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EFFECT OF MYCORRHIZAL INOCULATION ON YIELD AND DROUGHT TOLERANCE OF SOME FLAX VARIETIES.

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ABSTRACT

Two field experiments were conducted at Ismailia Agric. Res. Station Farm, Ismailia Governorate, Egypt, in two successive seasons of 2004/05 and 2005/06, to study the influence of vesicular - arbuscular (**VA**) mycorrhizal and sprinkler irrigation intervals (2,4 and 6 days) on the yield and yield components as well as drought tolerance of the three flax genotypes viz., Sakha 2 (dual type), S.2419/1/1 (oil type) and Viking (fiber type).

Results indicated that, all characters under study were significantly affected by irrigation intervals **(Ir)**. Soil inoculation with VA mycorrhizal fungi **(M)** significantly increased plant height, technical stem length, straw weight per plant, straw yield per fed, fiber yield per fed, number of capsules per plant, number of seeds per capsule, 1000-seed weight, seeds weight per plant, seed yield per fed, oil yield per fed, long fiber percentage, oil percentage compared with those un-inoculation. In contrast, soil inoculated with VA mycorrhizal fungi significantly decreased fiber fineness.

Sakha 2 gave the highest means of straw weight per plant as well as straw yield per fed but, Viking ranked first for plant height, technical stem length and long fiber yield per fed while, S.2419/1/1 gave the highest means of capsules number per plant, 1000-seed weight, seeds weight per plant, seed and oil yields per fed when soil was inoculated with mycorrhizal and irrigated every / 2 or 4 days, without significant differences between them (2 and 4 days).

Results revealed significant differences among flax varieties **(V)** in straw, seed yields and their components as well as quality characters. Also, all interactions between the studied factors were not significant except **Ir**x **M** for straw, seeds and oil yields per fed as well as plant height, number of capsules per plant, 1000-seed weight, fiber fineness, and oil percentage as well as **M** x **V** for fiber yield per fed in addition **Ir** x **M** x **V** for plant height, technical stem length, number of capsules per plant, 1000-seed weight, fiber fineness, oil percentage as well as straw, fiber, seed and oil yields / fed.

It can be concluded that under sandy soil condition its recommended to cultivate flax and inoculation with VA mycorrhizal fungi with irrigation at intervals of 2 or 4 days to obtain the highest straw yield, seeds yield and oil yield. This means that, soil inoculation by mycorrhizal fungi can increase the drought tolerance of flax plant from one irrigation / 2days to one irrigation / 4days.

INTRODUCTION

The extension of flax (*Linum usitatissimum* L.) cultivation in Egypt is hampered by several factors. During the winter season the land is occupied by wheat, berseem, fababean …*etc*, which need to be cultivated the alluvial lands. Therefore, the most probable way to increase flax production may be through the use of new developed varieties of high yield potential along with application of the best agronomic practices among which irrigation plays an important role in increasing yield of flax. Also, The extension of the flax cultivated area in sandy soil has become a must. But, this soil is leaching water. Sine new areas reclaimed land are used for producing flax and other crops. So, water for irrigation is considered a limiting factor. Flax investigators try to solve this problem by releasing drought tolerant cultivars and/or the pest management of irrigation under sandy soil conditions (Such information in flax is limited) and/or using any other treatments that could help plants for drought tolerance conditions, such as infection of the soil by mycorrhizal fungi. On the other hand, the differences between flax genotypes were studied by several investigators namely, Momtaz *et al.*(1990), Zahana *et al.* (2003) and Abo-Kaied *et al.* (2006). Concerning soil inoculation by mycorrhizal, Zahana, *et al*., (2003) concluded that cultivation of flax after maize or inoculation with VA mycorrhizal fungi with the application of $ZnSO_4$ 10 kg / fed gave the highest straw yield, seeds yield and oil yield.

