RESULTS AND DISCUSSION

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A. Growth characters

Means of growth characters for each of the two flax strains supplied with three microelement treatments and seeded at six rates in 1989/90 and 1990/91 seasons are presented in Table 4 and 5.

1. Plant height

Results showed that means of plant height continued to increase as the plant advanced in age until the last sampling date for the two strains in both seasons.

The results indicated that the differences between the two strains in plant height were not significant at the first, second and third stages, while at the fourth stage there was a significant difference in both seasons. However, S_1 (19/31) was higher than S_2 (2419/1) in plant height at all growing stages (Table 4 and 5).

The difference in plant height at the end of the growing season is mainly due to the difference in the genetical constitution of the two strains. Many investigators found marked differences in plant height among different flax strains (**El-Farouk *et al*., 1982; El-Kalla and El-Kassaby, 1982; Salama, 1983; Momtaz *et al*., 1989** and **Kineber, 1991**).

Table 4. Effect of strains (S), microelements (M) and seeding rates (R) on growth characters of flax plants in 1989/90 season.

Days from sowing	Characters	Strains					Microelements						Seeding rates								
		Sig.	L.S.D. 1%	L.S.D. 5%	S1 19/31	S2 2419/1	Sig.	L.S.D. 1%	L.S.D. 5%	M1 Zn	M2 Cu	M3 Control	Sig.	L.S.D. 1%	L.S.D. 5%	R1	R2	R3	R4	R5	R6
55 days	Plant height (cm)	N.S.	-	-	48.47	46.73	*	-	4.28	46.63	45.20	44.46	*	-	1.64	43.25	43.61	43.73	44.43	44.63	44.96
	Dry weight per plant (gm)	N.S.	-	-	0.25	0.28	N.S.	-	-	0.25	0.25	0.24	*	-	0.09	0.26	0.25	0.24	0.23	0.22	0.22
	(Stem dry wt./Total dry wt.) x 100	*	-	2.93	34.70	37.18	*	-	2.26	36.96	33.98	31.64	*	-	3.89	33.30	33.21	34.01	35.06	36.42	38.84
	Leaves dry wt./Total dry wt.) x 100	N.S.	-	-	39.46	39.15	*	-	2.34	36.85	40.65	35.85	*	-	1.59	40.81	40.14	39.44	39.23	38.50	38.10
	Roots dry wt. /Total dry wt.) x 100	N.S.	-	-	24.59	23.03	N.S.	-	-	21.53	21.18	22.07	*	-	3.55	25.11	24.75	24.08	23.66	22.32	21.22
75 days	Plant height (cm)	N.S.	-	-	62.57	59.63	*	-	4.27	63.45	59.51	58.93	*	-	4.07	55.97	56.86	58.73	59.87	61.57	62.79
	Dry weight per plant (gm)	N.S.	-	-	0.30	0.35	N.S.	-	-	0.32	0.32	0.31	*	-	0.10	0.41	0.38	0.36	0.34	0.32	0.29
	(Stem dry wt./Total dry wt.) x 100	N.S.	-	-	44.04	43.20	N.S.	-	-	46.50	45.06	45.29	N.S.	-	-	48.16	48.99	49.35	49.51	50.36	50.54
	Leaves dry wt./Total dry wt.) x 100	N.S.	-	-	30.25	32.99	N.S.	-	-	31.15	31.91	31.79	*	-	1.91	31.91	31.80	31.63	31.58	30.51	28.61
	Roots dry wt. /Total dry wt.) x 100	N.S.	-	-	22.61	21.34	N.S.	-	-	21.09	21.75	21.09	N.S.	-	-	23.61	23.53	22.68	22.53	21.16	20.76
95 days	Plant height (cm)	N.S.	-	-	91.62	89.71	*	-	3.04	93.22	90.86	89.93	*	-	3.21	89.55	89.76	90.13	90.42	91.64	92.50
	Technical stem length (cm)	*	-	2.09	75.80	70.41	*	-	1.73	74.98	74.21	72.14	*	-	1.92	73.12	73.15	73.20	74.00	74.14	75.05
	Dry weight per plant (gm)	N.S.	-	-	1.13	1.24	N.S.	-	-	1.24	1.24	1.23	*	-	0.18	1.28	1.18	1.05	1.04	1.02	1.01
	(Stem dry wt./Total dry wt.) x 100	N.S.	-	-	50.69	50.20	N.S.	-	-	51.40	50.88	50.04	N.S.	-	-	51.67	52.49	53.07	54.05	54.15	55.23
	Leaves dry wt./Total dry wt.) x 100	N.S.	-	-	27.63	27.98	N.S.	-	-	27.82	28.93	28.67	*	-	1.99	30.37	29.60	28.17	27.75	27.15	26.79
	Roots dry wt. /Total dry wt.) x 100	N.S.	-	-	20.90	20.26	N.S.	-	-	20.22	20.67	20.87	N.S.	-	-	21.10	20.98	20.41	20.42	20.28	20.18
115 days	Plant height (cm)	*	-	3.61	99.46	92.67	**	4.56	2.82	95.73	91.66	88.30	*	-	2.82	96.62	96.83	96.79	97.46	98.64	99.90
	Technical stem length (cm)	*	-	3.11	81.23	72.82	*	-	1.56	81.57	80.83	79.62	*	-	1.63	79.22	79.29	79.34	82.22	82.59	82.98
	Dry weight per plant (gm)	N.S.	-	-	1.37	1.55	N.S.	-	-	1.57	1.46	1.40	*	-	0.26	1.68	1.68	1.42	1.35	1.30	1.20
	No. of capsules per plant	**	7.26	3.63	14.79	22.14	N.S.	-	-	18.33	18.45	18.64	*	-	4.18	22.54	19.97	19.65	17.13	17.93	15.72
	No. of upper branches per plant	*	-	0.67	5.63	6.22	N.S.	-	-	6.96	6.61	6.26	*	-	0.49	6.99	6.68	5.92	5.85	5.35	5.21
	(Stem dry wt./Total dry wt.) x 100	*	-	2.76	51.44	52.11	N.S.	-	-	55.11	54.60	54.34	N.S.	-	-	53.69	55.62	55.73	56.14	56.56	56.89
	Leaves dry wt./Total dry wt.) x 100	N.S.	-	-	28.90	29.92	*	-	1.15	27.52	28.63	25.12	*	-	1.42	28.82	28.08	27.97	27.84	27.68	26.94
	Roots dry wt. /Total dry wt.) x 100	N.S.	-	-	17.72	17.87	N.S.	-	-	17.10	17.07	17.85	N.S.	-	-	18.03	18.81	17.92	17.55	17.29	17.17

Table 5. Effect of strains (S), microelements (M) and seeding rates (R) on growth characters of flax plants in 1990/91 season.

No. of Days from sowing	Characters	Strains					Microelements						Seeding rates								
		Sig.	L.S.D. 1%	L.S.D. 5%	S1 19/31	S2 2419/1	Sig.	L.S.D. 1%	L.S.D. 5%	M1 Zn	M2 Cu	M3 Control	Sig.	L.S.D. 1%	L.S.D. 5%	R1	R2	R3	R4	R5	R6
55 days	Plant height (cm)	N.S.	-	-	46.38	37.69	*	-	4.27	44.61	41.13	42.36	*	-	1.52	41.23	41.45	41.69	42.42	42.55	42.87
	Dry weight per plant (gm)	N.S.	-	-	0.23	0.25	N.S.	-	-	0.22	0.22	0.22	*	-	0.02	0.13	0.12	0.12	0.11	0.11	0.11
	(Stem dry wt./Total dry wt.) x 100	*	-	2.62	40.42	43.20	*	-	1.26	36.48	36.16	33.19	*	-	3.98	38.83	40.21	41.91	42.49	42.09	42.99
	Leaves dry wt./Total dry wt.) x 100	N.S.	-	-	29.78	28.06	*	-	2.61	31.39	32.45	30.92	*	-	1.63	34.02	31.32	30.26	31.07	30.16	29.69
	Roots dry wt. /Total dry wt.) x 100	N.S.	-	-	28.65	28.59	N.S.	-	-	28.22	28.14	28.81	*	-	3.73	30.23	28.13	27.28	26.03	25.86	25.31
75 days	Plant height (cm)	N.S.	-	-	60.65	52.95	*	-	4.93	60.08	59.47	56.86	*	-	3.99	53.90	54.76	54.47	56.48	59.49	60.71
	Dry weight per plant (gm)	N.S.	-	-	0.23	0.30	N.S.	-	-	0.27	0.26	0.26	*	-	0.07	0.32	0.30	0.28	2.64	0.22	0.20
	(Stem dry wt./Total dry wt.) x 100	N.S.	-	-	42.12	41.04	N.S.	-	-	39.18	39.23	39.23	N.S.	-	-	38.34	38.93	39.14	40.32	40.56	40.99
	Leaves dry wt./Total dry wt.) x 100	N.S.	-	-	31.50	33.86	N.S.	-	-	32.14	33.19	32.71	*	-	2.42	33.43	33.26	32.77	32.38	31.51	30.32
	Roots dry wt. /Total dry wt.) x 100	N.S.	-	-	26.15	25.18	N.S.	-	-	27.22	27.13	26.67	N.S.	-	-	26.84	27.79	25.53	26.96	27.52	27.19
95 days	Plant height (cm)	N.S.	-	-	88.96	86.46	*	-	3.35	90.96	89.07	87.59	*	-	2.93	87.08	87.18	87.48	87.58	89.48	90.45
	Technical stem length (cm)	*	-	2.33	72.35	68.13	*	-	1.87	72.83	72.37	70.96	*	-	1.94	71.24	71.60	71.78	72.11	72.31	73.14
	Dry weight per plant (gm)	N.S.	-	-	1.15	1.16	N.S.	-	-	1.16	1.16	1.15	*	-	0.06	1.12	1.11	1.04	1.03	1.01	1.01
	(Stem dry wt./Total dry wt.) x 100	N.S.	-	-	48.25	47.27	N.S.	-	-	48.07	48.63	47.58	N.S.	-	-	47.14	47.56	47.63	48.12	49.49	50.82
	Leaves dry wt./Total dry wt.) x 100	N.S.	-	-	28.95	28.21	N.S.	-	-	28.59	28.97	29.57	*	-	1.52	30.28	29.68	29.68	29.22	28.91	28.32
	Roots dry wt. /Total dry wt.) x 100	N.S.	-	-	21.81	21.85	N.S.	-	-	21.45	21.70	21.83	N.S.	-	-	22.39	23.19	22.55	22.20	20.73	20.26
115 days	Plant height (cm)	*	-	3.31	96.79	90.52	**	3.96	2.84	90.15	88.14	86.18	*	-	2.61	94.25	94.33	94.61	95.54	95.78	96.94
	Technical stem length (cm)	*	-	2.21	79.12	76.82	*	-	1.98	80.29	79.41	76.72	*	-	1.56	76.08	77.24	78.58	79.01	80.44	81.38
	Dry weight per plant (gm)	N.S.	-	-	1.77	1.85	N.S.	-	-	1.82	1.82	1.80	*	-	0.15	1.52	1.51	1.43	1.32	1.32	1.31
	No. of capsules per plant	**	6.19	3.71	13.74	21.08	N.S.	-	-	17.25	17.32	17.54	*	-	4.02	21.51	18.93	18.80	18.03	14.79	14.63
	No. of upper branches per plant	*	-	0.45	5.79	6.39	N.S.	-	-	6.78	6.38	6.32	*	-	0.51	6.99	6.69	5.82	5.95	5.31	5.28
	(Stem dry wt./Total dry wt.) x 100	*	-	1.37	51.68	52.31	N.S.	-	-	54.45	54.87	54.15	N.S.	-	-	53.65	54.29	54.71	55.84	56.11	56.34
	Leaves dry wt./Total dry wt.) x 100	*	-	2.81	25.09	28.62	*	-	1.12	26.03	26.92	24.78	*	-	1.33	27.63	27.40	26.66	26.26	26.07	25.91
	Roots dry wt. /Total dry wt.) x 100	N.S.	-	-	17.52	17.45	N.S.	-	-	17.06	17.76	17.63	N.S.	-	-	17.65	17.66	17.67	17.47	17.05	16.61

stages in both seasons, which were 49.21 and 93.21 cm in the first season, and being 46.16 and 90.31 cm, in the second season, respectively. In the second stage the highest values were 63.58 and 60.72 cm in both seasons recorded with the combination of S_1 supplied with Zn and seeded at 2000 seeds/m^2.

The tallest plants in the fourth stage was recorded with S_1 (19/31) plants supplied with Zn and seeded at 1500 seeds/m^2 in both season, with an average of 102.80 and 97.69 cm in 1989/90 and 1990/91 season, respectively.

2. Technical stem length

This character was recorded only at the third and the fourth stages of growth as shown in Tables (4 and 5).

The results indicated that there were significant differences between the two studied strains in technical stem length in both seasons, and S_1 (19/31) was higher than S_2 (2419/1) at the third and fourth stages. Results reported by **Yousef (1968), El-Farouk *et al.*, (1982), El-Kalla and El-Kassaby (1982), Salama (1983 and 1988), El-Kady (1985), Momtaz *et al.*, (1985), Hella *et al.*, (1986), El-Kady *et al.*, (1988), Sorour *et al.*, (1988)** and **Kineber (1991)** showed also marked differences in technical stem length of the different

Table 6. Summary of interaction effects among strains (S), microelements (M) and seeding rates (R) on growth characters of flax plants in 1989/90 season.

No. of days from sowing	Characters	S x M	Highest value	S x R	Highest value	M x R	Highest value	S x M x R	Highest value
55 days	Plant height (cm)	NS (S_1 x Zn)	46.37	NS (S_1 x 2000)	45.40	NS (Zn x 1750)	46.23	NS (S_1 x Zn x 1750)	49.21
	Dry weight per plant (gm)	NS (S_2 x Cu)	0.24	NS (S_2 x 1000)	0.24	NS (Cu x 750)	0.22	NS (S_2 x Cu x 750)	0.25
	(Stem dry wt./Total dry wt.) x 100	NS (S_2 x Zn)	41.12	NS (S_2 x 1250)	40.82	NS (Zn x 1250)	41.58	NS (S_2 x Zn x 1250)	41.76
	Leaves dry wt./Total dry wt.) x 100	NS (S_1 x Cu)	41.22	NS (S_1 x 750)	42.13	NS (Cu x 1000)	41.61	NS (S_1 x Cu x 750)	41.86
	Roots dry wt. /Total dry wt.) x 100	NS (S_2 x Cu)	25.42	NS (S_1 x 750)	26.22	NS (Cu x 750)	23.52	NS (S_2 x Cu x 750)	26.33
75 days	Plant height (cm)	NS (S_1 x Zn)	57.58	NS (S_1 x 2000)	62.25	NS (Zn x 2000)	63.13	NS (S_1 x Zn x 2000)	63.58
	Dry weight per plant (gm)	* (S_2 x Zn)	0.41	NS (S_2 x 750)	0.40	NS (Zn x 750)	0.35	NS (S_2 x Zn x 750)	0.40
	(Stem dry wt./Total dry wt.) x 100	NS (S_2 x Zn)	52.14	NS (S_2 x 1250)	51.88	NS (Zn x 1250)	51.05	NS (S_2 x Zn x 1250)	52.61
	Leaves dry wt./Total dry wt.) x 100	* (S_2 x Cu)	33.59	NS (S_2x 750)	33.36	NS (Cu x 750)	32.52	NS (S_2x Zn x 750)	32.67
	Roots dry wt. /Total dry wt.) x 100	NS (S_1 x Zn)	21.59	NS (S_1 x 1000)	21.71	NS (Zn x 1000)	22.28	NS (S_1 x Cu x 1000)	22.91
95 days	Plant height (cm)	NS (S_1 x Zn)	92.39	NS (S_1 x 1750)	92.53	NS (Zn x 1750)	93.00	NS (S_1 x Zn x 1750)	93.21
	Technical stem length (cm)	NS (S_1 x Zn)	73.79	NS (S_1 x 1500)	73.21	* (Zn x 1500)	75.93	NS (S_1 x Zn x 1500)	73.61
	Dry weight per plant (gm)	NS (S_2 x Cu)	1.20	NS (S_1 x 750)	1.22	NS (Cu x 750)	1.267	NS (S_2 x Cu x 750)	1.27
	(Stem dry wt./Total dry wt.) x 100	NS (S_1 x Zn)	55.10	NS (S_1 x 1250)	54.52	NS (Zn x 1250)	53.71	NS (S_1 x Zn x 1250)	55.42
	Leaves dry wt./Total dry wt.) x 100	NS (S_2 x Cu)	29.39	NS (S_2 x 750)	31.21	NS (Cu x 750)	29.78	NS (S_2 x Cu x 750)	31.37
	Roots dry wt. /Total dry wt.) x 100	NS (S_1 x Cu)	21.45	NS (S_1 x 1000)	20.83	NS (Cu x 1500)	21.33	NS (S_1 x Cu x 1000)	21.69
115 days	Plant height (cm)	NS (S_1 x Zn)	102.05	NS (S_1 x 1500)	102.15	NS (Zn x 1500)	100.25	NS (S_1 x Zn x 1500)	102.80
	Technical stem length (cm)	NS (S_1 x Zn)	82.35	NS (S_1 x 2000)	81.58	* (Zn x 1500)	83.45	NS (S_1 x Zn x 1500)	83.13
	Dry weight per plant (gm)	* (S_2 x Zn)	1.70	NS (S_2 x 750)	1.68	NS (Zn x 750)	1.64	NS (S_2 x Zn x 750)	1.68
	Number of capsules per plant	NS (S_2 x Zn)	23.00	NS (S_2 x 750)	23.83	NS (Zn x 750)	23.90	NS (S_2 x Zn x 750)	23.91
	Number of upper branches per plant	NS (S_2 x Cu)	6.27	NS (S_2 x 750)	6.88	NS (Zn x 750)	6.65	NS (S_2 x Zn x 750)	7.21
	(Stem dry wt./Total dry wt.) x 100	NS (S_1 x Zn)	56.58	NS (S_1 x 1250)	56.36	NS (Zn x 1250)	56.09	NS (S_1 x Zn x 1250)	56.74
	Leaves dry wt./Total dry wt.) x 100	NS (S_2 x Cu)	29.84	NS (S_2 x 750)	30.41	NS (Cu x 750)	28.26	NS (S_2 x Cu x 750)	30.51
	Roots dry wt. /Total dry wt.) x 100	NS (S_1 x untr.)	17.64	* (S_2 x 1000)	18.87	NS (Cu x 1000)	17.56	NS (S_1 x untr x 1000)	17.91

Table 7. Summary of interaction effects among strains (S), microelements (M) and seeding rates (R) on growth characters of flax plants in 1990/91 season.

