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Micronutrients, B-Vitamins and Yeast in Relation to Increasing Flax (*Linum usitatissimum* L.) Growth, Yield Productivity and Controlling Associated Weeds

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Abstract: The results of applying (post-em.) micronutrients (1.5 mg L^{-1}), yeast (2.5, 5, 7.5 g), thiamine and riboflavin (25, 50, 75 mg/each) have shown great activity on increasing growth and yield productivity of flax cv. Giza 5 with no advantage set of one upon another, particularly when applied individually not in mixture. Yet, the combined application of the two vitamins plus micronutrients was, to some extent, much more effective. Applying riboflavin plus micronutrients precisely at the moderate concentration of riboflavin (50 mg L^{-1}) was the best in this regard. The data recorded in that 13.33-189.74% increment in growth and up to 63.23% in yield productivity. Hand weeded was almost good, causing significant increments in crop growth and yield productivity estimated by up to 163.15 and 92.25%, respectively. Significant results were also reported on increasing oil yield percentage of all crop treatments. On the opposite side of the activity, weeds growth were also affected (a reduction effect was occurred) and the most significant results (76.19-85.71% inhibition) were also obtained with applying riboflavin plus micronutrients at 50+1.5 mg L^{-1}. There is a strong thought to be believed that increasing the competitive and/or the allelopathic ability of flax-treated plants could be the real reason behind this authority. Increasing growth vigor of flax plants representing in the plant height, fresh and dry weights of shoot biomass is a strong evidence of the first assumption. The *in vitro* investigation of flax-yielded seeds strengthens the second vision. The results of that showed a significant decreasing in the seed germination percentage (7.44-42.26%) and seedling root (16.41-54.07%) and shoot (10.58-57.64%) growth of the two seeds selected for the investigation, including *Portulaca oleracea* L. and *Echinochloa crus-galli* L. Upon the results obtained and drawn conclusions, using such naturally sources of crop treatments either alone or in combination is hardly required not only for the best yield could be obtained, but also in term of continuous searching for more friendly and economically sounder agro-chemicals. We may, therefore, recommend riboflavin plus micronutrients at 50+1.5 mg L^{-1} as the best treatment could be chosen for the best results could be obtained over the two sides of action; combating weeds and increasing crop productivity.

Key words: Allelopathy, flax, riboflavin, thiamine, weeds, yeast

INTRODUCTION

When we are talking about the dual purpose crops for producing fibers and oil, flax (*Linum usitatissimum* L.) is coming quickly to mind after cotton as one of the most economic important crop all-over the world. The history of flax is too old and no evidence is stronger than those

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discovered in the Pharaonic caves where the plant and its products were perfectly used in embalming human bodies of Pharaonic kings. From that time on, flax has a special value within the Egyptian community for its multifarious utilizations. It is implicated in several household and industrial tasks such as making ropes, textile, spinning and wearing materials as well as twines and extracting oils. The oil of the plant is an edible for human feeding and also common in fabricating paints and different types of varnishes. Nowadays, the benefits of flax have passed all expectations. Regardless the well-known ordinary uses, the crop has more benefits in producing feeding stuff for animals and poultry and moreover in producing some kinds of compact wood, popular in name particle board. The crop is also popular in several fine industries in which making electric insulations and non-textile medical materials are the most important. More valuable is that related to producing bank note papers. These all and more in reasons are created a good basic for researchers and governments to work on enhancing and developing such impressive plant. The selection of new varieties had a great impact in this regard. Preserving plants from pest hazards was an obligatory of all strategies of development and progress and the results were magnificent. Subjugating the plant to the different programs of fertilization had also a large stride of digging and research (El-Gazzar, 2000; El-Hariri *et al*., 2002). Using growth regulators had also a great history of examination (El-Hariri *et al*., 1998; El-Gazzar, 2006).

Weeds like many other pests are so dangerous. It causes crop growth and hence its productivity reduced to a minimum. In a crop like what we have (flax), the losses in yield were estimated in between 67 and 70%, to complete crop failure as in many cases of heavy infestation (Al-Kaisi, 1987; Wall and Smith, 2000). To be in or under the economic threshold of infestation is then an obligatory to keep our crops safe and healthy. The way for that to be achieved is multifarious. The agricultural, mechanical and chemical methods for controlling weeds were killed in research and still to be in a circus of interest. Searching for new friendly chemicals for weed control is the new hope for the coming future. Great efforts are given now to use natural products from plants and microbes as a new approach of commercial herbicides. Great successes were obtained in some cases and great failure was recorded in others (Lydon and Duke, 1989; Duke *et al*., 2002). As a new prospect, allelopathy (the main source of natural products with herbicidal potential) has also received all concern. As a cheapest, effective and friendly tool, it is gained all respect of researcher's side. Allelopathy has been used in several agricultural practices such as controlling weeds, intercroppings, nutrient recycling and low external-input farming practices (Rizvi and Rizvi, 1987). Developing such ability within our economic crops is a new point of research. Quintessential example is that released by El-Shahawy *et al*. (2007), who showed great influence of glutathione and ascorbic acid in their applying of marjoram plants. The main conclusion of the author and his colleagues is that the resultant plants have become more virulence and competitive than their correspondence of untreated plants.