VA mycorrhizal fungi is known to increase nutrient uptake, particularly P, and biomass accumulation of many land plant species in low P soil (Nelsen and Safir, 1982). Furthermore, mycorrhizal fungi can increase the drought tolerance of host plants (Hardie and Leyton, 1981 and Allen and Allen, 1986). The growth of mycorrhizal treated plants was greater than non-treated ones. The increased growth was attributed to increased stomatal conductance (Allen and Boosalis, 1983) and root conductivity (Graham and Syvertsen, 1984) provided by increased surface area of mycorrhizal hyphae (Hardie and Leyton, 1981 and Allen, 1982). These reported changes could be secondary responses to better P nutrition (Nelsen and Safir, 1982; Michelsen and Rosendahel, 1990 and Osonubi *et al*. 1990) or mediated via direct mycorrhizal effects (Henderson and Davies, 1990).

Therefore, The main objectives of this study were to evaluate the influence of VA mycorrhizal on the yield and yield components as well as drought tolerance of the three flax genotypes (Sakha2, S.2419/1/1 and Viking) and to assess the efficiencies of mycorrhizal with respect to the above objectives under well-watered (one irrigation / 2 days) and drought-stressed conditions (one irrigation / 4 or 6 days).

MATERIALS AND METHODS

Two field experiments were conducted at Ismailia Agric. Res. Station Farm, Ismailia Governorate, Egypt, in the two successive seasons of 2004/05 and 2005/06 to study the influence of VA mycorrhizal on the yield and yield components as well as drought tolerance of three flax genotypes viz., Sakha 2 (dual purpose type), S.2419/1/1 (oil type) and Viking (fiber type). The previous crop was peanut in both seasons. The soil texture was sandy (coarse sand 69.13%, fine sand 35.48%, silt 2.73%, clay 1.48%, organic matter of 0.047 %, available N 6.77 ppm, available P 1.27, available K 49.13 ppm and pH value of 7.44).

The three types of flax varieties were tested under three different sprinkler irrigation treatments. The three sprinkler irrigation treatments were irrigation every 2, 4, and 6 days, respectively in the last four months before harvesting in the adjacent three experiments. The number of sprinklers per fed (fed = 0.42 hectare) were 35 and the amount of water for each sprinkler was 1.3 cubic meter per hour. Sprinkler irrigation used lasted for two hours. Thus, the amount of water added during the last four months of growth season for the three treatments was 2730, 1820 and 910 cubic meters per fed, respectively.. The inoculum used in this experiment was propagated on maize plant grown in Ismailia Agric. Res. Station Farm for 12 weeks before sowing date of the experiments. A split plot design with three replications was used in each irrigation experiment in both seasons. The two inoculation treatments with VA mycorrhizal fungi (+M) and un-inoculated (-M) as main plot (soil was inoculated by VA mycorrhizal fung and irrigated just after planting) and three flax genotypes viz, Sakha 2 (local variety), S.2419/1/1 {(selection from Humpata (Hungarian introduction)} and Viking (French introduction) as sub plot. Sowing data was the second week of November in both seasons. The sub plot size was 6 m^2 (3 x 2 m). Seeds were drilled in rows 3 meters long and 20 cm apart. Plant density of 2000 seeds / m^2 was used. Zinc sulphate ($ZnSO_4$ 10 kg / fed) was applied after 21 days from sowing and other agronomic practices were carried out as usual.

At harvest, data on ten randomly guarded plants were taken to determine the average of the individual plant traits. Straw, seed and fiber yields / fed was calculated on plot basis. Oil percentage (%) was determined as an average of two random seed samples / plot using Soxhlet apparatus (A.O.A.C. Society, 1995). The following characters were recorded:

I) Straw yield and its components as well as fiber yield:

(1) Plant height (cm), (2) Technical length (cm), (3) Straw weight (g) / plant, (4) Straw yield (ton) / fed, and (5) Fiber yield (kg) / fed.

II) Seed yield and its components as well as oil yield:

(1) No. of capsules / plant, (2) No. of seeds / capsule, (3) 1000-seed weight (g), (4) Seeds weight (g) / plant, (5) Seed yield (Kg) / fed and (6) Oil yield (Kg) / fed,

III) Technological characters:

(1) Fiber percentage (2) Fiber fineness (Nm) were determined according to the technique described by Radwan and Momtaze (1966), and (3) Oil percentage (%).

Analysis of variance was carried out according to Sendecor and Cochran (1980) and means were compared by Least Significant Difference (LSD) at 0.05 level was used. The combined analysis of variance over the two seasons and three irrigation trials was performed after tested of homogeneity (Bartlett,s test) for error terms of each set of analysis for all characters (Le Clerg *et al.,* 1966).