No. of days from sowing	Characters	S x M	Highest value	S x R	Highest value	M x R	Highest value	S x M x R	Highest value
55 days	Plant height (cm)	NS (S_1 x Zn)	45.26	NS (S_1 x 2000)	42.22	NS (Zn x 1750)	45.66	NS (S_1 x Zn x 1750)	46.16
	Dry weight per plant (gm)	NS (S_2 x Cu)	0.24	NS (S_2 x 1000)	0.20	NS (Cu x 750)	0.19	NS (S_2 x Cu x 750)	0.25
	(Stem dry wt./Total dry wt.) x 100	NS (S_2 x Zn)	42.57	NS (S_2 x 1000)	42.82	NS (Zn x 1000)	42.22	NS (S_2 x Zn x 1000)	43.19
	Leaves dry wt./Total dry wt.) x 100	NS (S_1 x Cu)	34.56	NS (S_1 x 750)	34.12	NS (Cu x 1000)	34.56	NS (S_1 x Cu x 750)	35.36
	Roots dry wt. /Total dry wt.) x 100	NS (S_2 x Cu)	30.13	NS (S_1 x 750)	30.11	NS (Cu x 750)	30.23	NS (S_2 x Cu x 750)	30.71
75 days	Plant height (cm)	NS (S_1 x Zn)	60.18	NS (S_1 x 1000)	60.61	NS (Zn x 1000)	60.53	NS (S_1 x Zn x 1000)	60.72
	Dry weight per plant (gm)	* (S_2 x Zn)	0.33	NS (S_2 x 750)	0.29	NS (Zn x 750)	0.31	NS (S_2 x Zn x 750)	0.31
	(Stem dry wt./Total dry wt.) x 100	NS (S_2 x Zn)	43.18	NS (S_2 x 1000)	41.79	NS (Zn x 1000)	40.19	NS (S_2 x Zn x 1000)	43.81
	Leaves dry wt./Total dry wt.) x 100	* (S_2 x Cu)	33.98	NS (S_2x 750)	33.67	NS (Cu x 750)	33.13	NS (S_2x Cu x 750)	33.89
	Roots dry wt. /Total dry wt.) x 100	NS (S_1 x Zn)	26.99	NS (S_1 x 1000)	27.86	NS (Zn x 1000)	26.43	NS (S_1 x Cu x 1000)	27.93
95 days	Plant height (cm)	NS (S_1 x Zn)	89.96	NS (S_1 x 1750)	88.99	NS (Zn x 1750)	89.96	NS (S_1 x Zn x 1750)	90.31
	Technical stem length (cm)	NS (S_1 x Zn)	72.83	NS (S_1 x 1500)	72.36	* (Zn x 1500)	73.86	NS (S_1 x Zn x 1500)	73.31
	Dry weight per plant (gm)	NS (S_2 x Cu)	1.16	NS (S_1 x 750)	1.11	NS (Cu x 750)	1.15	NS (S_2 x Cu x 750)	1.16
	(Stem dry wt./Total dry wt.) x 100	NS (S_1 x Zn)	51.17	NS (S_1 x 1000)	50.26	NS (Zn x 1000)	49.22	NS (S_1 x Zn x 1000)	52.37
	Leaves dry wt./Total dry wt.) x 100	NS (S_2 x Cu)	29.54	NS (S_2 x 750)	30.24	NS (Cu x 750)	30.57	NS (S_2 x Cu x 750)	30.71
	Roots dry wt. /Total dry wt.) x 100	NS (S_1 x Cu)	22.86	NS (S_1 x 1000)	22.35	NS (Cu x 1500)	25.51	NS (S_1 x Cu x 1000)	22.99
115 days	Plant height (cm)	NS (S_1 x Zn)	93.47	NS (S_1 x 1500)	94.98	NS (Zn x 1500)	92.34	NS (S_1 x Zn x 1500)	97.69
	Technical stem length (cm)	NS (S_1 x Zn)	77.55	NS (S_1 x 2000)	79.25	* (Zn x 1500)	81.65	NS (S_1 x Zn x 1500)	80.94
	Dry weight per plant (gm)	* (S_2 x Zn)	2.00	NS (S_2 x 750)	1.34	NS (Zn x 750)	1.41	NS (S_2 x Zn x 750)	1.53
	Number of capsules per plant	NS (S_2 x Zn)	19.17	NS (S_2 x 750)	21.35	NS (Zn x 750)	18.43	NS (S_2 x Zn x 750)	21.92
	Number of upper branches per plant	NS (S_2 x Cu)	6.28	NS (S_2 x 750)	6.68	NS (Zn x 750)	6.88	NS (S_2 x Zn x 750)	6.99
	(Stem dry wt./Total dry wt.) x 100	NS (S_1 x Zn)	55.57	NS (S_1 x 1000)	55.76	NS (Zn x 1000)	55.35	NS (S_1 x Zn x 1000)	56.63
	Leaves dry wt./Total dry wt.) x 100	NS (S_2 x Cu)	28.72	NS (S_2 x 750)	28.43	NS (Cu x 750)	27.63	NS (S_2 x Cu x 750)	28.91
	Roots dry wt. /Total dry wt.) x 100	NS (S_1 x untr.)	17.53	NS (S_1 x 1000)	17.76	NS (Cu x 1000)	17.65	NS (S_1 x untr x 1000)	17.81

genotypes.

Microelement application significantly affected technical stem length at both third and fourth stages in both seasons. Zinc application significantly increased technical stem length compared with cupper and untreated check. Results reported by **Kadry (1981)** showed that Zn or Cu application had no significant effect on technical stem length. On the other hand, **Bottini (1964)** and **Stetsenko and Chepikov (1970)** found that growth characters of flax were positively affected by Zn and Cu application.

There was an upward trend in technical stem length with increasing plant population, and the differences between treatments reached the significant level comparing the lowest seed rate with the highest one. In other words, differences in technical length were only significant between the two extremes of seed rate. Similar results were also recorded by **El-Hariri (1964)**, **El-Nakhlawy *et al.*, (1978)** and **Hella *et al.*, (1986)**.

Results in Tables (6, 7, 8 and 9) showed that there was no significant effect for all interactions on technical stem length except the interaction between microelements and seeding rates at the third and the fourth stages in both seasons, which had significant effect.

Generally, the highest values were obtained by the combination of plants supplied with zinc and seeded at 1500 seed/m^2, being 75.93 and 83.45 cm at the third and fourth stages, respectively in 1989/90 season. The corresponding values in 1990/91 were 73.86 and 81.65 cm.

3. Dry weight per plant

Means of dry matter accumulation (dry weight per plant) for each of the two strains supplied with three microelement treatments and grown at six seeding rates in 1989/90 and 1990/91 successive seasons are presented in Tables (4 & 5).

Dry weight per plant continued to increase as the plant advanced in age until the last growth stage for the two strains in both seasons.

The results showed that dry weight per plant at all growth stages was not significantly different for the two strains. Results showed that S_2 (2419/1) plants insignificantly outweighed S_1 (19/31) plants at all growth stages.

Many investigators found marked differences in dry weight per plant in different genotypes (**Momtaz *et al.*, 1979b; Nasr El-Din, 1983** and **Zahran *et al.*, 1984**).

Table 8. Effect of interaction between microelements (M) and seeding rates (R) on technical stem length (cm) after 95 days from sowing in 1989/90 and 1990/91 seasons.

Seeding rates (seeds/m²)	Microelement treatments							
	Zn	Cu	Control	Mean	Zn	Cu	Control	Mean
	1989/90				1990/91			
750	74.19	74.79	70.38	73.12	71.93	71.78	70.01	71.24
1000	74.83	73.72	70.90	73.15	72.70	71.89	70.21	71.60
1250	74.91	73.73	70.96	73.20	72.87	71.91	70.41	71.73
1500	75.93	73.92	72.15	74.00	73.86	72.03	70.99	72.11
1750	75.31	74.08	73.03	74.14	72.76	72.98	71.19	72.31
2000	75.30	74.63	75..22	75.05	72.86	73.61	72.95	73.14
Mean	74.98	74.21	72.14		72.83	72.37	70.96	
L.S.D. (0.05 level) M x R =				1.89				1.91

Table 9. Effect of interaction between microelements (M) and seeding rates (R) on technical stem length (cm) after 115 days from sowing in 1989/90 and 1990/91 seasons.

Seeding rates (seeds/m²)	Microelement treatments							
	Zn	Cu	Control	Mean	Zn	Cu	Control	Mean
	1989/90				1990/91			
750	79.79	79.25	78.62	79.22	77.13	76.50	74.61	76.08
1000	79.81	79.39	78.09	79.29	78.92	78.09	74.81	77.24
1250	79.91	79.97	78.14	79.34	80.82	79.80	75.12	78.58
1500	83.45	80.14	78.71	82.22	81.65	79.71	75.87	79.07
1750	83.26	82.91	81.60	88.59	81.63	80.87	78.92	80.44
2000	83.19	83.29	82.56	82.98	81.64	81.51	80.99	81.38
Mean	81.57	80.83	79.62		80.29	79.41	76.72	
L.S.D. (0.05 level) M x R =				1.59				1.55

Microelement application failed to exert any significant effect on dry weight at all growth stages in both seasons, at the same time, microelement application insignificantly increased dry weight per plant compared with untreated plants. This result may be due to the improvement in plant growth due to micronutrients, (**Stetsenko and Chepikov, 1970**).

There was a downward trend in dry weight per plant with increasing plant population. The differences were significant at all stages of growth throughout the two seasons. The reduction in dry weight per plant at higher plant densities may be due to the competition among plants to obtain their requirements from water, light and nutrients.

These results were in harmony with those mentioned by **El-Hariri (1964)**; **Obeid *et al.*, (1967)**; **Momtaz *et al.*, (1982)**; **Nasr El-Din (1983)** and **Hella (1983)**.

Results in Tables (6, 7, 10 and 11) showed that the interaction between strains and microelements had significant effect on dry weight per plant at the second and fourth stages in both seasons. The highest values were 0.414 and 1.695 gm at the second and fourth stage, respectively in 1989/90 season, and were produced by the combination of S_2 supplied with zinc. Corresponding values were 0.331 and 1.998 gm in 1990/91 season and were obtained by the same combinations. All other interactions did not significantly affect this character.

4. Percentage of stem dry weight to total dry weight per plant

Data in Table (4 and 5) indicated that percentage of stem dry matter to total dry weight per plant continued to increase as the plant advanced in age until the fourth stage at 115 days after sowing throughout the two growing seasons.

There were no significant differences between the two strains in this character at the second and third stages while at the first and fourth stages the difference was significant in both seasons. S_2(2419/1) strain showed higher percentage of stem weight compared with S_1 (19/31) at the first and fourth stages. Opposite trend was observed where S_1 (19/31) recorded higher percentage of stem dry weight at the second and third stages in both seasons. Results obtained by **Momtaz *et al.*, (1979b), Hella (1983)** and **Nasr El-Din (1983)** showed marked differences in different plant organ percentages to total plant dry weight.

It is also evident that no significant effect was detected due to microelement application on percentage of stems to total dry weight at all growth ages in both

Table 10. Effect of the interaction between strains (S) and microelements (M) on dry weight per plant (gm) after 75 days from sowing in 1989/90 and 1990/91 seasons.

Microelement treatments	Dry weight per plant (gm) after 75 days					
	S_1	S_2	Mean	S_1	S_2	Mean
	1989/90			1990/91		
Zn	0.228	0.414	0.321	0.207	0.331	0.269
Cu	0.313	0.321	0.317	0.243	0.283	0.263
Control	0.297	0.325	0.311	0.247	0.271	0.259
Mean	0.279	0.353		0.232	0.295	
L.S.D. (0.05 level) for S x M			0.01			0.02

Table 11. Effect of the interaction between strains (S) and microelements (M) on dry weight per plant (gm) after 115 days from sowing in 1989/90 and 1990/91 seasons.

Microelement treatments	Dry weight per plant (gm) after 115 days					
	S_1	S_2	Mean	S_1	S_2	Mean
	1989/90			1990/91		
Zn	1.315	1.695	1.505	1.644	1.998	1.821
Cu	1.400	1.524	1.462	1.849	1.781	1.815
Control	1.387	1.429	1.408	1.820	1.772	1.796
Mean	1.367	1.549		1.771	1.850	
L.S.D. (0.05 level) for S x M			0.29			0.17

seasons, except at the first stage (55 days after planting). Zinc application significantly increased stem weight percentage compared with Cu and untreated plants. Other investigators, however, showed that application of Zn or Cu favourably affected flax growth (**Bottini, 1964; Stetsenko and Chepikov, 1970** and **Abo-El-Soad *et al.*, 1975**).

With regard to effect of seeding rates on stem percentage, results indicated that there were insignificant differences in both seasons except at the first growth stage. It was observed that the percentage of stems increased as the seeding rate increased. This increase might be due to the decrease in number of upper branches at higher plant densities. These results were in harmony with those obtained by **Momtaz et al., (1982); Nasr El-Din (1983)**, on flax in Egypt.

Data in Tables (6 and 7), showed that no significant differences were obtained in percentage of stem to total dry weight per plant as affected by the interaction between treatments under study at all sampling dates in both seasons. Such result indicates that each experimental factor acted independently in affecting this character.

Generally, at the first and second stages, the combination of S_2(2419/1) supplied with zinc and seeded at 1250 seeds/m² produced the highest values in stem percentage which recorded 41.76 and 52.61%, respectively, while the combination of S_1 (19/31) supplied with Zn and seeded at the same seed rate produced the highest values being 55.42 and 56.74% at the third and fourth stage, respectively in 1989/90 season. The corresponding values in 1990/91 season were 43.19, 43.81% in the first and the second growth stages, respectively, which were obtained by the combination of S_2 (2419/1) supplied with Zn and seeded at 1000 seeds/m². While the combination of S_1 (19/31) supplied with Zn and seeded at the same seed rate produced the highest values of dry stem percentage being 52.37 and 56.63% at the third and fourth stage, respectively.

