المرحلة الأخيرة (١٠٢–١٢٣ يوم من الزراعة) والطول الثمرى وقطر الساق ومحصول النبات من القش ومحصول الفدان من القش بالكبسول والنسبة المئوية للألياف وطول الألياف وإستطالة ونعومة الألياف وعدد الكبسولات النبات وعدد بذور الكبسولة ووزن الألف بذرة ومحصول البذرة للنبات فى كلا الموسمين.

كان التفاعل بين معدلات التقاوى والتسميد الفوسفاتي والبوتاسى معنويا فى معظم الصفات تحت الدراسة.

للحصول على أعلى محصول للكتان كما ونوعا يمكن التوصية بإستخدام صنف سخا ١ والتسميد بمعدل ٣٠ كجم سوبر فوسفات (فو٢أ٥) مع ٢٤ كجم سلفات بوتاسيوم (بو٢أ) تحت ظروف منطقة كفر الشيخ.