RESULTS AND DISCUSSION

I - Straw yield and its components as well as fiber yield:

A - Irrigation treatments effect:

Combined data in Table 1 showed that prolonging irrigation interval (**Ir**) had a negative effect on straw yield and its components as well as fiber yield. The results indicated that plant height, technical stem length, straw weight / plant, straw yield / fed and fiber yield / fed were significantly affected by irrigation intervals. The highest values were produced when plants were irrigated every 2 days followed by irrigation every 4 days and 6 days in a descending order. Stress conditions resulted in a marked decrease in the forementioned characters compared with the regular irrigation treatment (2 days). Plant height decreased from 102.16 to 83.62 cm, technical stem length from 80.05 to 58.97 cm, straw weight / plant from 2.37 to 1.26 g, straw yield /

fed from 2.833 to 1.916 ton and fiber yield / fed from 363.14 to 209.11 kg under stress treatment 6 days. It seems that water stress during vegetative stage and early flowering markedly depressed length measurements. The decrease in length measurements accompanying lower number of irrigation may be attributed to the fact that rate of cell enlargement and stem elongation can be inhibited by water deficits (Sltatyer, 1957). These findings are in line with those of El Kady (1985), Mlodenova (1986) and El-Sweify *et al*. (2002). On the other hand, the decrease in straw yield as a result of water stress, obtained by the drought at the vegetative stage or the beginning of flowering may be attributed to the fact that mineral nutrient uptake is frequently reduced to a considerable degree in stressed plant, which in turn reduced photosynthetic efficiency and consequently dry matter accumulation (Slatyer, 1957 and Foster *et al.*, 1998).

B – VA mycorrhizal fungi effect:

Soil inoculation with VA mycorrhizal fungi (**M**) significantly increased plant height (97.93 cm), technical stem length (74.85 cm), straw weight / plant (2.25 g), straw yield / fed (2.650 ton) and fiber yield / fed (330.13 kg) compared to untreated control (Table 1). The positive effect of soil inoculation may due to the VA mycorrhizal fungi is known to increase N uptake, particularly P and biomass accumulation of many plant species in low P soil (Nelson and Safir, 1982). The increased growth was attributed to increased stomatal conductance (Allen and Boosalis, 1983).

C – Varieties performance:

Data in Table 1 showed significant differences among the three flax varieties (**V**) in plant height, technical stem length, straw weight / plant, straw yield / fed and fiber yield / fed. Sakha 2 (V1) gave the highest straw weight / plant (2.49 g) as well as straw yield / fed (2.729 ton). Viking variety (V3) ranked first for plant height (101.30 cm), technical stem length (87.48 cm) and fiber yield / fed (336.94 kg). S. 2419/1/1(V2) gave the shortest plants (81.68 cm), technical stem length (54.14 cm) and fiber yield / fed (232.15 kg). It is worth to mention that the lower straw yield of Viking (V3) was compensated by the higher percentage of fiber and finally produced the highest fiber yield / fed. Several investigators found differences among yield and yield components such as Momtaz *et al.* (1990), Zahana *et al.* (2003) and Abo-Kaied *et al*. (2006).

D – Interaction effects:

Data in Table 1 revealed that all interactions among the three studied factors were not significant, except **Ir** x **M** for plant height, straw yield / fed and **M** x **V** for fiber yield / fed as well as **Ir** x **M** x **V** for plant height, technical stem length, straw yield / fed and fiber yield / fed. The highest straw yield / fed (3.275 and 3.215 ton) were recorded from Sakha 2 (V1) when irrigation intervals of both 2 and 4 days, respectively and treated with mycorrhizal fungi, while the highest values of plant height (112.11 and 110.51 cm), technical stem length (101.72 and 99.70 cm) and fiber yield / fed (445.57 and 421.90 kg) were obtained from Viking (V3) treated with VA mycorrhizal and irrigation intervals of both 2 and 4 days without significant. Mycorrhizal fungi can increase the drought tolerance of host plant (Hardie and Leyton, 1981 and Allen and Allen, 1986).