5. Percentage of leaves dry weight to total dry weight per plant

The present results in Tables (4 and 5) indicated that leaves dry weight percentage to total plant weight gradually decreased as the plant advanced in age till the last sampling date in both seasons. The differences in leaves dry weight percentage between strains were not significant with the exception of the fourth sampling date at 115 days from planting in 1990/91 season. S_2 (2419/1) was higher than S_1 (19/31) in leaves dry weight percentage at the fourth stage. This increase might be due to the increase in number of upper branches at the end of growing season. Many investigators found marked differences in number of upper branches among different flax strains (**El-Farouk *et al.*, 1982; El-Kalla and El-Kassaby, 1982; Salama, 1983; Momtaz *et al.*, 1989 and Kineber, 1991**).

There were significant differences in leaves dry weight percentage due to microelement application at the first and the fourth sampling dates after 55 and 115 days from sowing in both seasons. Data indicated that the effect of Cu surpassed Zn and check treatment in increasing leaves dry weight percentage at the first stages, whereas at the fourth stage Cu as well as Zn were superior to the control treatment in their effect on this trait. The favourable effect of Cu and Zn may be due to their effect on the synthesis of chlorophyll material in treated plants (**Bottini, 1964;** and **Stetsenko and Chepikov, 1970**).

With regard to seeding rate effect on leaves percentage it could be noticed that this effect was significant at all growth stages in both seasons.

Percentage of leaves increased with decreasing seeding rate at all sampling dates in both seasons. Such trend is mainly due to the increase in stems dry weight percentage with the increase in seeding rate, consequently leaves percentage should follow an opposite trend. Also, higher plant population could lead to the reduction of dry matter in leaf portion as a result of natural defoliation of leaves formed under shading conditions. These results agree with those reported by **Momtaz *et al.*, (1982)** and **Nasr El-Din (1983)**.

There was no significant effect of the interactions between the experimental factors on leaves percentage except the interaction between strains and microelement at the second stage (75 days from sowing) in both seasons. From Tables (6, 7 and 12), it is evident that the highest values of leaves percentage were obtained by the combination of S_2 (2419/1) supplied with cupper, being 33.59 and 34.98% in the first and second season, respectively.

6. Percentage of roots dry weight to total dry weight per plant

Tables (4 and 5) indicated that percentage of roots dry weight to total dry weight per plant gradually decreased as the plants advanced in age.

Roots percentage of both strains did not significantly differ at al sampling dates in both seasons.

Microelements had no significant effect on roots dry weight percentage at all sampling dates as well as in both seasons.

Table 12. Effect of the interaction between strains (S) and microelements (M) on leaves dry weight to total dry weight percentage after 75 days from sowing in 1989/90 and 1990/91 seasons.

Microelement treatments	leaves dry weight to total dry weight percentage after 75 days					
	S_1	S_2	Mean	S_1	S_2	Mean
	1989/90			1990/91		
Zn	30.21	32.09	31.15	30.50	33.79	32.14
Cu	30.23	33.59	31.91	32.40	33.98	33.19
Control	30.30	33.28	31.79	31.60	33.82	32.71
Mean	30.25	32.99		31.50	33.86	
L.S.D. (0.05 level) for S x M			2.09			2.19

Table 13. Effect of the interaction between strains (S) and seeding rates (R) on roots dry weight to total dry weight percentage after 115 days from sowing in 1989/90 season.

Seeding rates (seeds/m²)	Strains		Mean
	S_1	S_2	
750	17.94	18.12	18.03
1000	18.75	18.87	18.81
1250	17.95	17.89	17.92
1500	17.49	17.61	17.55
1750	17.05	17.53	17.29
2000	17.13	17.21	17.17
Mean	17.72	17.87	
L.S.D. (0.05 level) for S x R		1.87	

Concerning effect of seeding rate on roots dry weight percentage data indicated that there was a significant effect on this trait only at the first stage (55 days from sowing) in both seasons.

It was evident that a gradual and consistent decrease in roots dry weight percentage was recorded with the increase in seeding rate at this stage.

There was no significant effect of the interactions between the experimental factors on the roots dry weight percentage, at all growth stages in both seasons with one exception of strain and seeding rate interaction at the fourth stage in 1989/90 season (Tables 6, 7 and 13).

Results in Tables (13) showed that S_2 (2419/1) strain seeded at 1000 seeds/m^2 produced the highest value being 18.87%, in 1989/1990 season.

7. Number of capsules per plant

This character was recorded on the last sample (115 days from planting) in both seasons.

Means of number of capsules per plant are presented in Tables (4 and 5) for the first and second season, respectively. Result indicated that in 1989/90 season number of capsules per plant was slightly higher than in 1990/91.

Data showed that highly significant differences were observed due to the effect of strains. S_2 (2419/1) surpassed S_1 (19/31) in number of capsules per plant in both seasons. The significant effect of strains on this character may be due to the different branching behaviour of the two strains.

Results reported by **El-Farouk *et al.*, (1982), Momtaz *et al.*, (1989)** and **Kineber (1991)** showed also marked differences in number of capsules per plant of the different genotypes.

The effect of microelement application on the number of capsules per plant was not significant in both seasons.

Reducing population density by means of seeding lower rates increased significantly number of capsules per plant in both seasons. The increase of capsules number per plant with decreasing seeding rate may due to the increase of number of basal and upper branches per plant as the plant population density decreased. These findings are in agreement with those obtained by **Momtaz *et al.*, (1979b)** and **Hella (1983)**.

The interaction effects of the experimental factors were not significant in both seasons as shown in Tables (6 and 7).

Generally, the highest values of this trait were obtained by the combination of S_2 (2419/1) supplied with zinc application and seeded at 750 seeds/m², being 23.91 and 21.92 capsules per plant in the first and second season, respectively.

8. Number of upper branches per plant

Results recorded in Tables (4 and 5) indicated that branches started to appear at the fourth age at 115 days after planting.

S_2 (2419/1) had significantly higher number of branches per plant than S_1 (19/31) in both seasons. This result may be due to the different branching behaviour of the different genotypes and is in harmony with those obtained by **Spratt *et al.*, (1963),; El-Farouk *et al.*, (1982), El-Ganayni *et al.*, (1985)** and **Salama (1988).**

No significant differences were obtained in number of upper branches per plant due to microelement application in both seasons. Zinc and Cupper insignificantly increased the number of upper branches per plant compared with check treatment. These results agree with those obtained by **Abo El-Soad *et al.*, (1975)** and **Mourad *et al.*, (1987).**

Increasing seeding rate significantly reduced upper branches number in both seasons due to the severe competition at dense planting. These results are in agreement with those obtained by **El-Hariri (1968), Gubels (1978)** and **El-Ganayni** ***et al.*****, (1985)**.

All interactions between the experimental factors had no significant effect on number of upper branches in both seasons as shown in Tables (6 and 7). Generally, the highest values were obtained by the combination of S_2 (2419/1) supplied with zinc and seeded at 750 seeds/m², being 7.21 and 6.99 branches per plant in 1989/90 and 1990/91 seasons, respectively.

B. Yield and yield components

1. Straw yield and its related characters.

Tables (14 and 15) illustrated the straw yield and its components for the two flax strains supplied with three microelement treatments and sown under six seeding rates in 1989/90 and 1990/91 seasons.

1. Technical stem length

Means of technical stem length in flax in the two successive seasons as affected by strains, microelement treatments and plant density are shown in Tables (14 and 15).

Results indicated that there was a significant difference between the two flax strains under study in

Table 15. Effect of strains (S), microelements (M) and seeding rates (R) on straw yield and its components of flax in 1990/91 seasons.

Characters	Strains					Microelements						Seeding rates								
	Sig	L.S.D. 1%	L.S.D. 5%	S1 19/31	S2 2419/1	Sig.	L.S.D. 1%	L.S.D. 5%	M1 Zn	M2 Cu	M3 Control	Sig.	L.S.D. 1%	L.S.D. 5%	R1	R2	R3	R4	R5	R6
Technical stem length (cm).	*	-	3.32	81.22	75.86	NS	-	-	81.49	79.78	78.66	**	5.64	4.23	79.19	80.73	81.21	82.92	85.33	86.88
Length of top capsule zone (cm).	*	-	4.66	14.61	19.44	NS	-	-	16.12	15.30	15.65	*	-	2.06	16.89	18.78	17.71	16.29	15.02	14.46
Stem diameter (mm)	*	-	0.11	2.29	2.42	NS	-	-	2.35	2.28	2.28	**	0.22	0.13	2.44	2.47	2.41	2.39	2.28	2.13
Number of basal branches per plant	*	-	0.20	1.39	1.12	NS	-	-	1.89	1.86	1.78	*	-	0.19	1.49	1.32	1.27	1.16	1.12	1.06
Straw yield per plant (gm).	*	-	0.18	2.18	2.00	NS	-	-	2.16	2.13	1.99	*	-	0.20	2.26	2.17	2.08	2.05	2.00	1.98
Straw yield per feddan (ton).	*	-	0.31	3.29	2.89	NS	-	-	3.32	3.30	3.29	*	-	0.21	2.97	3.04	3.22	3.39	3.46	3.49

increase in technical stem length of 11.1 and 8.9% in the first and second season, respectively. These results are in harmony with those obtained by **El-Hariri (1968), Nasr El-Din (1983), El-Haroun and Shaaban (1984), Hella *et al.*, (1986), Zeidan (1989)** and **Khalil (1990)**.

Data in Tables (16 and 17) showed that all interactions, i.e. strains x microelements, strains x seeding rate and strain x microelements x seeding rate, had no significant effect on technical stem length in both seasons. Generally, the highest technical length in 1989/90 season was 89.75 cm obtained by S_1 (19/31) treated with zinc and seeded at 2000 seeds/m², while in 1990/91 season it was 85.43 cm produced by S_1 (19/31), untreated with microelements and sown at 2000 seeds/m².

2. Length of top capsule zone

Means of length of top capsule zone in the two successive seasons as affected by strains, microelements and seeding rates are presented in Tables (14 and 15).

Statistical analysis revealed that there was a significant difference between the two strains under study. S_2 (2419/1) recorded higher mean values (20.71 and 19.44 cm) while S_1 (19/31) produced lower mean values (16.22 and 14.61 cm) in the first and the second season, respectively. The present results are in agreement with those obtained by **El-Farouk *et al.*, (1982)**, **El-Kady (1985)** and **Salama (1988)**.

Results indicated that there were no significant differences among the mean length of top capsule zone as affected by the microelements in both seasons. Zinc gave the highest values being 18.51 and 16.12 cm in the first and second season, respectively compared with cupper and untreated check. Similar result was obtained by **Nasr El-Din (1983)**. On the other hand, **El-Shimy *et al.*, (1986)** and **Mourad *et al.*, (1987)** recorded significant increase in this character by foliar spray with zinc.

With respect to seeding rate, data showed significant differences in the length of top capsule zone as affected by seeding rate. The lowest density (750 seeds/m^2) produced the highest values (19.98 and 16.89 cm) while the minimum values of this character (16.98 and 14.46 cm) were obtained from sowing at 2000 seeds/m^2.

Generally, there was a gradual reduction in this character with increasing plant density. This finding is in agreement with those obtained by **El-Ganayni *et al.*, (1985)**, **Hassan and El-Farouk (1987)** and **Zeidan (1989)**.

Table 16. Summary of interaction effects among strains (S), microelements (M) and seeding rates (R) on straw yield and its components of flax in 1989/90 season.

Characters	S x M	Highest value	S x R	Highest value	M x R	Highest value	S x M x R	Highest value
Technical stem length (cm)	NS (S_1 x Zn)	87.65	NS (S_1 x 2000)	86.40	NS (Zn x 1500)	86.01	NS (S_1 x Zn x 2000)	89.75
Length of top capsules zone (cm)	NS (S_2 x untr.)	20.39	NS (S_2 x 1250)	20.77	NS (Zn x 1000)	20.66	NS (S_2 x Zn x 1000)	20.78
Stem diameter (mm)	NS (S_2 x untr.)	2.45	NS (S_2 x 750)	2.57	NS (Untr. x 750)	2.58	NS (S_2 x Untr. x 750)	2.56
No. of basal branches per plant	NS (S_1 x Zn)	2.21	NS (S_1 x 750)	2.29	NS (Zn x 750)	2.28	NS (S_1 x Zn x 750)	2.24
Straw yield per plant (gm)	NS (S_1 x Zn)	2.34	NS (S_1 x 1250)	2.24	NS (Zn x 750)	2.47	NS (S_1x Zn x 750)	2.50
Straw yield per feddan (ton)	NS (S_1 x Zn)	3.53	NS (S_1 x 1500)	3.82	NS (Zn x 1500)	3.59	NS (S_1 x Zn x 1500)	3.57

Table 17. Summary of interaction effects among strains (S), microelements (M) and seeding rates (R) on straw yield and its components of flax in 1990/91 season.

Characters	S x M	Highest value	S x R	Highest value	M x R	Highest value	S x M x R	Highest value
Technical stem length (cm)	NS (S_1 x Zn)	84.40	NS (S_1 x 2000)	84.28	NS (Untr x 1750)	83.30	NS (S_1 x Untr x 2000)	85.43
Length of top capsules zone (cm)	NS (S_2 x untr.)	18.53	NS (S_2 x 1750)	18.44	NS (Untr x 1500)	18.48	NS (S_2 x Untr x 1750)	18.85
Stem diameter (mm)	NS (S_2 x Untr.)	2.41	NS (S_2 x 1250)	2.46	NS (Untr. x 750)	2.50	NS (S_2 x Untr. x 1000)	2.43
No. of basal branches per plant	NS (S_1 x Zn)	1.41	NS (S_1 x 750)	1.59	NS (Zn x 1000)	1.51	NS (S_1 x Zn x 1000)	1.48
Straw yield per plant (gm)	NS (S_1 x Untr)	2.21	NS (S_1 x 750)	2.29	NS (Zn x 750)	2.23	* (S_1 x Zn x 1250)	2.35
Straw yield per feddan (ton)	NS (S_1 x Zn)	3.21	NS (S_1 x 1500)	3.198	NS (Zn x 1750)	3.28	NS (S_1 x Zn x 1750)	3.35

Data in Tables (16 and 17) indicated that all interaction effects, i.e., strains x microelements, strains x seeding rates, microelement x seeding rates and the second order interaction, strains x microelements x seeding rates) were not significant on this trait. In general, the highest value (20.78 and 18.85 cm in 1989/90 and 1990/91, respectively) was obtained by S_2 (2419/1) sprayed with zinc and seeded at 1000 seeds/m² in 1989/90 and by untrated plant seeded at 1750 seeds/m² in 1990/91 season.

3. Stem diameter

Averages of stem diameter of flax x plants in the two successive seasons as affected by strains, microelements and seeding rates are presented in Tables (14 and 15).

Results showed significant differences between the two strains concerning stem diameter. S_2 (2419/1) gave higher values in the two seasons (2.46 and 2.42 mm) than S_1 (19/31) which gave the lowest measurement being 2.33 and 2.29 mm in the first and second seasons, respectively. The above mentioned results are in harmony with those obtained by **El-Farouk *et al.*, (1982)**, **El-Kady (1985)**, **Hella *et al.*, (1986)** and **Salama (1988)**.

stem diameter in the first season was 2.56 mm recorded with S_2 (2419/1) untreated with microelements and sown under 750 seeds/m², whereas in the second season the highest value was 2.43 mm produced by untreated S_2 (2419/1) plants seeded at 1000 seeds/m².

4. Number of basal branches per plant

Mean values of basal branches per plant recorded in Tables 14 and 15 indicated that there was a significant difference between the two strains under study, where S_1 (19/31) produced higher number of basal branches per plant (2.01 and 1.39) than the other strain S_2 (2419/1) which recorded 1.75 and 1.12 basal branches per plant in the first and second season, respectively. The present results are in harmony with those obtained by **Salama (1988)** who reported marked differences between flax strains in this character.

Regarding microelement application, zinc and cupper insignificantly increased the number of basal branches per plant compared with untreated check. The favourable effect of microelement may be due to the accelerationg of cell division and to improvement of growth in treated plants, (**Stetsenko and Chepikov, 1970**).

Seeding rate effects on this trait were significant. Results showed gradual reduction in number of basal branches per plant when plant density increased from 750 to 2000 seeds/m² in the two successive seasons. This means that the narrow distance between plants resulted in fewer number of basal branches per plant, as a result of increase in competition between plants. The present results are in agreement with those obtained by **Salama (1988)** and **Zeidan (1989)**.