Growth regulators were always a matter of researchers' concern for solving many agricultural problems related to inferior growth and less in productivity due to environment tough and/or contaminating its factors including air, water and soil. It composes hundreds of compounds differed in their properties and physiological activities. This includes hormones, vitamins, micronutrients and different others of miscellaneous compounds. They are well-known by managing and regulating many of pivotal positions e.g., photosynthesis, chlorophyll biosynthesis and enzymes activity (Samiullah *et al*., 1988; Belanger *et al*., 1996; Gamal El-Din *et al*., 2004; Gamal El-Din, 2005). They also have an amazing role of making plants tolerant to any of undesirable conditions like lack of nutrients, salinity, drought, pollution, frosting or any of other environmental stresses (Hausladen and Alscher, 1993; Sayed and Gadallah, 2002). These benefits are all, undoubtedly, pouring in the good of the plant. Increasing mass vegetative growth, root growth and hence yield productivity is then expected upon response. In growth regulators research, weeds growth and its direct or indirect influence by such chemicals was always the absent side, although of its extreme importance in the productivity of the crops.

The objective of the present study is, therefore, to study the effect of certain vitamins (e.g., thiamin and riboflavin), yeast (in its active form) and micronutrients on the growth and development of flax as it is considered one of the most economic important crops in Egypt, beside making a note on the effect of the associated weeds.

MATERIALS AND METHODS

Two greenhouse experiments were conducted in this regard. The experiments were taken place at the screening house of National Research Center, Egypt during the two successive seasons 2003-2005. Flax (*Linum usitatissimum* L. cv. Giza 5) seeds were obtained from Agricultural Research Center, Ministry of Agriculture, Egypt. The seeds were sown simultaneously with certain broad and narrow-leaved weeds in 30 cm diameter pottery pots (10 seeds/each). The weed seeds under investigation were lambsquarter, *Chenopodium album* L. and oat, *Avena fatua* L. The two species were selected as assay species because it is often found in the fields of flax growth. The soil content of any others of weedy species was also considered. The soil texture has been defined as a sandy loam soil of a sand representing (39.8%), silt (28.4%) and clay of about (31.8%). The emerged plants of flax have received all necessary care of watering and fertilization. Thiamine, riboflavin and yeast foliar application treatments were prepared in three concentrations; micronutrients were set in only one, that recommended by the producing company (Table 1). All possible combinations between the two vitamins and micronutrients were also considered. The treatments were all applied as a post-emergence 30 days after sowing.

After three weeks of the treatment, all data and other observations on flax and weeds growth were taken thoroughly. The data included several measurements on the plant height (cm), fresh and dry weights (g) of shoot biomass of flax and fresh and dry weights of weeds only. At harvest stage, the data on yield (g/plant) and its components including number of fruiting branches/plant, number of capsules/plant, weight of capsules/plant (g) weight of 1000 seeds (g) and biological yield/plant (g) were estimated of all grown plants. Certain other vegetative and chemical characteristics were also considered including total length (cm), technical length (cm), fruiting zone length (cm), straw yield/plant (g) and oil seed percentage. Six pots were used for each treatment in a completely randomized design; water was used as a control. The pots of each treatment were divided equally between taken weed and crop samples.

Table 1: The wholly foliar application treatments

Treatments (common name)	Trade name	Chemical structure	Rate of application (mg L^{-1})
Micronutrients	Fetrilon, Giri	Fe; Mn; Zn (3.8%)	1.5
Thiamine	Vitamin B1	$C_{12}H_{17}N_4OS$	25.0
			50.0
			75.0
Riboflavin	Vitamin B2	$C_{17}H_{20}N_4O_6$	25.0
			50.0
			75.0
Fresh yeast*	Baking yeast	--	2500.0
			5000.0
			7500.0
Thiamine + micronutrients	--	--	25 + 1.5
			50 + 1.5
			75 + 1.5
Riboflavin+ micronutrients	--	--	25 + 1.5
			50 + 1.5
			75 + 1.5
Hand weeded	--	--	--
Control (weedy check)	--	--	--

*: Yeast has a special way of preparation including dissolving with an equal amount of sucrose (50 g) in 500 mL of distilled water and left to stand at room temperature (25°C) till complete fermentation (12 h) to release growth substances (Methods established by Skook and Miller, 1957)

The chemical analysis of the oil seed content in the treated and untreated seeds was carried out by imbedding 1 g of all ground seeds in 50 mL of petroleum ether (40-60°C) and then allowed to extract overnight using Soxhlet apparatus (AOCS, 1964).

Screening Test for the Allelopathic Activity of Flax-Yielded Seeds

This experiment was carried out to measure any substantial changes in the allelopathic activity of flax-yielded seeds in response to the different foliar application treatments. Two seeds were examined for such ability representing certain broad-(purslane, *Portulaca oleracea* L.) and narrow-(barnyard-grass, *Echinochloa crus-galli* L.) leaved weeds. The selection of the two assayed species was based on the sensitivity to the natural phytotoxins not on their existence or nonexistence in flax fields. Ten of each of flax and weed seeds were sown simultaneously in 12 cm glass Petri dishes with continuous supplying of distilled water (3 mL at the beginning of the experiment followed by 1 mL/3 days) for a total of 15 days. The seed germination (%) was estimated within the first 5 days of the experiment; meanwhile the root and shoot length (cm) were estimated 10 days later. Three replicates were used for each treatment in a completely randomized design. An additional three replicates of distilled water treatments were used as a control.