II- Seed yield and its components as well as oil yield:

A - Irrigation treatments effect:

Data presented in Table 2 revealed that number of capsules / plant, number of seeds / capsule, 1000-seed weight, seeds weight / plant, seed yield / fed and oil yield / fed were significantly affected by the different irrigation intervals. The highest values of number of capsules / plant (8.74), number of seeds / capsules (8.26), 1000-seed weight (8.70 g), seeds weight / plant (0.60 g), seed yield / fed (558.11 kg) and oil yield / fed (216.06 kg) were obtained when plants irrigated every 4 days, meanwhile the lowest values of these characters were recorded when plants irrigated every 6 days. The decrease in number of capsules / plant with decreasing soil moisture might be due to the abortion of some flowers as a result of moisture stress which adversely affected different physiological processes in such critical period. The decrease in seed yield could be attributed to the decrease in number of capsules / plant and number of seeds / capsule and 1000-seed weight as mentioned before. These finding are in harmony with those obtained by El Kady (1985), Foster *et al*. (1998) and El-Sweify *et al*. (2002).

B – VA mycorrhizal fungi effects:

Data in Table 2 showed that flax plants treated with VA mycorrhizal fungi produced higher number of capsules / plant (7.58), number of seeds / capsule (7.68), 1000-seed weight (8.40 g), seeds weight / plant (0.51 g), seed yield / fed (502.01 kg) and oil yield / fed (196.89 kg) compared to untreated ones. These findings are in good agreement with those obtained by Elwan and Sharawy (1994).

C – Varieties performance:

Data in Table 2 indicated that varieties were significantly different in number of capsules / plant, number of seeds / capsule, 1000-seed weight, seeds weight / plant, seed yield / fed and oil yield / fed. S.2419/1/1 (V2) significantly surpassed Sakha 2 (V1) and Viking (V3) varieties in number of capsules / plant (8.44), 1000-seed weight (10.16 g), seed weight / plant (0.56 g), seed yield / fed (557.44 kg) and oil yield / fed (230.16 kg) while Viking (V3) surpassed Sakha 2 (V1) and S.2419/1/1 (V2) in number of seeds / capsule (8.24). The superiority of S.2419/1/1(V2) in oil production may due to its higher seed yield / fed as well as higher oil seed content. Similar results were also reported by Momtaz *et al.* (1990), Zahana *et al.* (2003) and Abo-Kaied *et al*. (2006).

D – Interaction effects:

The results in Table 2 showed that all interactions among the three studied factors were not significant except **Ir** x **M** for number of capsules / plant, 1000-seed weight, seed yield / fed and oil yield / fed as well as **Ir** x **M** x **V** for number of capsules / plant, 1000-seed weight, seed yield / fed and oil yield / fed. The highest values of number of capsules / plant (12.21 and 11.94), 1000-seed weight (10.88 and 10.24 g), seed yield / fed (690.40 and 671.61 kg) were obtained from S.2419/1/1 (V2) treated with VA mycorrhizal fungi and irrigation intervals of 2 and 4 days, respectively without significant differences between them.

1

2

III- Technological characters:

A - Irrigation treatments effect:

Data in Table 3 showed that differences among irrigation intervals were significant for fiber percentage, fiber fineness and oil percentage. The highest fiber percentage (12.87%) produced when plants were irrigated every 2 days followed by irrigation every 4 (12.09) and 6 (11.02) days, respectively. There was a trend of coarseness of fiber due to shorter intervals between irrigation. This indicates that any factor which gives possibilities of increasing nutrition and accumulation of cellulose in the fibers could affect fineness towards heavier weight for the give length of fiber recorded as metrical number (Nm). Similar results were reported by El Kady (1985) and El Sweify *et al*. (2002). The highest values of oil percentage were obtained when plants were irrigated every 6 days while, the highest oil yield / fed was obtained from irrigation at 2 days intervals.

Table 3. Effect of Irregation periods and VA mycorrhizal fungi (M) on fiber percentage, fiber fineness and oil percentage (combined analysis of the two seasons).