Data presented in Tables (16 and 17) showed that all interaction combinations between the experimental factors had no significant effect on number of basal branches per plant in both seasons. In general, the highest value of this trait was recorded with S_1 (19/31) plants supplied with Zn sown at 750 seeds/m² in 1989/90 season, being 2.24 basal branches per plant, whereas in 1990/91 season, basal branches number per plant reached a maximum value of 1.48 resulting from S_1 (19/31) plants supplied with zinc and seeded at 1000 seeds/m².

5. Straw yield per plant

Average of straw yield per plant in the two successive seasons as affected by strains, microelements and seeding rates indicated that there was a significant difference between the two strains in straw yield per plant, (Tables 14 & 15). Plants of S_1 (19/31) were higher in mean values, being 2.32 and 2.18

gm in the first and second season, respectively as against 2.25 and 2.00 gm for S_2 (2419/1). Many investigators found marked differences in straw yield per plant among different flax strains (**Salama, 1988; Sorour *et al.*, 1988; Hella *et al.*, 1989; El-Gazzar, 1990** and **Kineber, 1991**).

The superiority of S_1 over S_2 in straw yield per plant is mainly due to the its superiority in technical stem length and basal branches numbers per plant.

The effect of spraying plants with the two microelements on straw yield per plant was insignificant in both season. The two microelements insignificantly increased this trait compared with untreated check. Results reported by **Kadry (1976 and 1981)** and **Nasr El-Din (1983)** showed that Zn or Cu application had no significant effect on straw yield per plant. On the other hand, these results disagreed with those reported by **Bottini (1964), Stetsenko and Chepikov (1970), Porokhnevich and Bykov (1972), Abo El-Soad *et al.*, (1975), El-Shimy *et al.*, (1986)** and **Mourad *et al.*, (1987)**.

Results showed that there was a gradual decrease in straw yield per plant with increasing plant density. There were significant differences between 750 seeds/m^2 which produced the highest value of straw yield per plant and the rates of 1500, 1750 and 2000 seeds/m². Growing 2000 seeds/m² produced the lowest value of straw yield per plant. These results are in agreement with those obtained by **Hella *et al.*, (1986), Hassan and El-Farouk (1987), Salama (1988)** and **Zeidan (1989)**. The present result is mainly due to the increase in competition among growing plants at dense population, which decreased length of top capsule zone, stem diameter and number of basal branches per plant. Consequently, straw yield per plant is markedly reduced with the increase in population density.

The interaction effects on this character were not significant with all combinations, i.e., strains x microelements, strains x seeding rates, microelements x seeding rate, with an exception of the three factors interaction which showed a significant effect in both seasons (Tables, 16, 17, 18 and 19).

Results in Tables (18 and 19) show that the highest straw yield per plant in 1989/90 was 2.50 gm recorded with S_1 (19/31) supplied with Zn and seeded at 750 seeds/m², while in 1990/91 season the highest value was 2.35 gm resulting from S_1 supplied with Zn and seeded at 1250 seeds/m².

Table 18. Effect of the second order interaction on straw yield per plant (gm) in 1989/90 season.

Strain	Microelement treatments	Seeding rates (seeds/m²)						Mean
		750	1000	1250	1500	1750	2000	
S_1	Zn	2.50	2.46	2.41	2.26	2.23	2.20	2.34
	Cu	2.49	2.45	2.40	2.25	2.22	2.19	2.33
	Control	2.45	2.38	2.24	2.22	2.21	2.18	2.28
Mean		2.48	2.43	2.35	2.24	2.22	2.19	2.32
S_2	Zn	2.43	2.40	2.36	2.30	2.27	2.23	2.33
	Cu	2.41	2.38	2.35	2.29	2.26	2.23	2.32
	Control	2.30	2.27	2.22	2.19	2.07	1.57	2.10
Mean		2.38	2.35	2.31	2.26	2.20	2.01	2.25
Over all means	Zn	2.47	2.43	2.39	2.28	2.25	2.22	2.34
of microelements	Cu	2.45	2.42	2.38	2.27	2.24	2.21	2.33
	Control	2.38	2.33	2.23	2.21	2.14	1.88	2.20
Over all mean of seeding rate		2.43	2.39	2.33	2.26	2.22	2.20	

L.S.D. at 0.05 level for

S x M = NS
S x R = NS
M x R = NS
S x M x R = 0.25

Table 19. Effect of the second order interaction on straw yield per plant (gm) in 1990/91 season.

Strain	Microelement treatments	Seeding rates (seeds/m²) 750	1000	1250	1500	1750	2000	Mean
S_1	Zn	2.35	2.21	2.24	2.20	2.17	2.15	2.21
	Cu	2.25	2.20	2.22	2.17	2.15	2.13	2.19
	Control	2.27	2.13	2.20	2.17	2.04	2.05	2.14
Mean		2.29	2.18	2.2	2.18	2.12	2.11	2.18
S_2	Zn	2.25	2.19	2.13	2.07	1.99	1.96	2.10
	Cu	2.24	2.18	2.11	1.97	1.94	1.92	2.06
	Control	2.20	2.11	1.58	1.72	1.71	1.67	1.83
Mean		2.23	2.16	1.94	1.92	1.88	1.85	2.00
Over all means of microelements	Zn	2.28	2.20	2.19	2.14	2.08	2.06	2.16
	Cu	2.27	2.19	2.17	2.07	2.05	2.03	2.13
	Control	2.24	2.12	1.89	1.95	1.88	1.86	1.99
Over all mean of seeding rate		2.26	2.17	2.08	2.05	2.00	1.98	

L.S.D. at 0.05 level for

S x M = NS
S x R = NS
M x R = NS
S x M x R = 0.30

6. Straw yield per feddan

Means of straw yield in tons per feddan in the two successive seasons for each of the two strains supplied with microelements and seeded with six seeding rates are recorded in Tables (14 and 15).

Data showed that there was a significant difference between the two strains. S_1 (19/31) significantly outyielded S_2 (2419/1) in both seasons with regard to straw yield per feddan. The differences reached 0.15 and 0.40 t/fed., being 4.2 and 12.2% in the first and second season, respectively.

The superiority of S_1 over S_2 in this trait is mainly due to its higher technical stem length, number of basal branches per plant and straw yield per plant. Consequently, straw yield per feddan is markedly increased. The present results are mainly due to the differences in flax genetical make up of the tested strains and are in agreement with those obtained by **Nazif (1958)**, **Momtaz *et al.*, (1985)**, **El-Kady *et al.*, (1988)**, **Salama (1988)**, **Hella *et al.*, (1989)**, **Momtaz *et al.*, (1989)** and **Kineber, (1991)**.

With regard to foliar spraying with microelements, the results indicated that there were insignificant increases due to supplying plants with zinc and cupper.

Zn and Cu application increased straw yield per feddan by 0.03 and 0.02 tons compared with untreated plants in 1989/90 season, respectively. The corresponding increases in 1990/91 season were 0.03 and 0.01 ton per feddan. These results are in agreement with those obtained by **Stetsenko and Chepikov (1970), Abo El-Soad *et al.*, (1975), Kadry (1981), Nasr El-Din (1983)** and **Mourad *et al.*, (1987)**. On the other hand, **El-Shimy *et al.*, (1986)** found that Zn significantly increased straw yield. The results of technical stem length and straw yield per plant followed the same pattern of response as that of straw yield per feddan. Since the straw yield per feddan depends upon straw yield per plant x number of plants per unit area. The favourable effect of microelements on the straw yield per feddan is mainly due to the increase in straw yield components i.e., technical stem length , number of basal branches per plant and straw yield per plant.

Data recorded in Table (14 and 15) indicated that there were significant differences among the six plant population densities in both seasons. The straw yield per feddan increased as seeding rate increased up to 2000 seeds/m^2.

The significant differences were only between the lowest rate of 750 seeds/m^2 (R1 treatment) and the rates of 1250, 1500, 1750 and 2000 seeds/m^2. The increase in seed rate from 750 to 1000, 1250, 1500, 1750 and 2000 seeds/m^2 increased straw yield per feddan by 3.5, 12.9, 15.4, 18.2 and 18.9%, respectively in 1989/90 season. The corresponding increases were 2.4, 8.4, 14.1, 16.5 and 17.5% in 1990/91 season.

Moreover, the differences between the higher seed rates of 1500m 1750 and 2000 seeds/m² (R4, R5 and R6 treatments) did not reach the level of significance in the two seasons. Similar conclusions were obtained by **El-Hariri, (1968), Sin *et al.*, (1975), Momtaz *et al.*, (1982), Zahran *et al.*, (1984), Balass *et al.*, (1986), Hella *et al.*, (1986), Salama (1988)** and **Khalil (1990)**.

Straw yield per feddan depends upon its components and is the result of number of plants per feddan x straw yield per plant. As the number of plants per unit was decreased, straw yield per plant increased, but the increase resulting from straw yield per plant is smaller than the decrease resulting from the reduction in number of plants per unit area. Also, with regard to growth character it could be observed that the reduction in dry matter per plant with increased seeding rate was not great enough to counteract the increase in number of plants per unit area. This explains why the straw yield per feddan increased with the increase in number of plants per unit area but not with the increase of stem percentages recorded with low plant population.

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Table 20. Effect of the interaction between strains (S) and seeding rates (R) on straw yield per feddan (t) in 1989/90 season.

Seeding rates (seeds/m²)	Strains		Mean
	S_1	S_2	
750	3.25	3.11	3.18
1000	3.36	3.22	3.29
1250	3.68	3.50	3.59
1500	3.82	3.52	3.67
1750	3.81	3.71	3.76
2000	3.80	3.76	3.78
Mean	3.62	3.47	
L.S.D. (0.05 level) for S x R		0.18	

Statistical analysis showed that all interaction combinations did not significantly affect straw yield per feddan, except that between strains x seeding rates which were significant in 1989/90 season at 5% level only, (Table 16, 17 and 20). The highest straw yield per feddan in 1989/90 (3.82 tons) was produced by S_1 (19/31) planted with 1500 seeds/m^2.

Generally, the combination of S_1 supplied with Zn and seeded at 1500 seeds/m^2 produced the highest straw yield in 1989/90 season, being 3.57 ton per feddan. The corresponding value in 1990/91 season was 3.35 ton/feddan resulting from S_1 (19/13) supplied with Zn and sown at 1750 seeds/m^2.

II. Seed yield and its related characters

Mean values of seed yield and its components in the two successive seasons as affected by the two strains, supplied with three microelement treatments and seeded at six seeding rates are presented in Tables (21 and 22).

1. Number of capsules per plant

Results indicated that there was a significant difference between the two strains in both seasons.

S_2 (2419/1) had higher mean values (14.96 and 12.02) which significantly surpassed S_1 (19/31) by

5.75% and 11.89% in 1989/90 and 1990/91 season, respectively. In this connection, **Spratt *et al.*, (1963)**, **Kumar and Singh (1967)**, **Salama (1983)**, **El Kady (1985)**, **Momtaz *et al.*, (1985)**, **Salama (1988)**, **Sorour *et al.*, (1988)**, **Hella *et al.*, (1989)** and **Kineber (1991)** found also marked differences among flax strains in this character.

As for microelements application, data showed significant differences in both seasons. Zinc and cupper application significantly increased number of capsules per plant by 18.57 and 14.97% in 1989/90 season while in 1990/91 season, it was increased by 7.90 and 2.87% over the untreated check. Results reported by **Abo El-Soad *et al.*, (1975)** and **Mourad *et al.*, (1987)** indicated that zinc application increased number of capsules in flax plant. On the other hand, **Sorour *et al.*, (1984)** obtained insignificant effect for zinc application on this trait.

There was a gradual reduction in the number of capsules per plant with increasing plant population density. The differences were found to be significant in both seasons. The highest values were 15.99 and 10.98 in the first and second season, respectively which were obtained by the lowest rate (750 seeds/m^2), whereas the highest density (2000 seeds/m^2) gave the

Table 21. Effect of strains (S), microelements (M) and seeding rates (R) on seed yield and its components of flax in 1989/90 seasons.

Characters	Strains					Microelements						Seeding rates								
	Sig	L.S.D. 1%	L.S.D. 5%	S1 19/31	S2 2419/1	Sig.	L.S.D. 1%	L.S.D. 5%	M1 Zn	M2 Cu	M3 Control	Sig.	L.S.D. 1%	L.S.D. 5%	R1	R2	R3	R4	R5	R6
Number of capsules per plant	*	-	0.61	14.10	14.96	*	-	1.03	15.77	15.10	12.84	**	1.95	0.89	15.99	14.97	14.69	13.94	13.87	13.72
Number of seeds per capsule	*	-	0.93	4.56	5.71	NS	-	-	4.92	5.03	5.74	*	-	0.92	5.71	5.75	5.58	5.10	4.39	4.20
Number of seeds per plant	*	-	8.99	64.23	85.45	NS	-	-	77.66	75.97	70.90	**	11.76	7.01	91.36	86.15	81.92	71.09	60.95	57.63
Number of upper branches per plant	*	-	1.01	21.59	23.30	*	-	1.96	23.34	22.98	21.02	**	4.13	2.93	25.09	23.67	23.18	21.78	21.50	19.45
Seed yield per plant (gm).	**	0.14	0.09	0.61	0.76	NS	-	-	0.69	0.70	0.66	*	-	0.15	0.78	0.75	0.71	0.69	0.65	0.60
Seed yield per feddan (kg/fed.).	**	14.33	11.07	660.83	676.90	NS	-	-	681.95	679.79	676.15	**	15.22	11.66	632.13	663.42	679.14	683.08	689.50	689.78
Seed index (1000-seed weight, gm)	**	1.21	0.46	8.51	10.24	NS	-	-	9.48	9.45	9.39	NS	-	-	9.58	9.45	9.47	9.43	9.41	9.36

Table 22. Effect of strains (S), microelements (M) and seeding rates (R) on seed yield and its components of flax in 1990/91 seasons.

Characters	Strains					Microelements						Seeding rates								
	Sig	L.S.D. 1%	L.S.D. 5%	S1 19/31	S2 2419/1	Sig.	L.S.D. 1%	L.S.D. 5%	M1 Zn	M2 Cu	M3 Control	Sig.	L.S.D. 1%	L.S.D. 5%	R1	R2	R3	R4	R5	R6
Number of capsules per plant	**	1.34	1.06	10.59	12.02	*	-	0.81	11.39	10.80	10.49	**	1.89	0.76	10.68	10.57	9.90	8.91	8.65	8.38
Number of seeds per capsule	*	-	0.05	5.73	6.73	NS	-	-	5.82	5.79	5.45	*	-	0.47	6.41	6.23	6.07	5.85	5.77	5.63
Number of seeds per plant	*	-	9.92	60.72	80.87	NS	-	-	66.29	62.53	57.20	**	12.21	9.11	68.48	65.87	60.12	52.12	49.91	47.18
Number of upper branches per plant	*	-	0.93	17.90	19.00	*	-	1.31	19.31	18.61	17.43	**	4.97	2.64	22.91	19.15	18.16	17.11	16.97	16.38
Seed yield per plant (gm).	**	0.12	0.05	0.54	0.64	NS	-	-	0.66	0.67	0.64	*	-	0.13	0.69	0.63	0.57	0.55	0.54	0.51
Seed yield per feddan (kg/fed.).	**	13.42	10.78	653.06	669.59	NS	-	-	667.15	663.69	659.15	**	16.11	13.66	622.19	656.42	666.14	673.18	679.50	679.79
Seed index (1000-seed weight), gm	**	1.35	0.54	8.28	10.08	NS	-	-	9.29	9.25	9.16	NS	-	-	9.25	9.42	9.29	9.26	9.19	9.09

lowest values of this characters (13.72 and 8.38 capsules per plant) in both seasons. This reduction in the number of capsules per plant with increasing plant density is due to the competition among growing plants at dense population. This result was in harmony with those obtained by **El-Hariri (1964), Alberchtsen and Dybing (1973), Zahran *et al.*, (1984), El-Ganayni (1985), Hella *et al.*, (1986), Salama (1988)** and **Zeidan (1989).**

The statistical analysis of the data which is presented in Tables (23, 24, 25 and 26) showed that all interaction combinations i.e., strains x microelements, strains x seeding rates, microelement x seeding rate and the three factors interaction had no significant effect on number of capsules per plant in both seasons, with two exceptions of the interaction between strain x seeding rate and strain x microelements x seeding rates in the first season. Results in Table (25) showed that the highest number of capsules per plant in 1989/90 season was 16.52 obtained by S_2 seeded at 750 seeds/m². The second order interaction in 1989/90 season (Table 26) showed also that the highest value was 18.90 capsules per plant resulting from S_2 (2419/1) plants supplied with zinc and seed at 750 seeds/m².