All data were subjected to analysis variation using ANOVA, followed by the least significant differences test (LSD, p = 0.05) according to the methods of Gomez and Gomez (1984). The biological activity of wholly crop treatments on weeds and crop development was also estimated following the equation of Itokawa *et al.* (1982).

RESULTS

The effect of applying the different treatments on growth and development of flax is shown in Table 2. It was obvious that the different treatments either applied alone or in combination, have significantly increased the mass vegetative growth of the plant including the plant height, number of branches/plant and fresh and dry weights of shoot biomass. Applying micronutrients alone at

Table 2: Effect of different treatments and their combinations on the growth and development of flax (Combined analysis of two successive seasons, 2003-2005)

		Three weeks of treatment				Harvest stage			
Treatments	Conc. (mg L^{-1})	Plant height (cm)	Fresh weight (g)	Dry weight (g)	No. of branches/ plant	Total length (cm)	Technical length (cm)	Fruiting zone length (cm)	Strawyield/ plant (g)
Micronutrients	1.5	50.80	1.88	0.45	2.60	85.90	62.30	23.60	3.30
Thiamine	25	40.00	1.00	0.22	2.10	77.40	54.60	22.60	3.00
	50	48.00	1.20	0.25	2.00	82.20	56.30	25.50	3.10
	75	39.60	1.03	0.22	1.50	75.40	51.50	23.50	2.90
Riboflavin	25	42.50	1.30	0.29	2.00	79.60	56.70	22.50	3.90
	50	43.50	1.36	0.30	2.00	85.20	60.70	24.50	4.00
	75	43.10	1.33	0.30	2.10	82.60	59.00	23.60	3.70
Yeast	2500	48.00	1.17	0.26	2.20	83.00	58.40	24.60	3.20
	5000	51.30	1.92	0.42	2.50	87.80	59.03	28.77	3.50
	7500	50.80	2.00	0.46	2.40	88.40	63.20	25.20	3.70
Thiamine +	25+1.5	40.20	1.00	0.22	1.70	77.60	53.00	24.60	2.90
micronutrients	50+1.5	47.00	1.15	0.21	1.60	78.10	56.90	21.20	2.96
	75+1.5	39.20	0.99	0.20	1.70	74.50	55.00	19.50	2.83
Riboflavin +	25+1.5	50.80	1.85	0.37	2.30	81.30	58.80	22.50	3.80
micronutrients	50+1.5	55.20	2.28	0.55	2.50	89.30	63.40	25.50	4.20
	75+1.5	49.00	1.65	0.33	2.00	87.40	65.40	22.00	4.06
Hand weeded		54.00	2.15	0.50	2.30	88.00	64.80	23.60	4.10
Control		39.20	0.98	0.19	1.30	74.10	51.20	22.50	2.80
LSD 0.05		4.43	0.59	0.11	NS	4.61	3.00	1.50	0.55

NS: Not Significant

Table 3: The biological response of different treatments on increasing growth and development of flax

		Increasing (%) of control							
		Three weeks of treatment				Harvest stage			
Treatments	Conc. (mg L^{-1})	Plant height	Fresh weight	Dry weight	No. of branches/ Plant	Total length	Technical length	Fruiting zone length	Straw yield/ Plant
Micronutrients	1.5	29.59	91.83	136.84	100.00	15.92	21.67	4.88	17.85
Thiamine	25	2.04	2.04	15.78	61.53	4.45	6.64	0.44	7.14
	50	22.44	22.44	31.57	53.84	10.93	9.96	13.33	10.71
	75	1.02	5.10	15.78	15.38	1.75	0.58	4.44	3.57
Riboflavin	25	8.41	32.65	52.63	53.84	7.42	10.74	0.00	39.28
	50	10.96	38.77	57.89	53.84	14.97	18.55	8.88	42.85
	75	9.95	35.71	57.89	61.53	11.47	15.23	4.88	32.14
Yeast	2500	22.44	19.38	36.84	69.23	12.01	14.06	9.33	14.28
	5000	30.86	95.91	121.05	92.30	18.48	15.29	27.86	25.00
	7500	29.59	104.08	142.10	84.61	19.29	23.43	12.00	32.14
Thiamine +	25+1.5	2.55	2.04	15.78	30.76	4.72	3.51	9.33	3.57
micronutrients	50+1.5	19.89	17.34	10.52	23.07	5.39	11.13	nil	5.71
	75+1.5	0.00	1.02	5.26	30.76	0.53	7.42	nil	1.07
Riboflavin +	25+1.5	29.59	88.77	94.73	76.92	9.72	14.84	0.00	35.71
micronutrients	50+1.5	40.81	132.65	189.47	92.30	20.51	23.82	13.33	50.00
	75+1.5	25.00	68.36	73.68	53.84	17.94	27.73	nil	45.00
Hand weeded		37.75	119.38	163.15	76.92	18.75	26.56	4.88	46.42

1.5 mg L^{-1} had a good impact in this regard, estimated in respect to the control by 29.59 to 136.48%. Applying thiamine and riboflavin alone at the different concentrations was less in efficiency particularly of increasing the plant height and fresh and dry weights of shoot biomass. However, the best result could ever be obtained with applying thiamine and riboflavin (alone) is that estimated on increasing the number of branches/plant which was estimated by 61.53% increment over control (Table 3). Using yeast (alone too) at the different concentrations was also in superior which had effect in equal or more efficiency (up to 142.10% increasing) of applying micronutrients or even the two vitamins under the study. The best results could ever be obtained is that reported with the highest concentration (7.5 g L^{-1}) of it.