Irregation periods	(M)	Fiber percentage (%)				Fiber fineness (Nm)				Oil percentage (%)			
		V1	V2	V3	Means	V1	V2	V3	Means	V1	V2	V3	Means
2days	+M	13.12	10.25	16.65	13.34	151.02	143.87	208.65	167.85	39.54	41.53	34.33	38.47
	-M	12.17	9.84	15.16	12.39	153.90	147.15	218.03	173.03	38.97	40.48	33.73	37.73
	Means	12.65	10.05	15.91	12.86	152.46	145.51	213.34	170.44	39.26	41.01	34.03	38.10
4days	+M	12.31	9.84	16.41	12.85	155.41	145.31	210.41	170.38	39.58	41.57	34.51	38.55
	-M	11.41	8.13	14.45	11.33	159.21	150.62	219.72	176.52	39.11	41.24	34.11	38.15
	Means	11.86	8.99	15.43	12.09	157.31	147.97	215.07	173.45	39.35	41.41	34.31	38.35
6days	+M	10.35	9.08	14.51	11.31	158.61	147.94	211.11	172.55	39.61	41.62	34.63	38.62
	-M	9.69	8.42	14.04	10.72	161.41	152.41	221.41	178.41	39.51	41.36	34.32	38.40
	Means	10.02	8.75	14.28	11.02	160.01	150.18	216.26	175.48	39.56	41.49	34.48	38.51
Mean for varieties		11.51	9.26	15.20	11.99	156.59	147.88	214.89	173.12	39.39	41.30	34.27	38.32
Mean for mycorrhizal													
	M+	11.93	9.72	15.86	12.50	155.01	145.71	210.06	170.26	39.58	41.57	34.49	38.55
	M-	11.09	8.80	14.55	11.48	158.17	150.06	219.72	175.98	39.20	41.03	34.05	38.09

LSD 5% level of significance for:

	Fiber percentage	Fiber fineness	Oil percentage
Irregation (Ir)	0.15	1.11	0.11
Mycorrhizal (M)	0.17	2.01	0.17
Varieties (V)	0.19	3.17	0.09
Ir x M	NS	NS	NS
Ir x V	NS	NS	NS
V x M	NS	NS	NS
Ir x M x V	NS	2.01	0.08

(+M),(-M) =with and without mycorrhizal fungi ,respectively.
NS = Non- Significant
V1= Sakha 2 V2= S.2419/1/1 V3= Viking

B – VA mycorrhizal fungi effects:

Data in Table 3 revealed that soil inoculation with VA mycorrhizal fungi significantly increased fiber percentage from 11.48 to 12.50%, oil percentage from 38.09 to 38.55% compared to those without inoculation. These results are in harmony with those reported by Elwan and Sharawy (1994). On the other hand, inoculation with VA mycorrhizal fungi significantly decreased fiber fineness from 175.98 to 170.26.

C – Varieties performance:

Data in Table 3 indicated that significant differences among flax varieties in fiber percentage, fiber fineness and oil percentage. Fiber percentage and fiber fineness reached maximum values in Viking (V3) in comparison with other investigated varieties (Sakha 2 (V1) and S.2419/1/1 (V2)). It could be concluded that these varietal differences are due to variability in genetic constitution. These findings are in line with those of Momtaz *et al.*(*1*990), Zahana *et al.* (2003) and Abo-Kaied *et al*. (2006).

D – Interaction effects:

The interaction among the three studied factors were not significant, excepted **Ir** x **M** x **V** for fiber fineness and oil percentage. The highest values of fiber fineness (221.41) was obtained from Viking (V3) irrigated every 6 days without mycorrhizal inculation. While, the highest values of oil percentage 41.57 and 41.62% differences being insignificant was obtained from S.2419/1/1 (V2) when treated with VA mycorrhizal and irrigated every 4 and 6 days, respectively.

General conclusion:

It can be concluded that under sandy soil condition its recommended to cultivate flax and inoculation with VA mycorrhizal fungi with irrigation at intervals of 2 or 4 days to obtain the highest straw yield, seed yield and oil yield. This means that, soil inoculation by mycorrhizal fungi can increase the drought tolerance of flax plant from one irrigation / 2days to one irrigation / 4days.