Table 23. Summary of interaction effects among strains (S), microelements (M) and seeding rates (R) on seed yield and its components of flax in 1990/91 season.

Characters	S x M	Highest value	S x R	Highest value	M x R	Highest value	S x M x R	Highest value
Number of capsules per plant	NS (S_2 x Zn)	16.50	* (S_2 x 750)	16.52	NS (Zn x 750)	16.26	* (S_2 x Zn x 750)	18.90
Number of seeds per capsule	NS (S_2 x Zn)	6.54	NS (S_2 x 750)	6.55	NS (Untr. x 750)	6.62	NS (S_2 x Untr x 750)	6.64
Number of seeds per plant	NS (S_2 x untr.)	89.26	NS (S_2 x 750)	87.77	NS (Zn x 750)	88.53	* (S_2 x Zn x 750)	103.63
Number of upper branches per plant	NS (S_2 x untr)	24.39	NS (S_1 x 750)	26.08	NS (Zn x 750)	25.83	* (S_2 x Zn x 1000)	27.23
Seed yield per plant (gm)	NS (S_2 x Zn)	0.76	NS (S_2 x 1000)	0.70	NS (Zn x 1000)	0.72	NS (S_2 x Zn x 750)	0.79
Seed yield per feddan (kg/fed.)	NS (S_2 x Zn)	699.33	NS (S_2 x 1500)	695.42	NS (Cu x 1500)	696.88	NS (S_2 x Zn x 1500)	687.25
Seed index (1000-seed weight, gm)	NS (S_2 x Zn)	9.17	NS (S_2 x 750)	9.24	NS (Zn x 750)	9.33	NS (S_2 x Zn x 750)	9.47

Table 24. Summary of interaction effects among strains (S), microelements (M) and seeding rates (R) on seed yield and its components of flax in 1990/91 season.

Characters	S x M	Highest value	S x R	Highest value	M x R	Highest value	S x M x R	Highest value
Number of capsules per plant	NS (S_2 x Zn)	10.89	NS (S_2 x 750)	10.98	NS (Zn x 750)	10.86	NS (S_2 x Zn x 750)	12.23
Number of seeds per capsule	NS (S_2 x Cu)	6.24	NS (S_2 x 1000)	6.14	NS (Zn x 1000)	6.43	NS (S_2 x Cu x 1000)	6.44
Number of seeds per plant	NS (S_2 x Cu)	83.81	NS (S_2 x 1000)	81.72	NS (Cu x 1000)	82.87	NS (S_2 x Zn x 1000)	84.61
Number of upper branches per plant	NS (S_2 x Zn)	17.68	NS (S_2 x 750)	19.37	NS (Untr x 1000)	19.24	* (S_2 x Zn x 750)	23.98
Seed yield per plant (gm)	NS (S_2 x Untr)	0.62	NS (S_2 x 750)	0.55	NS (Zn x 1000)	0.62	NS (S_2 x Zn x 1000)	0.70
Seed yield per feddan (kg/fed.)	NS (S_2 x Zn)	671.58	NS (S_2 x 1500)	669.67	NS (Zn x 1500)	627.75	NS (S_2 x Zn x 1500)	675.75
Seed index (1000-seed weight, gm)	NS (S_2 x Cu)	9.09	NS (S_2 x 750)	9.15	NS (Untr x 750)	9.13	NS (S_2 x Zn x 750)	9.20

Table 25. Effect of the interaction between strains (S) and seeding rates (R) on number of capsules per plant in 1989/90 season.

Seeding rates (seeds/m²)	Strains		
	S_1	S_2	Mean
750	15.46	16.52	15.99
1000	14.75	15.19	14.97
1250	14.62	14.76	14.69
1500	13.33	14.55	13.94
1750	13.22	14.52	13.87
2000	13.22	14.22	13.72
Mean	14.10	14.96	
L.S.D. (0.05 level) for S x R		0.85	

Table 26. Effect of the second order interaction on number of capsules per plant in 1989/90 season.

Strains	Microelement treatments	Seeding rates (seeds/m²)						Mean
		750	1000	1250	1500	1750	2000	
S_1	Zn	16.36	15.64	15.51	14.22	14.11	14.11	14.99
	Cu	15.56	14.45	14.34	13.23	13.12	13.29	14.00
	Control	14.49	14.16	14.01	12.54	12.43	12.26	13.32
Mean		15.47	14.75	14.62	13.33	13.22	13.22	14.10
S_2	Zn	18.90	17.89	15.99	15.89	15.81	15.61	16.52
	Cu	17.61	16.25	15.88	15.63	15.59	15.11	16.01
	Control	13.02	12.43	12.41	12.13	12.16	11.94	12.35
Mean		16.51	15.19	14.76	14.55	14.52	14.22	14.96
Over all means	Zn	17.63	16.27	15.75	15.06	14.96	14.86	15.76
of microelements	Cu	16.59	15.35	14.99	15.11	14.36	14.20	15.10
	Control	13.76	13.30	13.21	12.34	12.30	12.10	12.84
Over all mean of seeding rate		15.99	14.97	14.69	13.94	13.87	17.32	

L.S.D. at 0.05 level for

S x M = NS
S x R = 0.85
M x R = NS
S x M x R = 3.69

2. Number of seeds per capsules

Concerning the two strains, data in Tables (21 and 22) showed significant difference between them in number of seeds per capsule. Higher values (5.71 and 6.73 seeds) were obtained by S_2 (2491/1), which surpassed S_1 (19/31) by 20.14% and 14.86% in 1989/90 and 1990/91 season, respectively. These results are in agreement with those obtained by **Spratt *et al.*, (1963)**, **Kumar and Singh (1967) and Hella *et al.*, (1987)** and **Salama (1988)** who reported marked differences in this trait among the tested flax genotypes.

The effect of spraying flax plants with the two microelements on number of seeds per capsule was insignificant in both seasons. Zinc and cupper application caused slight increase in number of seeds per capsule, but the increase was below the significant level only in the second season. The increases were 0.40 and 0.34 for Zn and Cu, respectively. While in the first season untreated plants had the highest number of seeds per capsules compared with Zn and Cu. In this respect **Mourad *et al.*, (1987)** found that Zn increased number of seeds per capsule in flax plant.

Data in Tables (21 and 22) revealed that there were significant differences in number of seeds per capsule due to the seeding rate in both seasons.

Generally, number of seeds per capsule was gradually decreased with increasing plant density. This behaviour was due to that more plants were grown per unit area and the competition among plants for nutrients, water and light has been increased. Consequently a reduction in seeds number per capsule was associated with dense population (2000 seeds/m^2).

The highest values in this character were 5.71 and 6.41 in 1989/90 and 1990/91 seasons, respectively., which were obtained by the lowest density (750 seeds/m^2).

The statistical analysis of the data, presented in Tables (23 and 24) showed that all interaction combinations i.e., strains x microelements, strains x seeding rates, microelements x seeding rates and the three factors interaction had no significant effect on this trait. In general, the highest values in number of seeds per capsule were 6.64 and 6.44 seeds which were obtained by S_2 for untreated plants and seeded at 750 seeds/m^2 in 1989/90 season, and by S_2 (2419/1) supplied with cupper and seeded at 1000 seeds/m^2 in 1990/91 season.

3. Number of seeds per plant

Data in Tables (21 and 22) indicated that there was a significant difference between the two strain; S_2

Table 27. Effect of the second order interaction on number of seeds per plant in 1989/90 season.

Strains	Microelement treatments	Seeding rates (seeds/m²)						Mean
		750	1000	1250	1500	1750	2000	
S_1	Zn	86.62	80.53	76.21	56.26	54.85	50.81	67.55
	Cu	82.42	78.31	77.41	56.15	52.72	49.12	66.02
	Control	81.49	71.20	62.77	50.28	48.25	40.77	59.12
Mean		83.51	76.68	72.13	54.23	51.94	46.90	64.23
S_1	Zn	103.63	97.73	93.82	88.94	71.99	70.47	87.76
	Cu	98.74	95.84	91.93	88.95	70.82	69.21	85.92
	Control	95.26	93.29	89.38	85.60	67.07	65.40	82.67
Mean		99.21	95.62	91.71	87.83	69.96	68.36	85.45
Over all means	Zn	95.13	89.13	85.02	72.60	63.42	60.64	77.66
of microelements	Cu	90.58	87.08	84.67	72.55	61.77	59.17	75.97
	Control	88.38	82.25	76.08	67.94	57.66	53.09	70.90
Over all mean of seeding rates		91.36	86.15	81.92	71.03	60.95	57.63	

L.S.D. at 0.05 level for

S x M = NS
S x R = NS
M x R = NS
S x M x R = 17.21

(2419/1) showed higher average in this character, bearing 21.22 and 20.15 seeds more than S_1 (19/31) in the first and second season, respectively. Many investigators found marked differences in number of seeds (**Kumar and Singh, 1967; Salama, 1983 and 1988; Hella *et al.*, (1989)** and **Kineber, 1991)**.

The effect of spraying flax plants with the two microelements on the number of seeds per plant was insignificant in both seasons. Data showed that zinc and cupper application produced slight increases, being 6.76 and 5.06 in the first season and 9.09 and 5.33 in the second season compared with untreated check. These results are in harmony with those obtained by **Mourad *et al.*, (1987)**. It could be indicated that foliar application with zinc and cupper seemed to accelerate cell division and to encourage seed production in flax.

Regarding plant density, data showed significant differences in this character among the different seeding rates under study. The highest mean values were 91.36 and 68.48 seeds per plant which were obtained by the lowest rate (750 seeds/m^2) in the first and second season, respectively. The difference was highly significant between the lowest rate and the three highest rates (1500, 1750 and 2000 seeds/m^2) which produced 71.09, 60.95 and 57.63 seeds per plants in

1989/90 season, and 52.12, 49.91 and 47.18 seeds/m², respectively in 1990/91 season. Generally, there was a gradual reduction in the number of seeds per plant with increasing plant density. That is mainly due to the increase in competition among flax plants at dense seeding. Similar conclusions were obtained by **Salama (1988)** and **Zeidan (1989)**.

From the results presented in Tables (23, 24 and 27), the effects of all first order interaction combinations were not significant on this trait, while a significant effect of the second order interaction was evident in the first season. The highest number of seeds per plant was 103.63 in 1989/90 season resulting from S_2 (2419/1) supplied with zinc and seeded at 750 seeds/m². Whereas in 1990/91 season the highest number of seeds per plant averaged 84.61 and was produced by S_2 supplied with zinc and seeded at 1000 seeds/m².

4. Number of upper branches per plant

Results presented in Tables (21 and 22) indicated that there was a significant difference between the two strains under study. S_2 (2419/1) surpassed S_1(19/31) by 1.71 and 1.10 branches per plant in 1989/90 and 190/91 season, respectively.

The significant effect of strains on this character may be due to the different branching behaviour of the strains. Many investigators found marked differences in number of upper branches among different flax strains (**Spratt *et al.*, 1963; El-Farouk *et al.*, 1982; El-Kalla and El-Kassaby, 1982; Salama, 1983; Momtaz *et al.*, 1989** and **Kineber, 1991**).

Microelement application significantly affected number of upper branches per plant in both seasons. Zinc and cupper caused increases in this character, being 2.32 and 1.96 in 1989/90 season; and 1.88 and 1.18 in 1990/91 season, over the untreated control, respectively. This result indicates that foliar application with zinc and cupper seemed to accelerate both cell division and elongation. Similar results were obtained by **Abo El-Soad *et al.*, (1975)** and **Mourad *et al.*, (1987)**. On the other hand, **Sorour *et al.*, (1984)** found insignificant effect on the number of upper branches per plant due to microelements application.

There was a downward trend in number of upper branches per plant with increasing plant population. Data showed that the differences were highly significant, especially between the lowest rate (750 seeds/m^2) and the highest rate (2000 seeds/m^2). The increase in upper branches number per plant was 22.48 and 28.50% due to seeding 750 seeds per m^2 compared with 2000 seeds/m^2 in the first and second season, respectively.

This reduction in number of upper branches per plant with increasing plant density was due to the competition among plants with those obtained by **El-Ganayni *et al.*, (1985)**.

The statistical analysis of the data presented in Tables (23, 24, 28 and 29) indicated that all interaction combinations i.e. strains x microelements, strains x seeding rates, microelements x seeding rates did not reach the level of significance, whereas the second order interaction was significant in both seasons. The highest numbers of upper branches per plant were 27.23 and 23.98 in the first and second seasons, respectively and recorded with S_2 supplied with Zn and seeded at 1000 seeds/m^2.

5. Seed yield per plant

Means of seed yield per plant are presented in Tables 21 and 22. Results showed highly significant difference in seed yield per plant between the two strains in both seasons. S_2 (2419/1) significantly surpassed S_1 (19/31) in this character by 19.74 and 15.63% in 1989/90 and 1990/91 season, respectively.

The significant effect of strain on this character may be due to the different number of capsules, number of seeds and number of upper branches per plant of the two strains. Many investigators found marked

Table 28. Effect of the second order interaction on number of upper branches per plant in 1989/90 season.

Strains	Microelement treatments	Seeding rates (seeds/m²)						Mean
		750	1000	1250	1500	1750	2000	
S_1	Zn	24.36	23.63	22.59	21.84	21.13	19.46	22.17
	Cu	23.81	22.91	22.83	21.36	21.61	19.11	21.94
	Control	23.68	23.99	22.35	18.69	18.13	17.17	20.67
Mean		23.95	23.51	22.59	20.63	20.29	18.58	21.59
S_2	Zn	27.23	25.12	25.21	23.94	23.60	21.96	24.51
	Cu	26.62	24.51	24.66	23.81	23.51	20.93	24.01
	Control	24.84	21.95	21.44	21.04	21.02	18.05	21.39
Mean		26.23	23.86	23.77	22.93	22.71	20.32	23.30
Over all means of microelements	Zn	25.77	24.38	23.90	22.89	22.37	20.71	23.34
	Cu	25.22	23.71	23.75	22.59	22.56	20.02	22.98
	Control	24.26	22.97	21.80	19.87	19.58	17.61	21.02
Over all mean of seeding rate		25.09	23.67	23.18	21.78	21.50	19.45	

L.S.D. at 0.05 level for

S x M = NS
S x R = NS
M x R = NS
S x M x R = 3.66

Table 29. Effect of the second order interaction on number of upper branches per plant in 1990/91 season.

Strain	Microelement treatments	Seeding rates (seeds/m²)						Mean
		750	1000	1250	1500	1750	2000	
S_1	Zn	22.98	18.95	17.98	17.01	16.85	15.89	18.28
	Cu	22.91	18.28	17.66	16.72	16.61	15.87	18.01
	Control	22.66	16.86	16.59	16.40	16.37	15.55	17.41
Mean		22.85	18.03	17.41	16.71	16.61	15.77	17.90
S_2	Zn	23.98	21.12	20.01	19.31	18.92	18.68	20.34
	Cu	22.96	20.62	19.33	17.63	17.56	17.17	19.21
	Control	21.97	19.07	17.39	15.59	15.51	15.12	17.44
Mean		22.97	20.27	18.91	17.51	17.33	16.99	19.00
Over all means	Zn	23.48	20.04	18.99	18.16	17.89	17.29	19.31
of microelements	Cu	22.94	19.45	18.49	17.18	17.09	16.52	18.61
	Control	22.32	17.97	16.99	15.99	15.94	15.34	17.43
Over all mean of seeding rates		22.91	19.15	18.16	17.11	16.97	16.38	

L.S.D. at 0.05 level for

S x M = NS
S x R = NS
M x R = NS
S x M x R = 5.21

differences in seed yield per plant among different flax strains, (**Gupta *et al.*, 1964; Hermant, 1966; Kumar and Singh, 1967; Yousef, 1968; Momtaz *et al.*, 1977 and 1980; Salama, 1983; El-Kady, 1985; Momtaz *et al.*, 1985; Salama, 1988** and **Hella *et al.*, 1989**).