Applying the two vitamins in combination with micronutrients at the different concentrations hasn't offered a new of applying either of them separately. However, using riboflavin plus micronutrients was far good on increasing growth if compared with its correspondence of thiamine/micronutrients mixed one. The effect on total length, technical length, fruiting zone length and straw yield of the plant at harvest stage has also taken a similar trend of all treatments and attributes mentioned before. Hand weeded was of great efficiency as well. It caused crop growth to increase by up to 163.15% in comparison with control.

The effect on associated weeds is shown in Table 4 and 5. It was clear the significant effect of all treatments either applied alone or in combination in reducing the growth of the different associated weeds including broad and narrow-leaved species at both stages of growth, seedling and harvest stages. The weed growth with applying micronutrients alone was reduced by 57.15 to 79.11% in comparison with control. The weed reduction in thiamine and riboflavin foliar application was estimated in between 7.04 and 73.36%. Meanwhile, the results recorded 47.62-78.32% with applying yeast at the different concentrations. Overall, the activity was increased as the concentration increased. Applying the two vitamins in combination with micronutrients was, to some extent, much more effective than the individual application of either of them, particularly when to be used at the moderate (50 mg L^{-1}) and highest (75 mg) concentrations. However, still to be using riboflavin plus micronutrients was much more efficient (65.31-85.71% growth reduction)

Table 4: Effect of different treatments and their combinations on the growth and development of flax accompanying weeds. (Combined analysis of two successive seasons, 2003-2005)

		Three weeks of treatment						Harvest stage		
		Broad leaves		Narrow leaves		Total weeds		Broad leaves	Narrow leaves	Total weeds
Treatments	Conc. (mg L^{-1})	Fr. Wt. (g)	Dr. Wt. (g)	Fr. Wt. (g)	Dr. Wt. (g)	Fr. Wt. (g)	Dr. Wt. (g)	Fr. Wt. (g)	Dr. Wt. (g)	Fr. Wt. (g)
Micronutrients	1.5	0.80	0.18	0.57	0.08	1.37	0.26	2.98	0.78	3.76
Thiamine	25	3.56	0.38	1.40	0.25	4.96	0.64	9.40	3.33	12.73
	50	2.60	0.28	1.16	0.18	3.76	0.46	7.00	2.26	9.26
	75	2.50	0.27	1.04	0.18	3.54	0.45	7.30	2.46	9.76
Riboflavin	25	1.35	0.19	0.98	0.17	2.33	0.37	4.26	1.26	5.52
	50	1.06	0.19	0.90	0.17	1.96	0.36	3.46	1.11	4.57
	75	1.02	0.18	1.00	0.17	2.02	0.36	3.95	1.38	5.33
Yeast	2500	1.40	0.22	0.80	0.16	2.20	0.38	3.50	1.83	5.33
	5000	1.03	0.19	0.70	0.10	1.73	0.29	3.20	1.13	4.33
	7500	0.83	0.16	0.57	0.08	1.40	0.24	2.95	0.65	3.60
Thiamine +	25+1.5	2.26	0.23	1.11	0.18	3.37	0.41	5.86	2.16	8.02
micronutrients	50+1.5	2.16	0.22	1.06	0.18	3.22	0.40	5.50	2.05	7.55
	75+1.5	2.10	0.22	1.32	0.25	3.42	0.47	5.80	2.21	8.01
Riboflavin +	25+1.5	0.83	0.13	0.60	0.08	1.43	0.21	3.36	1.20	4.56
micronutrients	50+1.5	0.60	0.10	0.37	0.05	0.97	0.15	2.56	0.50	3.06
	75+1.5	0.63	0.10	0.43	0.06	1.06	0.17	2.90	0.85	3.75
Hand weeded		nil	nil	nil	nil	nil	nil	nil	nil	nil
Control		3.83	0.42	2.40	0.35	6.23	0.77	12.16	3.46	15.62
LSD 0.05		0.16	0.009	0.12	0.008	0.23	0.016	0.73	0.64	1.290