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تأثير التلقيح بالميكروهيزا علي المحصول وتحمل ظروف الجفاف لبعض أصناف الكتان

حسين مصطفي حسين أبوقايد ، عفاف السيد عبد الواحد زهانة و طه عبد المنعم أبو زيد
معهد المحاصيل الحقلية-مركز البحوث الزراعية-الجيزة

أجريت تجربتان حقليتان خلال موسمي ٢٠٠٤ / ٢٠٠٥ – ٢٠٠٥ / ٢٠٠٦ بمحطة البحوث الزراعية بالإسماعيلية - م الإسماعيلية – مصر. وذلك لدراسة تأثير تلقيح التربة بفطر بالميكروهيزا والري بالرش علي فترات كل ٢، ٤، ٦ أيام علي المحصول ومكوناته وكذلك تحمل ظروف الجفاف علي ثلاث تراكيب وراثية من الكتان وهي سخا ٢ (طراز ثنائي الغرض)، س ١/١/٢٤١٩ (طراز زيتي)، والمستورد فايكنج (طراز ليفي) , وكانت أهم النتائج ما يلي:

تشير النتائج إلى أن كل الصفات تحت الدراسة تأثرت تأثرا معنويا بفترات الري . أيضا أدى التلقيح بالميكروهيزا إلى زيادة معنوية في الطول الكلي ، الطول الفعال ، وزن القش / نبات ، محصول القش / فدان ، محصول الألياف / فدان ، عدد الكبسولات / نبات ، عدد البذور / كبسولة ، وزن الألف بذرة ، وزن البذور / نبات ، محصول البذور / فدان ، محصول الزيت / فدان ، النسبة المئوية للألياف والنسبة المئوية للزيت مقارنة بعدم التلقيح . وعلى العكس من ذلك أدى تلقيح التربة بالميكروهيزا إلى نقص نعومة الألياف

أعطى الصنف التجاري سخا ٢ أعلى قيمتان لصفتي محصول القش / فدان ووزن القش / نبات . كما أعطى المستورد فايكنج أعلى قيم لصفات الطول الكلي ، الطول الفعال ومحصول الألياف الطويلة / فدان . بينما أعطت السلالة ١/٢٤١٩ أعلى قيم لصفات عدد الكبسولات / نبات ووزن الألف بذرة ووزن البذور / نبات ومحصولي البذور والزيت / فدان وذلك عند تلقيح التربة بالميكروهيزا والري كل ٢ يوم أو ٤ أيام.

كما تشير النتائج إلى وجود اختلافات معنوية بين الأصناف تحت الدراسة في محصولي القش والبذور ومكوناتهما وكذلك صفات الجودة . بينما كانت التفاعلات بين العوامل المختلفة تحت الدراسة غير معنوية ما عدا التفاعل بين الري **x** معملة الميكروهيزا كان معنويا لصفات القش والبذور والزيت / فدان ، الطول الكلي وعدد الكبسولات / نبات ، ووزن الألف بذرة ونعومة الألياف والنسبة المئوية للزيت . كذلك التفاعل بين الأصناف **x** الميكروهيزا كان معنويا فقط لطول الألياف / فدان ومحصول الألياف / فدان . كذلك التفاعل الثلاثي (الري **x** الميكروهيزا **x** الأصناف) كان معنويا لصفات الطول الكلي والطول الفعال وعدد الكبسولات / نبات ووزن الألف بذرة ونعومة الألياف ونسبة الزيت ومحصول كل من القش والألياف والبذور والزيت / فدان .

ويمكن أن نلخص أهم النتائج في عند زراعة الكتان وتلقيح التربة بالميكروهيزا والري كل ٢ يوم أو ٤ أيام أعطى أعلى محصول من القش والبذور والزيت تحت ظروف الأراضي الرملية والري بالرش . وهذا يعني أن تلقيح التربة بالميكروهيزا أدى إلى زيادة تحمل ظروف الجفاف من ريه / ٢ يوم إلى ريه / ٤ أيام في الكتان .

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Table 1.Effect of Irregation periods and VA mycorrhizal fungi (M) on plant height, technical stem length, straw weight / plant,straw yield /fed (ton) and fiber yield/fed (kg) (combined analysis of the two seasons).