As for microelement application, data showed insignificant effect on seed yield per plant in both seasons. Zinc and cupper increased seed yield per plant by 0.03 and 0.01 gm in 1989/90 season and by 0.02 and 0.03 gm in 1990/91 season, respectively, over the untreated control. This increases reached 4.5 and 6.1% in the first season, and 3.1 and 4.7% in the second one for Zn and Cu, respectively. These results are in agreement with those obtained by **Abo El-Soad *et al.*, (1975); Nasr El-Din (1983)** and **Mourad *et al.*, (1987)**. On the other hand, results reported by **Spratt and Smid, (1978)** showed that Zn or Cu application had no significant effect on seed yield per plant.

Concerning the seeding rates, analysis of variance indicated significant differences in seed yield per plant between the lowest rate (750 seeds/m^2) producing the highest values being (0.78 and 0.69 gm in the first and second season, respectively, when compared with the two highest rates (1750 and 2000 seeds/m^2). Generally, there was gradual reduction in this character with increasing plant population density. This reduction was due to the decrease in the number of upper branches, capsules and seed per plant with the increase in seeding rates. Results reported by **Gubbels (1978)**; **Hella *et al.*, (1986)**; **Salama (1988)** and **Zeidan, (1989)** showed similar conclusion.

Data in Tables (23 and 24) showed that all interaction combinations and the three factors interaction had no significant effect on seed yield per plant in both seasons. The highest values where 0.79 and 0.70 gm which were obtained by S_2 (2419/1) supplied with Zn and seeded at 750 seeds/m² in 1989/90 season and at 1000 seeds/m² in 1990/91 season.

6. Seed yield per feddan

Mean values of seed yield per feddan in flax in the two successive seasons for each the two strains as affected by microelement application and seeding rates are presented in Tables (21 and 22).

Results indicated that there was a highly significant difference between the two strains under study in both seasons. S_2 (2419/1) significantly outyielded S_1(19/31) by 2.4% in 1989/90 season and by 2.47% in 1990/91 season. The superiority of S_2 (2419/1) in seed yield per feddan over S_1 (19/31) is quite expected since S_2 (2419/1) surpassed S_1 (19/31) in seed yield components such as number of capsules, seeds and upper branches per plant as well as number of seeds per capsule and seed yield per plant. The present results are mainly due to the differences in the genetical make up of the tested strains and are in agreement with those obtained by **Nazif (1958)**, **Vasilica (1976)**, **Kenaschuk (1977)**, **Robles (1979)**, **El-Farouk *et al.*, (1982)**, **El-Kalla and El-Kassaby (1982)**, **El-Kady *et al.*, (1988)**, **Salama (1988)**, **Sorour *et al.*, (1988)**, **Hella *et al.*, (1989)** and **Momtaz *et al.*, (1989)**.

As for microelement application, data showed insignificant differences in both seasons. Zinc application produced insignificant increase in seed yield per feddan of 0.86 and 0.54% over untreated check in the first and second season, respectively. Cupper caused a slight increase in seed yield in both seasons (1.21 and 0.69%) but such increase was below the level of significance. The present result is mainly due to the favourable effects of Zn and Cu on seed yield components.

These results are in harmony with those obtained by **Batagin and Beiyankina (1968)**, **Chepikov and Shchetinina, (1970)**, **Stetsenko and Chepikov (1970)**, **Shekhawat *et al.*, (1971)**, **Abo El-Soad *et al.*, (1975)** and **Mourad *et al.*, (1987)**. On the other hand, **Dasture and**

Bhalt (1965), Spratt and Smid (1978), Kadry (1981) and Soroure *et al.*, (1984) obtained insignificant effect of microelement application on this character.

Concerning seeding rates, progressive significant increases in seed yield per feddan were obtained with increasing seeding rates. The differences between the three higher seeding rates were insignificant.

It is clear that sowing at 1500 seeds/m^2 produced the highest economic yield, being 683.08 and 673.18 kg in the first and second season, respectively, compared with the lowest rate (750 seeds/m^2) which produced 632.13 and 622.19 kg.

Similar findings were reported by **El-Hariri (1968), Vasilica (1974), Sin *et al.*, (1975), Momtaz *et al.*, (1981), Zahran *et al.*, (1984), Gulerie and Singh (1985), Tabara *et al.*, (1987)** and **Salama (1988)**. On the other hand, different results were obtained by **Liefstingh and Blink (1972)** and **Hella *et al.*, (1986)** who reported that seed yield per feddan decreased with increasing seeding rates.

Data in Tables 23 and 24 showed that the interaction effects on this trait were not significant in all combinations i.e., strains x microelements, strains x seeding rates, microelements x seeding rates and the three factors interaction, i.e., strains x microelements x seeding rates.

Generally, the highest seed yield per feddan was produced in both seasons by the combination of S_2 (2419/1), supplied with Zn and seeded at 1500 seeds/m². Seed yield per feddan was 687 and 675 kg/fed. in the first and second seasons, respectively.

7. Seed index (1000-seed weight)

Averages of seed index in gram for each of the two strains, treated with two microelements and planted at six seeding rates in both seasons are presented in Tables (21 and 22).

As regards the two strains, data indicated a highly significant difference in seed index. S_2 (2491/1) recorded higher value which surpassed S_1 (19/31) by 16.89 and 17.86% in the first and second season, respectively. Many investigators reported significant differences among strains in seed index (**Kumar and Singh, 1967; Remussi *et al.*, 1967; Momtaz *et al.*, 1980; Salama, 1983; El-Kady, 1985; El-Kady *et al.*, 1988; Salama, 1988; Sorour *et al.*, 1988; Hella *et al.*, 1989** and **Momtaz *et al.*, 1989**).

The effect of spraying flax plants with the two microelements on seed index was insignificant in both seasons. Zinc and cupper produced slight increases over untreated check. The favourable effects of micro-elements on seed yield and its components might be due to the progress in plant growth and the effect on some physiological processes in plant. This result is in harmony with those obtained by **Abo El-Soad *et al.*, (1975)** and **Mourad *et al.*, (1987)**.

In respect of the seeding rates effect on seed index, analysis of variance indicated that there were insignificant differences among the different treatments. Generally, there was a gradual reduction in seed index with increasing plant population density. This reduction may be due to the competition among plants grown at dense population. This result was in harmony with those obtained by **El-Farouk (1968)**. On the other hand, results reported by **Alberchtsen and Dyling (1973)** and **Momtaz *et al.*, (1982)** indicated that seeding rates did not significantly affect seed index.

Results presented in Tables (23 and 24) showed that all interaction combinations had no significant effect on seed index in both seasons. In general, the highest seed index was 9.47 gm in the first season which was the result of combining S_2 (2419/1) x Zn x 750 seeds/m², whereas in the second seasons S_2 (2419/1) supplied with Cu and seeded at 750 seeds/m² recorded the highest seed index which was 9.20 gm.

III Technological characters

Tables (30 and 31) illustrated the technological characters for the two flax strains supplied with three microelement treatments and sown under six seeding rates in 1989/90 and 1990/91 seasons.

1. Fiber yield per plant (gm)

Results indicated that there was a significant difference between the two flax strains under this study. Plants of S_1 (19/31) yielded more fibers (0.29 and 0.27 gm) than those of S_2 (2419/1) which yielded 0.20 and 0.18 gm in the first and second season, respectively. The difference in fiber yield per plant between the two strains is mainly due to the difference in straw yield per plant. results of the present study are in accordance with those obtained by **El-Kady (1985)**, **Salama (1988)**, **El-Gazzar (1990)** and **Kineber (1991)**.

With respect to microelement applications data recorded in Tables (30 and 31) indicated that there were no significant differences in the fiber yield per plant due to microelements in both seasons. However, zinc and cupper insignificantly increased fiber yield per plant by 7.4% in 1989/90 season and 8.0 and 4.2%, respectively, in 1990/91 season. The favourable effect of microelements on fiber yield per plant might be due

Table 30. Effect of strains (S), microelements (M) and seeding rates (R) on the technological characters of flax in 1989/90 seasons.

Characters	Strains					Microelements						Seeding rates								
	Sig	L.S.D. 1%	L.S.D. 5%	S1 19/31	S2 2419/1	Sig.	L.S.D. 1%	L.S.D. 5%	M1 Zn	M2 Cu	M3 Control	Sig.	L.S.D. 1%	L.S.D. 5%	R1	R2	R3	R4	R5	R6
Fiber yield per plant (gm)	*	-	0.02	0.29	0.20	NS	-	-	0.27	0.27	0.25	*	-	0.01	0.32	0.31	0.30	0.29	0.26	0.24
Fiber yield per feddan (kg)	*	-	36.13	463.41	350.55	NS	-	-	470.11	462.99	459.25	*	-	39.30	403.54	425.73	454.55	463.25	466.82	469.95
Fiber length (cm)	*	-	1.91	75.03	71.46	*	-	1.89	75.46	74.98	73.05	*	-	2.15	69.48	71.97	72.92	74.98	74.99	75.75
Long fiber percentage	**	0.98	0.51	14.04	12.67	NS	-	-	13.35	13.46	13.27	*	-	0.65	12.69	12.74	13.11	13.64	13.96	13.98
Fiber fineness (N.m.)	**	6.66	2.23	196.87	161.40	*	-	2.09	199.90	198.47	196.13	**	6.88	2.63	167.51	171.94	176.97	193.93	196.63	199.91
Oil percentage	*	-	2.19	39.95	42.17	NS	-	-	41.79	41.51	40.39	NS	-	-	41.47	41.39	41.28	41.22	41.20	41.09
Oil yield per feddan (kg)	**	16.32	12.64	264.00	285.45	NS	-	-	284.98	282.18	273.09	*	-	13.59	262.14	274.59	280.35	281.56	284.07	283.43

Table 31. Effect of strains (S), microelements (M) and seeding rates (R) on the technological characters of flax in 1990/91 seasons.

Characters	Strains					Microelements						Seeding rates								
	Sig	L.S.D. 1%	L.S.D. 5%	S1 19/31	S2 2419/1	Sig.	L.S.D. 1%	L.S.D. 5%	M1 Zn	M2 Cu	M3 Control	Sig.	L.S.D. 1%	L.S.D. 5%	R1	R2	R3	R4	R5	R6
Fiber yield per plant (gm)	*	-	0.06	0.27	0.18	NS	-	-	0.25	0.24	0.23	*	-	2.02	0.27	0.26	0.25	0.24	0.23	0.22
Fiber yield per feddan (kg)	*	-	31.35	402.69	284.83	NS	-	-	360.03	356.68	347.93	*	-	42.21	362.48	383.07	390.79	404.00	406.36	409.31
Fiber length (cm)	*	-	1.42	71.32	66.86	*	-	1.93	69.15	68.98	66.55	*	-	4.32	61.33	63.67	63.96	67.92	68.25	69.37
Long fiber percentage	**	1.02	0.62	13.91	12.61	NS	-	-	13.45	13.38	12.96	*	-	0.60	12.69	12.74	13.11	13.64	13.96	13.98
Fiber fineness (N.m.)	**	7.24	2.61	195.97	169.64	*	-	1.17	198.19	197.26	189.47	**	-	3.73	166.36	169.92	176.78	192.19	194.48	196.10
Oil percentage	*	-	2.18	39.89	42.18	NS	-	-	41.59	41.51	40.29	NS	7.03	-	41.48	41.44	41.30	41.25	41.33	41.18
Oil yield per feddan (kg)	**	17.76	11.41	260.51	282.43	NS	-	-	277.46	275.49	265.57	*	-	10.53	258.08	272.02	275.12	277.81	280.83	279.93

to their effect in increasing straw yield per plant. These results are in harmony with those obtained by **Stetsenko and Chepikov (1970)**, **Sen'kov (1974)**, **Nasr El-Din (1983)** and **Mourad *et al.*, (1987)**.

Concerning the effect of seeding rates, data showed a downward trend in fiber yield per plant with the increase in seeding rate. The differences were significant and the lowest rate produced the highest values (0.32 and 0.27 gm) in both seasons. Fiber yield per plant showed the same previous trend of straw yield per plant concerning its response to seeding rate. Similar results were recorded by **Salama (1988)** and **Khalil (1990)**.

The interaction effects between all experimental factors i.e., strain x microelements, strains x seeding rates, microelements x seeding rate and the three factor interaction on fiber yield per plant were not significant.

Results in Tables (32 and 33) show that the highest fiber yield per plant in 1989/90 was 0.33 gm recorded with S_1 (19/31) supplied with Zn and seeded at 1000 seeds/m², while in 1990/91 season, the highest value was 0.24 gm resulting from S_1 (19/31) supplied with Cu and seeded at 750 seeds/m².

Table 32. Summary of the interaction effects between strains (S), microelements (M) and seeding rates (R) on the technological characters of flax in 1989/90. season.

Characters	S x M	Highest value	S x R	Highest value	M x R	Highest value	S x M x R	Highest value
Fiber yield (gm/plant)	NS (S_1 x Zn)	0.32	NS (S_1 x 1000)	0.31	NS (Zn x 1000)	0.31	NS (S_1 x Zn x 1000)	0.33
Fiber yield (kg/fed.)	NS (S_1 x Zn)	433.47	NS (S_1 x 1750)	439.31	NS (Zn x 1750)	468.49	NS (S_1 x Zn x 1750)	469.38
Fiber length (cm)	NS (S_1 x Zn)	75.70	NS (S_1 x 1500)	75.13	NS (Zn x 1750)	75.31	NS (S_1 x Zn x 1750)	75.58
Long fiber percentage	NS (S_1 x Zn)	12.97	NS (S_1 x 1500)	13.71	NS (Zn x 1500)	13.25	* (S_1 x Zn x 1500)	14.39
Fiber fineness (N.m.)	NS (S_1 x Zn)	198.53	NS (S_1 x 2000)	198.31	NS (Zn x 2000)	201.54	NS (S_1 x Zn x 2000)	202.96
Oil percentage	NS (S_2 x Zn)	42.46	NS (S_2 x 1000)	42.35	NS (Zn x 1000)	41.83	NS (S_2 x Zn x 1000)	41.74
Oil yield (Kg/fed.)	NS (S_2 x Zn)	283.42	NS (S_2 x 1750)	283.62	NS (Cu x 750)	285.71	NS (S_2 x Zn x 1750)	286.84

Table 33. Summary of the interaction effects between strains (S), microelements (M) and seeding rates (R) on the technological characters of flax in 1990/91 season.

Characters	S x M	Highest value	S x R	Highest value	M x R	Highest value	S x M x R	Highest value
Fiber yield (gm/plant)	NS (S_1 x Cu)	0.21	NS (S_1 x 750)	0.23	NS (Zn x 750)	0.22	NS (S_1 x Cu x 750)	0.24
Fiber yield (kg/fed.)	NS (S_1 x Cu)	418.12	NS (S_1 x 1500)	480.42	NS (Cu x 1500)	428.19	NS (S_1 x Cu x 1500)	429.69
Fiber length (cm)	NS (S_1 x Cu)	66.63	NS (S_1 x 1750)	69.08	NS (Cu x 1750)	67.00	NS (S_1 x Cu x 1750)	69.50
Long fiber percentage	NS (S_1 x Zn)	12.49	NS (S_1 x 2000)	13.03	NS (Zn x 2000)	13.60	* (S_1 x Zn x 2000)	14.40
Fiber fineness (N.m.)	NS (S_1 x Cu)	199.56	NS (S_1 x 1750)	196.38	NS (Cu x 2000)	197.45	NS (S_1 x Cu x 2000)	201.54
Oil percentage	NS (S_2 x Zn)	42.29	NS (S_2 x 1000)	42.22	NS (Zn x 1000)	41.78	NS (S_2 x Zn x 1000)	41.69
Oil yield (Kg/fed.)	NS (S_2 x Zn)	280.61	NS (S_2 x 1500)	281.51	NS (Zn x 1500)	277.62	NS (S_2 x Zn x 1750)	285.57

2. Fiber yield per feddan (kg)

Means of fiber yield per feddan in flax in the two successive seasons as affected by strains, micro-elements and plant density are shown in Tables (30 and 31).

Results indicated that there was a significant difference between the two flax strains with regard to fiber yield per feddan in both seasons. S_1 (19/31) significantly outyielded S_2 (2419/1) in both seasons. The differences reached 112.86 and 117.86 and 117.86 kg/feddan, being 24.35 and 29.27% in the first and second season, respectively.