Table 5: The biological responses on inhibiting flax accompanying weeds

		Inhibition (%) of control								
		Three weeks of treatment						Harvest stage		
		Broad leaves		Narrow leaves		Total weeds		Broad leaves	Narrow leaves	Total weeds
Treatments	Conc. (mg L^{-1})	Fr. Wt.	Dr. Wt.	Fr. Wt.	Dr. Wt.	Fr. Wt.	Dr. Wt.	Fr. Wt.	Dr. Wt.	Fr. Wt.
Micronutrients	1.5	79.11	57.15	76.25	77.14	78.01	66.23	75.49	77.45	75.92
Thiamine	25	7.04	9.52	41.66	28.57	20.38	18.18	22.69	3.75	18.50
	50	32.11	33.33	51.66	48.57	39.64	40.26	42.43	34.68	40.71
	75	34.72	35.71	56.66	48.57	43.17	41.56	39.96	28.90	37.51
Riboflavin	25	64.75	54.76	59.16	51.42	62.60	53.25	64.96	63.58	64.66
	50	72.32	54.76	62.50	51.42	68.53	53.25	71.54	67.91	70.74
	75	73.36	57.14	58.33	51.42	67.57	54.55	67.51	60.11	65.87
Yeast	2500	63.44	47.62	66.66	54.28	64.68	50.56	71.21	47.10	65.87
	5000	73.10	54.76	70.83	71.42	72.23	62.34	73.68	67.34	72.27
	7500	78.32	61.90	76.25	77.14	77.52	68.83	75.74	81.21	76.95
Thiamine +	25+1.5	40.99	45.24	53.75	48.57	45.90	46.75	51.80	37.57	48.65
micronutrients	50+1.5	43.60	47.62	55.83	48.57	48.31	48.05	54.76	40.75	51.66
	75+1.5	45.16	47.62	45.00	28.57	45.10	38.96	52.30	36.12	48.71
Riboflavin +	25+1.5	78.32	69.05	75.00	77.14	77.04	72.72	72.36	65.31	70.80
micronutrients	50+1.5	84.33	76.19	84.58	85.71	84.43	80.51	78.94	85.54	80.40
	75+1.5	83.55	76.19	82.08	82.85	82.98	79.22	76.15	75.43	75.99
Hand weeded		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

than in using thiamine plus micronutrients (28.57-55.83%); irrespective of the rate of application. Hand weeded is to be the best overall, entirely eradicated all grown weeds of all types and species.

The effect on yield and its components had a similar trend of increasing as much as those of mass vegetative growth Table 6 and 7. Micronutrients (in its single application) have caused crop yield

Table 6: Effect of different treatments on yield and its components including oil seed yield. (Combined analysis of two successive seasons, 2003-2005)

Treatments	Conc. (mg L^{-1})	No. of fruiting branches/plant	No. of capsules /plant	Weight of capsules/ plant (g)	Weight of 1000 seeds (g)	Biological yield/ plant (g)	Seed yield/ plant (g)	% of oil seed
Micronutrients	1.5	4.83	24.30	1.01	4.93	4.25	0.95	34.36
Thiamine	25	4.06	15.60	0.78	3.93	3.73	0.73	30.99
	50	4.10	21.90	0.86	4.16	3.90	0.80	31.91
	75	3.83	15.68	0.79	4.06	3.65	0.75	30.93
Riboflavin	25	4.60	21.90	0.94	4.46	4.78	0.88	33.59
	50	5.16	23.50	1.05	4.83	4.92	0.92	34.62
	75	5.01	23.00	0.98	4.73	4.61	0.91	33.59
Yeast	2500	4.40	22.20	0.95	4.50	4.10	0.90	33.59
	5000	4.76	23.80	1.03	4.66	4.41	0.91	37.42
	7500	5.10	24.80	1.11	5.33	4.69	0.99	42.27
Thiamine +	25+1.5	4.53	20.60	0.88	4.20	3.73	0.83	31.47
micronutrients	50+1.5	4.63	21.70	0.92	4.26	3.81	0.85	34.33
	75+1.5	4.30	18.90	0.80	3.99	3.58	0.75	30.68
Riboflavin +	25+1.5	5.16	24.80	1.01	4.93	4.76	0.96	36.82
micronutrients	50+1.5	6.20	28.60	1.16	5.60	5.31	1.11	42.85
	75+1.5	5.73	24.30	1.10	5.36	5.07	1.01	33.34
Hand weeded		5.16	25.50	1.13	5.50	5.16	1.06	39.48
Control		3.16	13.06	0.76	3.83	3.48	0.68	29.01
LSD 0.05		0.64	1.88	0.17	0.48	0.66	0.11	1.64

Table 7: The biological responses on increasing yield and its components including oil yield (%)

		Increasing (%) of control						
Treatments	Conc. (mg L^{-1})	No. of fruiting branches/plant	No. of capsules /plant	Weight of capsules/ plant	Weight of 1000 seeds	Biological yield/ plant	Seed yield/ plant	% of oil seed
Micronutrients	1.5	52.84	86.06	32.89	28.72	22.12	39.70	18.44
Thiamine	25	28.48	19.44	2.63	2.61	7.18	7.35	6.82
	50	29.74	67.68	13.15	8.61	12.06	17.64	9.99
	75	21.20	20.06	3.94	6.00	4.88	10.29	6.61
Riboflavin	25	45.56	67.68	23.68	16.44	37.35	29.41	15.78
	50	63.29	79.93	38.15	26.10	41.37	35.29	19.33
	75	58.54	76.11	28.94	23.49	32.47	33.82	15.78
Yeast	2500	39.24	69.98	25.00	17.49	17.81	32.35	15.78
	5000	50.63	82.23	35.52	21.67	26.72	33.82	28.99
	7500	61.39	89.89	46.05	39.16	34.77	45.58	45.70
Thiamine +	25+1.5	43.35	57.73	15.78	9.66	7.18	22.05	8.47
micronutrients	50+1.5	46.51	66.15	21.05	11.22	9.48	25.00	18.33
	75+1.5	36.07	44.71	5.26	4.17	2.87	10.29	5.75
Riboflavin +	25+1.5	63.29	89.89	32.89	28.72	36.78	41.17	26.92
micronutrients	50+1.5	96.20	118.98	52.63	46.21	52.58	63.23	47.70
	75+1.5	81.32	86.06	44.73	39.94	45.68	48.52	14.92
Hand weeded		63.29	95.25	48.68	43.60	48.27	55.88	36.09