Irregation	(M)	Plant height (cm)				Technical stem length (cm)				Straw weight / plant (g)				Straw yield / fed (ton)				Fiber yield / fed (kg)			
periods		V1	V2	V3	Means	V1	V2	V3	Means	V1	V2	V3	Means	V1	V2	V3	Means	V1	V2	V3	Means
2days	+M	109.61	91.97	112.11	104.56	82.01	65.61	101.72	83.11	3.72	3.16	1.78	2.89	3.275	2.926	2.674	2.958	429.68	299.92	445.57	391.72
	-M	104.15	87.92	107.21	99.76	75.51	60.32	95.11	76.98	2.41	2.11	1.03	1.85	2.943	2.630	2.551	2.708	358.16	258.79	386.73	334.56
	Means	106.88	89.95	109.66	102.16	78.76	62.97	98.42	80.05	3.07	2.64	1.41	2.37	3.109	2.778	2.613	2.833	393.92	279.36	416.15	363.14
4days	+M	108.57	85.94	110.51	101.67	80.91	59.46	99.70	80.02	3.17	2.64	1.27	2.36	3.215	2.812	2.571	2.866	395.77	276.70	421.90	364.79
	-M	92.71	80.12	96.41	89.75	72.36	52.24	82.51	69.04	2.11	1.74	0.86	1.57	2.641	2.471	2.211	2.441	301.34	200.89	319.49	273.91
	Means	100.64	83.03	103.46	95.71	76.64	55.85	91.11	74.53	2.64	2.19	1.07	1.97	2.928	2.642	2.391	2.654	348.56	238.80	370.70	319.35
6days	+M	92.61	74.94	95.13	87.56	63.21	45.61	75.42	61.41	2.01	1.64	0.88	1.51	2.351	2.313	1.712	2.125	243.23	210.02	248.41	233.89
	-M	83.41	69.21	86.41	79.68	57.54	41.62	70.41	56.52	1.51	1.11	0.40	1.01	1.949	1.741	1.421	1.704	188.86	146.59	199.51	178.32
	Means	88.01	72.08	90.77	83.62	60.38	43.62	72.92	58.97	1.76	1.38	0.64	1.26	2.150	2.027	1.567	1.915	216.05	178.31	223.96	206.10
Mean for varieties		98.51	81.68	101.30	93.83	71.92	54.14	87.48	71.18	2.49	2.07	1.04	1.86	2.729	2.482	2.190	2.467	319.51	232.15	336.94	296.20
Mean for mycorrhizal																					
	M+	103.60	84.28	105.92	97.93	75.38	56.89	92.28	74.85	2.97	2.48	1.31	2.25	2.947	2.684	2.319	2.650	356.23	262.21	371.96	330.13
	M-	93.42	79.08	96.68	89.73	68.47	51.39	82.68	67.51	2.01	1.65	0.76	1.48	2.511	2.281	2.061	2.284	282.79	202.09	301.91	262.26

LSD 5% level of significance for:

	Plant height	Technical stem length	Straw weight / plant	Straw yield / fed	Fiber yield / fed
Irregation (Ir)	**2.11**	**3.12**	**0.32**	**0.054**	**13.35**
Mycorrhizal(M)	**2.53**	**2.17**	**0.35**	**0.078**	**12.12**
Varieties (V)	**2.11**	**3.15**	**0.22**	**0.063**	**11.27**
Ir x M	**1.03**	**NS**	**NS**	**0.015**	**NS**
Ir x V	**NS**	**NS**	**NS**	**NS**	**NS**
V x M	**NS**	**NS**	**NS**	**NS**	**9.14**
Ir x M x V	2.37	3.13	NS	0.075	25.41

(+M),(-M) =with and without mycorrhizal fungi ,respectively.

NS = Non- Significant

V1= Sakha 2 V2= S.2419/1/1 V3= Viking

Table 2.Effect of Irregation periods and VA mycorrhizal (M) fungi on No.of capsules/plant,No.of seeds/capsule, 1000-seed weight, seeds weight/plant,seed yield/fed and oil yield/fed (combined analysis of the two seasons).