The superiority of S_1 over S_2 is mainly due to its higher straw yield per feddan. The present results are mainly due to the differences in the genetical make up of the tested strains and are in agreement with those obtained by **Vasilica (1976)**, **Momtaz *et al.*, (1980)**, **El-Farouk *et al.*, (1982)**, **Salama (1983)**, **Abd El-Raouf *et al.*, (1983)**, **El-Kady *et al.*, (1988)**, **Salama (1988)**, **Sorour *et al.*, (1988)**, **Momtaz *et al.*, (1989)**, **El-Gazzar (1990)** and **Kineber (1991)**.

With regard to foliar spraying with microelements, the results indicated that there were insignificant increases in fiber yield by supplying plants with zinc and cupper.

Zinc and cupper application increased fiber yield per feddan by 10.86 and 3.74 kg per feddan compared with untreated plants in 1989/90 season, respectively. The corresponding increases in 1990/91 season were 12.1 and 8.75 kg/fed. for Zn and Cu, respectively. The favourable effect of microelements on the fiber yield per feddan is mainly due to the increase in straw yield per feddan. These results were in harmony with those mentioned by **Shchetinina and Chepikov (1966), Batagin and Beiyankina (1968), Chepikov and Shchetinio (1968) and (1970), Stetsenko and Chepikov (1970), Sen'kov (1974)** and **Kadry (1981)** who obtained insignificant increase in fiber yield by microelements application.

Data showed that there were significant differences in fiber yield per feddan due to the different plant population densities in both seasons. The fiber yield per feddan increased as seeding rate increased up to 2000 seeds/m^2. Generally, results showed that there was a gradual increase in fiber yield per feddan with increasing plant density.

The increase in seed rate from 750 to 10000, 1250, 1500, 1750 and 2000 seeds/m^2 increased fiber yield per feddan by 5.2, 11.2, 12.9, 13.6 and 13.6%, respectively in 1989/90 season. The corresponding increases were 5.4, 7.4, 10.3, 10.8 and 11.4% in 1990/91 season. It is worth mentioning that the differences between the higher seed rates of 1500, 1750 and 2000 seeds/m² (R4, R5 and R6 treatments) did not reach the level of significance in the two seasons. The response of fiber yield per feddan to seeding rate showed a similar trend as that of straw yield per feddan. Consequently, the present result is quite expected. Similar findings were obtained by **Vasilica (1974)**, **Balass *et al.*, (1986)**, **Salama (1988)** and **Khalil (1990)**.

Tables (32 and 33) indicated that all interaction combinations i.e., strains x microelements, strains x seeding rates, microelements x seeding rates and the three factors interaction were not significant on fiber yield per feddan in both seasons. Generally, the highest fiber yield per feddan was 469.38 kg in the first season which was the result of growing S_1 supplied with Zn and seeded with 1750 seeds/m², whereas in the second season the highest yield 429.69 kg/fed. which was produced by S_1 supplied with Cu and seeded with 1500 seeds/m².

3. Fiber length (cm)

Mean values of fiber length of flax in the two successive seasons as affected by strains, microelements and seeding rates are presented in Tables (30 and 31).

Analysis of variance showed that the strains significantly differed in this character in both seasons. S_1 (19/31) produced significantly taller fibers than S_2 (2419/1) by 3.57 and 4.46 cm in the first and second season, respectively. The difference in fiber length between the two strains is mainly due to the differences in the genetical make up of the two tested strains. Also, S_1(19/31) plants were higher in technical length than S_2 ones and consequently taller fibers were produced,

The present results are in agreement with those obtained by **El-Farouk *et al.*, (1982)**, **Salama (1983 & 1988)**, **Hella *et al.*, (1986)**, **El-Kady *et al.*, (1988)**, **El-Gazzar (1990)** and **Kineber (1991)**.

Concerning the effect of foliar spraying with microelements on the fiber length, data indicated that there were significant differences among the three microelement treatments in the two successive season. Zn and Cu application significantly increased fiber length by 2.41 and 1.93 cm compared with untreated plants in 1989/90 and 1990/91 season, respectively. The corresponding increases in 1990/91 seasons were 2.60 and 2.43 cm for Zn and Cu, respectively. The favourable effect of microelements of fiber length is mainly due to the increase in technical stem length.

These finding coincide with those obtained by

Batagin and Beiyankina (1968), Chepikov and Shchetinina (1968), El-Shimy *et al.*, (1986) and **Mourad *et al.*, (1987)**.

Regarding seeding rates, results showed gradual increments in fiber length when seeding rate increased from 750 to 2000 seeds/m^2 in both seasons. It was also observed that the differences between the rates of 1500, 1750 and 2000 seeds/m^2 did not reach the level of significance in the two seasons. The increase in fiber length attributed to the increase in plant density is due to the increase in competition and consequently, flax plants tended to elongate searching for light.

Results reported by **El-Hariri (1968), Momtaz *et al.*, (1981), Hella *et al.*, (1986), Zeidan (1989)** and **Moustafa (1990)** showed similar findings in this respect.

Results presented in Tables (32 and 33) showed that the interaction effects on this character were not significant for all combinations in both seasons. Generally, the combinations of S_1 (19/31) plants supplied with Zn and seeded at 1750 sees/m^2 produced the tallest fibers in 1989/90 season being 75.58 cm. The corresponding value in 1990/91 season was 69.50 cm produced from S_1 (19/31) supplied with Cu and seeded at 1750 seeds/m^2.

4. Long fiber percentage

Average of long fiber percentage for each of the two strains supplied with two microelements and seeded at six seeding rates for the two successive seasons are presented in Tables (30 and 31).

Concerning the two strains, analysis of variance showed a significant difference between them in long fiber percentage. S_1 (19/31) significantly surpassed S_2 (2419/1) by 9.76 and 9.35% in 1989/90 and 1990/91 season, respectively. The present results may be due to the differences in the genetical constitution of the two tested strains and are in agreement with those obtained by **El-Kalla and El-Kassaby (1982)**, **Salama (1988)**, **Momtaz *et al.*, (1989)** and **El-Gazzar (1990)**.

As for microelement application, results showed insignificant effect on this character in both seasons. Zn and Cu application caused slight increases in long fiber percentage being 0.08 and 0.19% higher compared with untreated plants in 1989/90 season, respectively. The corresponding increases in 1990/91 season were 0.49 and 0.42 for Zn and Cu, respectively. These results indicate that foliar application with zinc and cupper seemed to accelerate both of cell division and cell elongation in flax plants. In this connection, **El-Soad *et al.*, (1975)** and **Mourad *et al.*, (1987)** found similar results, while **Kadry (1981)** recorded insignificant effect for microelements application on this trait.

Regarding plant density, results showed gradual increments in long fiber percentage with the increase in seeding rates from 750 to 2000 seeds/m². It was observed that the differences between 1500, 1750 and 2000 seeds/m² did not reach the level of significance in the two seasons. These results are in harmony with those obtained by **Momtaz *et al.*, (1981), Zahran *et al.*, (1984), Salama (1988)** and **Moustafa (1990).**

Results presented in Tables (32, 33, 34 and 35) showed that the effect of all first order interaction combinations i.e., strains x microelements, strains x seeding rates, microelements x seeding rates were not significant on this trait in both seasons, whereas the second order interaction had a significant effect on long fiber percentage. Results in Table (34) showed that the highest value of long fiber percentage in 1989/90 season (14.39%) was obtained by S_1 (19/31) supplied with Zn and seeded at 1500 seeds/m². The second order interaction in the second season, presented in Table (35) showed also that the highest value (14.40%) was obtained by S_1 (19/31) supplied with Zn and seeded at 2000 seeds/m².

5. Fiber fineness

From Tables (30 and 31) results indicated that there was a significant difference between the two strains under this study in both seasons. S_1 (19/31) had finer fibers than S_2 (2419/1) which produced the highest mean values in N.m. (196.87 and 195.97), while S_2 (2419/1) produced only 161.40 and 159.64 N.m. values in 1989/90 and 1990/91 season, respectively. The present results are mainly due to the differences in the genetical constitution of the tested strains. It is worthy to note that S_1 (19/31) is considered as a dual purpose variety, while S_2 (2419/1) is an oil type. Similar results were obtained by **El-Farouk *et al.*, (1982)**, **Salama (1988)**, **Hella *et al.*, (1986)**, **El-Kady *et al.*, (1988)**, **El-Gazzar (1990)** and **Kineber (1991)** who reported marked differences in this trait among the tested flax genotypes.

Concerning the effect of spraying flax plants with the two microelements on fiber fineness, results revealed significant differences among the three treatments (Zn, Cu and untreated). Microelement application produced finer fibers compared with untreated check. Zinc and Cupper increased N.m. values of flax fibers by 4.9 and 4.2% over the control in 1989/90 season, respectively. The corresponding increases in 1990/91 season were 4.4 and 3.9% for Zn and Cu application, respectively.

Table 34. Effect of the second order interaction on long fiber percentage in 1989/90 season.

Strains	Microelement treatments	Seeding rates (seeds/m²)						Mean
		750	1000	1250	1500	1750	2000	
S_1	Zn	13.89	13.91	13.92	14.39	14.31	14.31	14.12
	Cu	13.88	13.82	13.83	14.28	14.32	14.23	14.06
	Control	13.57	13.70	13.80	14.15	14.24	14.15	13.94
Mean		13.78	13.81	13.85	14.27	14.29	14.23	14.04
S_2	Zn	11.89	11.78	12.15	13.22	13.25	13.16	12.58
	Cu	11.78	11.56	12.26	13.21	14.23	14.09	12.86
	Control	11.13	11.67	12.68	12.60	13.41	13.94	12.57
Mean		11.60	11.67	12.36	13.01	13.63	13.73	12.67
Over all means of microelements	Zn	12.89	12.85	13.04	13.81	13.78	13.74	13.35
	Cu	12.83	12.69	13.05	13.75	14.28	14.16	13.46
	Control	12.35	12.69	13.24	13.38	13.93	14.05	13.27
Over all mean of seeding rates		12.69	12.74	13.11	13.64	13.96	13.98	

L.S.D. at 0.05 level for

S x M = NS
S x R = NS
M x R = NS
S x M x R = 1.76

Table 35. Effect of the second order interaction on long fiber percentage in 1990/91 season.

Strains	Microelement treatments	Seeding rates (seeds/m²)						Mean
		750	1000	1250	1500	1750	2000	
S_1	Zn	13.78	13.99	13.82	14.21	14.32	14.40	14.09
	Cu	13.76	13.89	13.73	14.16	14.26	14.29	14.02
	Control	13.53	13.85	11.93	13.96	14.05	14.39	13.62
Mean		13.69	13.91	13.16	14.11	14.21	14.36	13.91
S_2	Zn	11.69	11.96	12.83	13.66	13.51	13.13	12.80
	Cu	11.62	11.89	12.76	13.52	13.46	13.21	12.74
	Control	11.40	12.00	12.57	12.51	12.54	12.78	12.30
Mean		11.57	11.95	12.72	13.23	13.17	13.04	12.61
Over all means	Zn	12.74	12.98	13.33	13.94	13.92	13.77	13.45
of microelements	Cu	12.69	12.89	13.25	13.84	13.86	13.75	13.38
	Control	12.46	12.93	12.25	13.24	13.30	13.59	12.96
Over all mean of seeding rates		12.63	12.93	12.94	13.67	13.69	13.70	

L.S.D. at 0.05 level for

S x M = NS
S x R = NS
M x R = Ns
S x M x R = 1.30

These results are in harmony with those obtained by **Batagin and Beiyankina (1968), Lesik and Sen'kov (1974), Abo El-Soad *et al.*, (1975), Kadry (1981)** and **Mourad *et al.*, (1987).** On the other hand, **Sorour *et al.*, (1984)** and **El-Shimy *et al.*, (1986)** recorded insignificant effects of microelement treatments on this trait.

Concerning plant density, results showed gradual increments in fiber fineness when the seeding rate increased from 750 to 2000 seeds/m^2 in both seasons. It was observed that the differences between 1500 and the higher seeding rates (1750 and 2000 seeds/m^2() did not reach the level of significance in the two seasons.

The lowest value of N.m. (167.51) was obtained from sowing 750 seeds/m^2 while the highest mean (199.91) was produced by seeding 2000 seeds/m^2 in 1989/90 season. The corresponding values in 1990/91 season were 166.36 and 196.10 for 750 and 2000 seeds/m^2, respectively.

The present results may be due to the production of thin plants by sowing at the highest seeding rates.

These results are in agreement with those obtained by **Momtaz *et al.*, (1981), Hella *et al.*, (1986), Hassan and El-Farouk (1987), Salama (1988), Zeidan (1989)** and **Moustafa (1990).**

Results presented in Tables (32 and 33) showed that all interaction combinations, i.e. strains x microelements; strain x seeding rates; microelements x seeding rates and the second order interaction of strains x microelements x seeding rates were not significant in both seasons. Generally, the combination of S_1 (19/31) plants supplied with Zn and seeded at 2000 seeds/m² produced the finest fibers in 1989/90, being 202.96 N.m. The corresponding mean of N.m. in 1990/91 season was obtained by the combination of S_1 (19/31) plants supplied with Cu and seeded at 2000 seeds/m², being 201.54.

6. Oil percentage

Average of oil percentage in flax seeds in the two successive seasons as affected by the two strains, microelements and seeding rates are presented in Tables (30 and 31).

Analysis of variance showed that the two strains were significantly different in their oil content in both seasons. S_2 (2419/1) significantly contained higher values of oil percentage in flax seeds, being 42.17 and 42.18% in the first and second season, respectively. The corresponding values of S_1 (19/31) were 39.95 and 39.89% in 1989/90 and 1990/91 season, respectively. The present results are mainly due to the differences in the genetical constitution of the tested strains which indicated that S_1 (19/31)is considered as a dual purpose variety, and S_2 (2419/1) as an oil variety. The results are in agreement with those obtained by **Gupta *et al.*, (1964), El-Shamma and El-Hasan (1969), Salama (1983), Momtaz *et al.*, (1989), El-Gazzar (1990)** and **Kineber (1991)**.

With regard to spraying plants with microelements, data indicated that there were insignificant differences among microelements treatments in both seasons. Zinc and cupper insignificantly increased oil percentage by 1.40 and 1.12 in 1989/90 season, respectively. The corresponding values in 1990/91 season were 1.30 and 1.22, respectively. The present result is mainly due to the favourable effect of microelements on the photosynthetic productivity in plants.

Similar results were obtained by **Batagin and Beiyankina (1968), Chepikov and Shchetinina (1968), Abo El-Soad *et al.*, (1975)** and **Kadry (1976)**.

Regarding seeding rates and its effect on this character, the statistical analysis revealed that there were insignificant differences among the different plant densities. Generally, oil percentage decreased gradually as seeding rate increased from 750 to 2000 seeds/m² in both seasons. In this respect, **El-Hariri (1968)**, **Shehata and Comstock (1976)**, **Momtaz *et al.*, (1981)**, **Hella *et al.*, (1986)**, **Tabara *et al.*, (1987)**, **Zeidan (1989)**, **Khalil (1990)** and **Moustafa (1990)** reported similar results.

Data in Tables (32 and 33) showed that the effect of all interaction combinations i.e., strains x microelements; strains x seeding rates, microelements x seeding rates and the second order interaction among strain x microelements x seeding rates were not significant on oil percentage in both seasons.

Generally, the combination of S_2 (2419/1) supplied with Zn and seeded at 1000 seeds/m² produced seeds contained the highest oil content being 41.74 and 41.69% in the first and second season, respectively.

7. Oil yield (kg/feddan)

Means of oil yield per feddan of the two successive seasons as affected by strains, microelements and seeding rates are presented in Tables (30 and 31).

Results indicated that there was a highly significant difference between the two strains under study in both seasons. S_2 (2419/1) significantly outyielded S_1 (19/31) by 7.5 and 7.8% in the first and second seasons, respectively. The superiority of S_2 surpassed S_1 in seed yield per feddan as well as oil content in seeds. The present results are in agreement with those obtained by **Salama (1983)**, **Momtaz *et al.*, (1985)**, **Sorour *et al.*, (1988)**, **El-Gazzar (1990)** and **Kineber (1991)**.

As for microelements application, data showed insignificant differences in both seasons. Zinc and cupper application produced insignificant increase in oil yield per feddan of 4.17 and 3.22% over untreated check in the first season, respectively. The corresponding increases in 1990/91 season were 4.3 and 3.6%, respectively. The present result is mainly due to the favourable effects of Zn and Cu on seed yield per feddan and on oil content in flax seeds. These results are in harmony with those obtained by **Kadry (1981)**.