per plants to increase by 39.70% and its components by 22.12 to 86.06%. Applying riboflavin alone was far good than its similar of thiamine applied alone, too. The crop yield and its components was increased by 29.41-35.29 and 16.44-79.93%, respectively for applying riboflavin in comparison with 7.35-17.64 and 2.61-67.68% for applying thiamine. However, seeming to be clear that the best results be obtained are those of applying the moderate concentration (50 mg L^{-1}) of the two compounds. Applying yeast alone was also good in increasing yield and its components at either of the three concentrations have been used. However, the best results be obtained of micro-organism solution are those of applying the highest concentration (7.5 g L^{-1}) of it. The data estimated in this regard 45.58% increasing in crop yield and up to 89.89% in its components.

Applying thiamine and riboflavin in combination with micronutrients was fluctuated in their response of increasing yield and its components. Riboflavin in combination with micronutrients had the best results in this regard than thiamine/micronutrients mixed one. Of that, the data recorded up to 63.23% increasing in yield and 118.98% in its components for applying riboflavin plus micronutrients at the different rates of concentration compared to 25 and 66.15%, respectively for applying thiamine/micronutrients mixed one. However, it is worthy to mention that the moderate (50+1.5 mg L^{-1}) concentration in either two cases of applying the two vitamins plus micronutrients is the best overall particularly when compared with the two other mixed concentrations (lowest, 25+1.5 and highest, 75+1.5 mg, ones) either for increasing yield or its components. Hand weeded was of equal or more efficiency of the others including single and combined applications. It caused crop yield to increase by 55.88% and its components by up to 95.25% in comparison with control.

On oil content of yielded seeds, the data recorded the best results with applying the combined application treatments of riboflavin plus micronutrients particularly at 50+1.5 mg L^{-1}; that result was estimated by 47.7% increasing over control. Applying yeast alone at 7.5 g L^{-1} and hand weeded was the second in proficiency, scoring in respect to the control 45.70 and 36.09% increasing, respectively.

Enhancing the allelopathic ability of flax plants received treatments is the dominant action in Table 8. Applying the different treatments of flax yielded seeds significantly affected the growth and development of the two assayed species (a reduction effect was estimated), including purslane and barnyard-grass weeds. The effect was more pronounced on root and shoot growth rather than on the seed germination percentage. No much significant differences were observed between the two species with respect to certain reservation upon purslane seedlings which relatively was more sensitive than its similar of barnyard-grass.

Table 8: The allelopathic effect of flax yielded seeds under the different treatments of micronutrients, vitamins B1 and B2 and yeast applications

		Assayed seeds											
		Purslane, *Portulaca oleracea* L.						Barnyard-grass, *Echinochloa crus-galli* L.					
					Inhibition (%) of control						Inhibition (%) of control		
Mother source treatment	Conc. (Mg L^{-1})	G (%)	R (cm)	S (cm)	G	R	S	G (%)	R (cm)	S (cm)	G	R	S
Micronutrients	1.5	90.00	2.70	1.39	0.00	26.63	45.49	76.66	5.50	5.09	11.54	30.02	13.13
Thiamine	25	83.33	2.79	1.65	7.44	24.18	35.29	73.33	5.61	4.46	15.35	28.62	23.89
	50	80.00	2.43	1.49	11.11	33.96	41.56	63.33	5.45	4.30	26.90	30.66	26.62
	75	80.00	2.16	1.39	11.11	41.30	45.49	50.00	4.26	3.75	42.26	45.80	36.00
Riboflavin	25	80.00	2.48	1.72	11.11	32.60	32.54	60.00	5.16	4.91	30.71	34.35	16.21
	50	80.00	2.12	1.64	11.11	42.39	35.68	56.66	3.76	4.29	34.64	52.16	26.79
	75	80.00	1.87	1.47	11.11	49.18	42.35	50.00	3.61	3.90	42.26	54.07	33.44
Yeast	2500	90.00	2.42	1.58	0.00	34.23	38.03	73.33	5.54	4.80	15.35	29.51	18.08
	5000	70.00	2.28	1.43	22.22	38.04	43.92	60.00	4.50	4.46	30.71	42.74	23.89
	7500	66.66	2.19	1.28	26.00	40.48	49.80	53.33	4.02	3.72	38.45	48.85	36.51
Thiamine + micronutrients	25+1.5	80.00	2.62	2.04	11.11	28.80	20.00	76.66	6.57	5.08	11.54	16.41	13.31
	50+1.5	76.66	2.52	1.85	14.88	31.52	27.45	73.33	5.45	4.57	15.35	30.66	22.01
	75+1.5	80.00	2.40	1.08	11.11	34.78	57.64	53.33	5.15	3.84	38.45	34.47	34.47
Riboflavin + micronutrients	25+1.5	90.00	2.49	1.81	0.00	32.33	29.01	76.66	6.07	5.24	11.54	22.77	10.58
	50+1.5	76.66	2.35	1.73	14.88	36.14	32.15	53.33	5.71	4.53	38.45	27.35	22.69
	75+1.5	66.66	2.16	1.64	26.00	41.30	35.68	53.33	4.56	4.26	38.45	41.98	27.30
Control (free of treatment)		80.00	2.37	1.70	11.11	35.59	33.33	70.00	5.45	4.73	19.16	30.66	19.28
Control (weed seeds only)		90.00	3.68	2.55	--	--	--	86.66	7.86	5.86	--	--	--
LSD 0.05		NS	0.21	0.17	--	--	--	1.14	0.46	0.42	--	--	--