Irregation periods	(M)	No.of capsules/plant				No.of seeds/capsule				1000-seed weight (g)				Seeds weight/plant (g)				Seed yield/fed (kg)				Oil yield/fed (kg)			
		V1	V2	V3	Means	V1	V2	V3	Means	V1	V2	V3	Means	V1	V2	V3	Means	V1	V2	V3	Means	V1	V2	V3	Means
2days	+M	10.55	12.21	6.10	9.62	8.90	8.11	9.15	8.72	9.97	10.88	5.87	8.91	0.92	0.98	0.31	0.74	650.41	690.40	430.81	590.54	257.17	286.72	147.90	230.60
	-M	8.51	9.94	5.14	7.86	7.45	7.34	8.62	7.80	9.44	10.42	5.61	8.49	0.57	0.62	0.22	0.47	567.32	635.62	374.11	525.68	221.08	257.30	126.19	201.52
	Means	9.53	11.08	5.62	8.74	8.18	7.73	8.89	8.26	9.71	10.65	5.74	8.70	0.75	0.80	0.27	0.60	608.87	663.01	402.46	558.11	239.13	272.01	137.05	216.06
4days	+M	8.76	11.94	4.18	8.29	7.56	7.11	8.91	7.86	9.35	10.24	5.60	8.40	0.60	0.87	0.20	0.56	601.17	671.61	346.33	539.70	239.13	279.19	119.52	212.61
	-M	5.64	6.74	3.21	5.20	6.54	6.21	7.93	6.89	9.10	9.91	5.40	8.14	0.32	0.41	0.13	0.29	495.50	527.43	301.72	441.55	193.79	217.51	102.92	171.41
	Means	7.20	9.34	3.70	6.75	7.05	6.66	8.42	7.38	9.23	10.08	5.50	8.27	0.46	0.64	0.17	0.42	548.34	599.52	324.03	490.63	216.46	248.35	111.22	192.01
6days	+M	5.41	5.94	3.14	4.83	6.36	5.43	7.61	6.47	8.52	9.84	5.37	7.91	0.27	0.31	0.12	0.23	371.65	478.21	277.50	375.79	147.21	199.03	96.10	147.45
	-M	3.26	3.86	2.53	3.22	5.37	5.11	7.21	5.90	8.38	9.64	5.15	7.72	0.13	0.18	0.10	0.14	303.41	341.35	215.31	286.69	119.88	141.18	73.89	111.65
	Means	4.34	4.90	2.84	4.02	5.87	5.27	7.41	6.18	8.45	9.74	5.26	7.82	0.20	0.25	0.11	0.19	337.53	409.78	246.41	331.24	133.55	170.11	85.00	129.55
Mean for varieties		7.02	8.44	4.05	6.50	7.03	6.55	8.24	7.27	9.13	10.16	5.50	8.26	0.47	0.56	0.18	0.40	498.24	557.44	324.30	459.99	196.38	230.16	111.09	179.21
Mean for mycorrhizal																									
	M+	8.24	10.03	4.47	7.58	7.61	6.88	8.56	7.68	9.28	10.32	5.61	8.40	0.60	0.72	0.21	0.51	541.08	613.41	351.55	502.01	214.50	254.98	121.17	196.89
	M-	5.80	6.85	3.63	5.43	6.45	6.22	7.92	6.86	8.97	9.99	5.39	8.12	0.34	0.40	0.15	0.30	455.41	501.47	297.05	417.97	178.25	205.33	101.00	161.53

LSD 5% level of significance for:

	No.of capsules/plant	No.of seeds/capsule	1000-seed weight	Seeds weight/plant	Seed yield/fed	Oil yield/fed
Irregation (Ir)	0.45	0.26	0.22	0.12	15.19	5.19
Mycorrhizal (M)	0.57	0.17	0.12	0.05	13.34	8.54
Varieties (V)	0.38	0.24	0.35	0.06	21.11	6.87
Ir x M	0.27	NS	0.12	NS	12.14	5.61
Ir x V	NS	NS	NS	NS	NS	NS
V x M	0.22	NS	NS	NS	NS	NS
Ir x M x V	0.33	NS	0.39	NS	22.14	8.64

(+M),(-M) =with and without mycorrhizal fungi ,respectively.

NS = Non- Significant

V1= Sakha 2 V2= S.2419/1/1 V3= Viking