Concerning seeding rates, progressive significant increases in oil yield per feddan were obtained with the increase in seeding rate up to 2000 seeds/m² in the two seasons. The highest values of oil yield per feddan were obtained by sowing at 1750 seeds/m², being 283.43 and 280.83 kg/fed. in the first and the second season, respectively. This character is closely related to the seed yield per feddan and the oil percentage in flax seeds and consequently, it is quite expected.

Similar results were obtained by **Thimmoppa *et al.*, (1983)** and **Salama (1988)**. On the other hand, Moustafa

(1990) reported insignificantly effect of seeding rates on this trait.

Tables (32 and 33) showed that the interaction effects on this characters were not significant with all combinations i.e., strains x microelements, strains x seeding rates, microelements x seeding rates and the second order interaction among strains x microelements x seeding rates. Generally, the highest oil yield per feddan was produced in both seasons by the combination of S_2 (2419/1), supplied with Zn seeded at 1750 seeds/m^2. Oil yield per feddan was 286.84 and 285.57 kg in the first and second seasons, respectively.

C. Anatomical studies

I. Different stem tissue areas (mm^2)

Estimation of different stem tissue areas for the two flax strains as affected by microelements and seeding rates in the two successive seasons 1989/90 and 1990/91 are presented in Tables (36 and 37) and illustrated in Figures (1, 2, 3, 4, 5, and 6).

In relation to the two strains under study, results showed that the flax strain 2419/1 was superior to the strain 19/31 in total cross section, cortex and xylem areas by 34.6, 26.7 and 21.7 mm^2, respectively in 1989/90 season. The corresponding differences in 1990/91 season were 32.6, 28.4 and 22.3 mm^2 for the total cross section, cortex and xylem areas, respectively.

On the other hand, S_1 (19/31) recorded higher measurements in fiber and pith areas, being 10.8 and 43.8 mm^2 in 1989/90 season, while in 1990/91 season, the areas were 9.9 and 41.7 mm^2 for fiber and pith, respectively.

The differences in the area of stem tissues between the two strains are mainly due to the difference in their genetical constitution.

Many investigators found marked differences in the stem tissue areas in different genotypes (**Ivanova and Matveev, 1960; El-Shimy, 1975; Refai, 1975; Hella, 1983** and **Hella *et al.*, 1989**).

Regarding microelements application effect on the tissue areas of flax stems, it could be noticed that Zn and Cu caused an increase in the different tissue areas compared with the untreated check in both seasons. Zn produced increases over the untreated check by 2.5, 2.5, 2.7, 1.7 and 1.0 mm^2 for total cross section, cortex, fiber, xylem and pith areas, respectively, in 1989/90 season. The corresponding increases in 1990/91 season were 3.1, 2.2, 2.1, 1.0 and 2.5 mm^2.

The increases obtained over the untreated check by Cu application were 1.5, 1.4, 2.0, 1.3 and 0.4 mm^2 for the total cross section, cortex, fiber, xylem and pith areas, respectively in the first season, while in the second one, the increases were 2.3, 1.1, 1.8, 0.7 and 2.6 mm^2. This result may be due to that microelements application increased stem diameter in flax plants.

Similar results were obtained by **Porokhnevich and Bykov (1972)**, **Nasr El-Din (1983)**, **El-Shimy *et al.*, (1986)** and **Mourad *et al.*, (1987)**, who mentioned that microelements nutrition caused an increase in stem diameter of flax.

Concerning the seeding rates, data indicated that the lowest plant density (750 seeds/m^2) produced the highest values of the different tissue areas compared with the other rates, i.e., 1500 and 2000 seeds/m^2 in both seasons. The differences between plants seeded at the lowest density and that which seeded at the highest density were 49.7, 12.5, 0.50, 18.2 and 7.8 mm^2 for the total cross section, cortex, fiber, xylem and pith areas, respectively, in 1989/90 season. The corresponding differences in 1990/91 season were 47.9, 7.0, 1.1, 26.9 and 4.3 mm^2. This superiority in the tissue areas of stems in plants seeded at the lowest density is mainly due to the increase in stem diameter of these plants. Similar results were obtained by **Hella (1983) and El-Shimy** ***et al.*****, (1992)**.

II. Stem tissue area percentages per cross section

Estimates of different stem tissue areas as a percentage of the corresponding total cross section area for two flax strains as affected by microelements and seeding rates in the two successive seasons 1989/90 and 1990/91 are presented in Tables (38 and 39).

Results indicated that S_1 (19/31) ranked first in its percentages of fiber, pith areas and fiber/xylem being 7.67, 31.11 and 19.35%, respectively, in 1989/90 season. The corresponding percentages in 1990/91 season were 7.14, 30.06 and 18.44 for fiber area percentage, xylem area percentage and fiber/xylem percentage, respectively.

Some investigators obtained differences in tissue area percentages among different genotypes (**Hella, 1989** and **Sabh, 1989**).

For microelements application, data showed that Zn and Cu produced the highest percentages of fiber area, pith area and fiber/xylem in both seasons. Zinc increased these characters by 1.60, 0.23 and 3.98% in comparison with the untreated check in the first season. While in the second one, the increases were

Table 38. Estimates of different stem tissue areas as percentages of the corresponding total cross section area as affected by the two strains, microelements and seeding rates in 1989/90 season.

Characters	Strains		Microelements			Seeding rates (seeds/m²)		
	S1 (19/31)	S2(2419/1)	M1 (Zn)	M2 (Cu)	M3 (Control)	750	1500	2000
Fiber area percentage	7.67	4.68	7.73	7.34	6.13	6.45	6.63	7.38
Xylem area percentage	39.63	44.18	38.84	38.96	38.51	37.26	38.31	37.51
Pith area percentage	31.11	18.64	23.82	23.47	23.59	23.08	23.93	25.90
Fiber / Xylem percentage	19.35	10.58	19.90	18.83	15.92	17.31	17.31	19.67

Table 39. Estimates of different stem tissue areas as percentages of the corresponding total cross section area as affected by the two strains, microelements and seeding rates in 1990/91 season.

Characters	Strains		Microelements			Seeding rates (seeds/m^2)		
	S1 (19/31)	S2(2419/1)	M1 (Zn)	M2 (Cu)	M3 (Control)	750	1500	2000
Fiber area percentage	7.14	4.14	7.12	6.95	5.89	6.13	7.15	7.54
Xylem area percentage	38.72	44.37	39.91	39.92	40.06	44.29	46.53	39.92
Pith area percentage	30.06	17.86	24.62	24.81	23.49	20.71	24.43	25.08
Fiber / Xylem percentage	18.44	9.42	17.81	17.41	14.70	13.83	15.37	18.88

1.23, 1.13 and 3.11% for fiber and pith areas and fiber/xylem percentage, respectively. Moreover, Cu increased fiber area percentage by 1.21 and 1.06% in the 1989/90 and 1990/91 season, respectively. Fiber/xylem percentage increased as affected with Cu spraying by 2.91 and 2.71% in the first and second season, respectively.

With regard to seeding rate effects on the tissue area percentages, data indicated that the highest plant density recorded the highest percentages of fiber area, pith area and fiber/xylem, being 7.38, 25.9 and 19.67% respectively in 1989/90 season. The corresponding values were 7.54, 25.08 and 18.88% for fiber and pith areas and fiber/xylem, respectively. Similar results were obtained by **Hella (1983)** and **El-Shimy, (1992)**.

III. Microscopic studies and fiber index

Number of fiber cells per bundle, number of bundles per cross section, number of fiber cells per cross section and fiber index for the two flax strains as affected by microelements and seeding rates in two successive seasons are presented in Tables (40 and 41).

Data obtained indicated that S_1 (19/31) had higher numbers of fiber cells per bundle, number of fiber bundles per cross section and number of fiber cells per cross section, than the other strain S_2 (2419/1) by 3.9,

Table 40. Mean values of fiber cells per bundle, fiber cells per bundle, number of fiber cells per cross section and fiber index in the flax stem cross section as affected by strains, microelements and seeding rates in 1989/90 season.

Characters	Strains		Microelements			Seeding rates (seeds/m²)		
	S1 (19/31)	S2(2419/1)	M1 (Zn)	M2 (Cu)	M3 (Control)	750	1500	2000
Number of fiber cells per bundle	20.3± 1.3	16.4 ± 1.3	20.3± 1.2	19.9± 1.4	18.5± 1.1	16.8± 0.9	18.9± 1.0	20.6± 1.1
Number of bundle per cross section	26.0± 1.0	23.2 ± 0.7	26.3± 1.0	25.6± 0.8	24.9± 0.9	23.6± 0.9	25.0± 1.1	27.1± 0.8
Number of fiber cells per cross section	527.8	380.6	533.9	509.4	460.7	396.5	472.5	558.3
Fiber index (mm^3)	9218.9	6579.7	10576.8	9719.6	7967.0	8778.9	8949.5	9427.6

Table 41. Mean values of fiber cells per bundle, fiber bundles and fiber cells per cross section and fiber index in the flax stem cross section as affected by strains, microelements and seeding rates in 1990/91 season.

Characters	Strains		Microelements			Seeding rates (seeds/m²)		
	S1 (19/31)	S2(2419/1)	M1 (Zn)	M2 (Cu)	M3 (Control)	750	1500	2000
Number of fiber cells per bundle	20.1± 1.1	14.2± 1.2	20.1± 1.3	19.6± 1.1	17.5± 1.2	16.2± 0.8	18.6± 1.3	19.9± 1.0
Number of bundle per cross section	24.1± 1.1	21.1± 0.6	24.3± 0.7	23.4± 0.6	22.2± 0.7	21.9± 0.7	23.3± 0.8	25.9± 1.0
Number of fiber cells per cross section	484.4	299.6	488.4	458.6	388.5	354.8	433.4	515.4
Fiber index (mm^3)	8040.8	5386.1	9126.9	8696.0	7158.1	7998.2	8303.2	8514.2

cells per cross section, respectively. Cupper increased the number of fiber cells per bundle by 1.4 and 2.1 cells in 1989/90 and 1990/91, respectively, also, increased number of bundles per cross section by 0.7 and 1.2 bundle in the two successive seasons. Whereupon, the number of fiber cells per cross section increased by Cu application when compared with untreated check, this increase was 48.7 and 70.1 cells in the first and second season, respectively.

With regard to fiber index, data indicated that microelements favourably affected this trait in both seasons. Zinc and Cupper application increased fiber index values by 2609.8 and 1752.6 mm^3, respectively over the untreated check in 1989/90 season. The corresponding increases in 1990/91 season were 1968.8 and 1537.9 mm^3 for Zn and Cu, respectively.

It could be concluded that foliar applications with Zn and Cu seemed to accelerate cell division and to encourage fiber cells production in flax stems. Other investigators, however, showed that application of Zn or Cu favourably affected flax growth (**Bottini, 1964; Stetsenko and Chepikov, 1970** and **Abo El-Soad *et al.*, 1975**).

Concerning seeding rates, results showed that the highest plant density produced the highest number of fiber cells per bundle, number bundles per cross section and fiber cells per cross section in both seasons. The number of fiber cells per bundle in stems of plants seeded at 2000 seeds/m^2 were 20.6 and 19.9 cells in 1989/90 and 1990/91 season, respectively. In relation to number of bundles per cross section, means were 27.1 and 25.9 bundle per cross section of plant stems seeded at the highest plant density in the first and second season, respectively. Whereupon, the number of fiber cells per cross section increased in stem of plants seeded at 2000 seeds/m^2, being 558.3 and 515.4 cells in the two successive seasons.

Flax stems of plants seeded at the highest rates recorded the highest means of fiber index than those seeded at lowest rate by 6.88 and 6.06% in 1989/90 and 1990/91 season, respectively. Similar results were obtained by **El-Shimy *et al.*, (1992)**.

Generally, it can be concluded that the flax strain (19/31) was superior to the other one (2419/1) in fiber area per cross section, fiber ratio, fiber/xylem percentage, number of fiber cells per cross section and fiber index.

Concerning microelements application effects, zinc ranked first for increasing most of anatomical manifestations followed by cupper and the lowest mean

SUMMARY

Flax (*Linum usitatissimum* L.) crop is grown in Egypt as a dual purpose type " fiber and seeds", and its yield and quality are affected by many factors such as varieties, microelements and seeding rates.

Therefore, this study was carried out to investigate the effect of those factors on growth, yield and quality of fibers in flax.

Two field experiments were carried out at El-Gemmeiza Agricultural Research Station, ARC in 1989/90 and 1990/91 seasons, to evaluate two promising flax strains, S. (19/31), "released as Giza 7", and S. (2419/1); grown under different microelement treatments and different seeding rates in relation to growth, yield and yield components, in addition to anatomical and quality characters.

A split-split plot design with four replications was carried out in both seasons, the main plots were devoted for the two strains. The sub-plots were assigned to the three microelement treatments i.e., zinc, cupper at 250 ppm concentration and untreated control and the sub-sub plots for the six seeding rates i.e., 750, 1000, 1250, 1500, 1750 and 2000 seeds/m^2.

The main findings of the present investigation could be summarized as follows:

A: Growth characters

1. S_1 (19/31) plants were taller than S_2 (2419/1) plants, particularly at the later stages of growth. Also, S_1 plants had higher technical stem length compared with S_2 ones.

   No significant difference was detected with regard to dry weight per plant between the two strains. However, S_2 plants insignificantly outweighed S_1 plants at all stages of growth.

   With regard to percentage of different plant organs to total dry weight it was observed that S_1 plants had higher stem dry weight percentage at fourth stage of growth, whereas S_2 plants recorded higher leaves dry weight percentage, but no significant difference was detected in roots dry weight percentage.

   Also S_2 plants had higher number of upper branches and number of capsules per plant compared with S_1 plants.

2. Zinc application significantly increased plant height at all growth stages, stem dry weight percentage (at early stages of growth). Cupper application increased leaves dry weight percentage at early and later stages of growth.

B. Yield and yield components

I Straw yield and its related characters

1. S_1 (19/31) plants were significantly superior to S_2 (2419/1) plants with regard to technical stem length; and produced greater number of basal branches per plant and higher straw yield per plant and per feddan, whereas S_2 plants were higher in length of top capsules zone and stem diameter. S_1 outyielded S_2 in straw yield per feddan by 4.14 and 12.16% in the first and second season, respectively.

2. Zinc application insignificantly increased technical stem length. Also, Zn and Cu in general and Zn in particular insignificantly increased length of top capsule zone, stem diameter, number of basal branches per plant, straw yield per plant and per feddan.

3. Increasing seeding rate significantly increased technical stem length and straw yield per feddan, but significantly decreased length of top capsule zone, stem diameter, number of basal branches and straw yield per plant.

4. The effect of interactions between the experimental factors was only significant between:

strain x microelements on straw yield per feddan in the first season and among strains x microelements x seeding rates on straw yield per plant in both seasons.

II Seed yield and its related characters

1. S_2 (2419/1) plants were significantly superior to S_1 (19/31) with regard to number of capsules per plant, number of seeds per capsules and per plant, number of upper branches per plant, seed yield/plant and per feddan, and seed index.

   Such results indicate the superiority of S_2 in seed production where it outyielded S_1 by 2.40 and 2.47% in the first and second season, respectively.

2. Microelements application had no significant effect on all seed yield components. However, slight and insignificant increases in seed yield and its components were observed due to Zn and Cu application.

3. Increasing seeding rates significantly reduced seed yield components. On the other hand, seed yield per feddan significantly increased as a result of increasing seeding rate. The seed yield per feddan was increased by about 58 kg per feddan

due to increasing seeding rate from 750 to 2000 seeds/m^2 in the two seasons.

4. The effect of the interaction between strains and seeding rates was only significant on number of capsules per plant in 1989/90 season.

   Also, the second order interaction significantly affected number of capsules per plant (in the first season), number of seeds per plant (in the first season) and number of upper branches per plant in both seasons.

III Technological characters

1. S_1 (19/31) plants were significantly superior to S_2 (2419/1) plants in fiber yield per plant and per feddan, fiber length, long fiber percentage as well as fiber fineness. On the other hand, S_2 plants were significantly superior to S_1 plants with regard to oil percentage as well as oil yield per feddan.

   S_1 outyielded S_2 in fiber yield per feddan by 24 and 29%, respectively, in the first and second season, whereas S_2 outyielded S_1 in oil yield by 7.5 and 7.8%, respectively in 1989/90 and 1990/91 seasons.