G, germination; R, root length; S, shoot length; NS, not significant

The situation did not differ too much between the single and combined applications of their influencing the allelopathic ability of flax yielded seeds. Applying, micronutrients alone has caused flax seeds in more virulence, resulted in reducing seedling growth of both weedy types by up to 45.49% in comparison with control. Flax seeds with foliar application by thiamine and riboflavin alone have generally reduced growth by 16.21-54.07% and seed germination percentage by 7.44-42.26%. Using yeast alone was in similar position to thiamine and riboflavin foliar application. Applying thiamine and riboflavin in combination with micronutrients was also far good, but was not surpass any of their correspondence of the different individual application treatments listed in the study. As a common feature of all treatments, the efficiency increased as the concentration increased.

DISCUSSION

Drawn conclusions from the different treatments revealed of the reliability of the micronutrients, riboflavin, thiamine and yeast treatments on increasing growth and yield productivity of flax, our main target crop, either they applied alone or in combination. The physiological and/or nutrient role of such compounds and/or biological organs (e.g., yeast) entirely has a direct impact with such findings all. The supported publications are numerous and can be reviewing in the following;

Applying vitamins, recently, has the same importance beside growth regulators for being used in enhancing growth and overcoming many of undesirable conditions against growth. Researchers see vitamins as endemic growth factors influencing many of pivotal positions, of which increasing the metabolic rate within the plants is the most important all-over the others. Altering the redox system is the main mechanism of which they are thought to be acting through (Chailakhyan, 1957; Kydrev, 1966). Vitamins could then be considered as a basic part of plant growth regulators, which in a brief word functioned originally in regulating growth and development processes of the plants via altering the endogenous plant hormones level or by changing the capacity of the plant to respond to its natural hormones.

Regarding thiamine (vitamin B1), the data showed great activity of the compound in enhancing the growth and productivity of the plant. Of the many functions ascribed to thiamine, relatively few are well characterized. It is clear, however, that thiamine is a major primary component for carbohydrates and fats biosynthesis (Robinson, 1973; Bidwell, 1980). In addition to its importance in maintenance growth and preserving activated status within the plants (Kawasaki, 1992; Belanger *et al*., 1996). Certain other modifications (e.g., increasing protein, amino acids, fixed and essential oil components) were also reported with the different applications of thiamine (Youssef and Talaat, 2003; Reda and Gamal El-Din, 2005). Zaki and Tarraf (1999) found great activity of thiamine in oilseed sesame to be considered in all similar crops as flax.

The physiological roles of vitamin B2 (riboflavin) and its position in regulating growth are also well recognized. Riboflavin is a cofactor for several enzymes in which isoalloxazine nucleus are transferable between reduced and oxidized form (Ruhland *et al*., 1961). Kodendaramaiah and Gopala (1985) found a strong correlation between B-vitamins and increasing growth within the plants. The authors attributed such authority to the motivating effect on the endogenous levels of the plant hormones including cytokinins and gibberellins. The compound has also essential role in increasing the photosynthetic rates within the plants. The role of vitamins B-complex is also well documented (Samiullah *et al*., 1988). This includes many activities of controlling plant photosynthesis, biosynthesis of chlorophyll, germination and enzymes reaction (Chen and Chen, 1995; Montez-Lopez and Rodriguez, 2001; Sayed and Gadallah, 2002). These facts are all strengthen our findings regarding the reliability of thiamine and riboflavin on increasing growth and yield productivity of flax.

Considerable attention also has been given to micronutrients and yeast micro-organisms for increasing growth and yield productivity of the plants. So far, the results obtained were coincided with those of many researchers. Reviewing the research reports could explain many inquiries about such proficiency.

Of micronutrients, subsequent experiments have proved the reliability of such components on increasing growth and yield productivity of flax including oil and fiber quality (Moawed, 2001; Mostafa and El-Deeb, 2003). Micronutrients play a great part in plant growth, although of its small needed by the plants. It is entering in many critical positions of managing growth and development within the plants. Of those especially of our concern (Fe, Mn and Zn), they are considered a basic part of several enzymes that control redox reactions within the plants (Mengel and Kirkby, 1982). They are also essential for plant metabolism of carbohydrates, proteins, phosphate, RNA, chlorophyll synthesis, nucleic acid biosynthesis and ribosome formation (Bidwell, 1980; Marschner, 1995; Mohr and Schopfer, 1995). In addition to their valuable role as precursors of several phytohormones.

On the other hand, literature is full of yeast researches. Its highly composition of bioorganic matters/nutrients is the essence of all researches. The chemical analysis of yeast revealed of affluent amounts of protein (47.2%) and less in quantity of arginine (2.6%), glysin (2.6%), histidin (1.4%), isolysine (2.9%), leucine (3.5%), lysine (3.8%), methionine (2.3%), cystine (0.6%), phenyl-alanine (3%), tyrosine (2.1%), therionine (2.6%), treptophan (0.5%) and vitamin B-complex in a percentage of about 2.9% of the total (NRP, 1977). In addition to its valuable containing of carbohydrates, sugars, fatty acids, hormones and macro-and micro-elements in a suitable balance for achieving the best results of growth (Ahmed *et al*., 1997; Khedr and Farid, 2000). Researchers, therefore, found yeast as an attractive medium of bio-fertilization researches for increasing growth and productivity of many of our economic crops (Fathy *et al*., 2000; Ali, 2001; Wahba, 2002). With these, many of our findings regarding yeast and micronutrients could then find a reasonable way for explanation which in most cases came in agreement with those of the different researchers dealing with this point.

Another direct reason that couldn't be ignored on increasing flax growth is that related to the great injuries have been found on the associated weeds. As it is well-known, weeds are one of the most serious pests influencing flax growth, reaching in some cases to complete crop failure as we know, so eliminating such interacting factors are, undoubtedly, reflected on increasing growth and yield productivity of our main target crop. The mechanism of action is not definitely clear; as should be the physiological effect on crop and weed is to be the same. On converse the truth, flax growth was dramatically increased in while weeds were headed down on the opposite side of the activity, a reduction influence was recorded. Increasing the competitive ability of flax plants upon the others of weeds could be one effective reason of what actually happened. The review has provided the proof on this assumption, since many cases of vitamins, micronutrients as well as yeast applications have caused significant increments in stem length, total biomass, No. of branches, No. of leaves and total leaf area of the different of treated plants (Modak *et al*., 1989; Naguib and Khalil, 2002; Mostafa, 2004). These all, of course, are the factors determined the competitive ability of one plant to be more virulence upon another.

Increasing the allelopathic ability of flax is another possible reason of action. However, any conclusion drawn with allelopathy as a sole reason for the observed inhibition would be unfair of the explanation. Willis (1985) listed a six-point protocol of allelopathy to be done. Most of them are coming in close contact with our findings. The one of great interest that could offer certain explanations of our results is that related to 'The observed pattern of inhibition can not be explained solely by physical factors or other biotic factors, especially competition or herbivory'. There is something should be like a chemical interaction is involved beside such factors (Olofsdotter *et al*., 1997). The observed pattern of inhibition is then better explained by a synergistic action of several mechanism of interference including allelopathy, competition and microbial interaction (may be). We agreed on this point as nature is too dynamic to be solely explained by a mechanism of plant interference (Blum, 1999). The present results provided the proof of this assumption, although there is no research work has been done on microbial interfering. The consistency between lab and greenhouse tests is a good finding strengthens this fact of the two factors could be involved in the study, allelopathy and

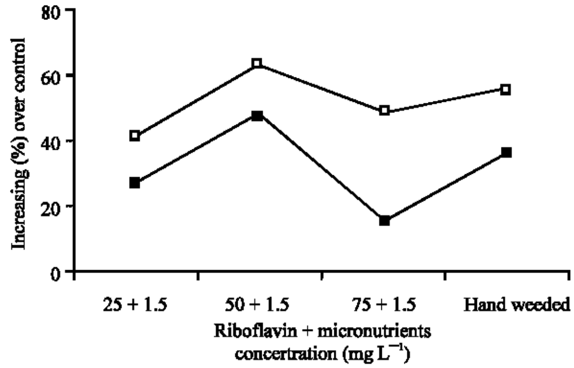

Fig. 1: The two most bioactive treatments, riboflavin plus micronutrients and hand weeded, in regard to increasing seed yield (□) and oil seed content (■)

competition. Researchers of allelopathy concern are always considering lab and field tests for well separation between allelopathy and competition (Olofsdotter *et al*., 1997; El-Shahawy *et al*., 2007). This explains why we are often going through such two ways of examination.

Not too much significant differences were observed between the different treatments of using vitamins, micronutrients and yeast either for controlling weeds or enhancing crop productivity. Comparison made between the individual applications of the different materials didn't favor one upon another. Yet, using the combined application treatments particularly those of riboflavin plus micronutrients at 50+1.5 mg L^{-1} was, to a large extent, much more better. It wasn't only good in term of improving yield productivity, but also had from the positive side on increasing oil yield content to be considered in highly position of grading. In converse to the highest concentration of such mixtures all, which headed down in most cases of the study (Fig. 1). We may conclude that mixing them in the right suitable balance is the main point of one mixture getting superior upon another. There is adequate literature of using riboflavin in aid of different adjuvant e.g., yeast and micronutrients and evidences accumulated of the proficiency of such combinations all on increasing growth and productivity of the plants (Rafaat and Balbaa, 2001; Naguib and Khalil, 2002).

From the results obtained and drawn conclusions, we may in suggestion of recommend riboflavin plus micronutrients at 50+1.5 mg L^{-1} as the best treatment for the best results could be obtained. Such treatment of crop application is not only quit useful, as we think, in increasing crop productivity or eliminating weeds growth, but also is highly appreciated in term of conserving our health and environments safely from any hazards of herbicidal uses.

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