IRRIGATION WITH MAGNETIZED WATER, A NOVEL TOOL FOR IMPROVING CROP PRODUCTION IN EGYPT

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ABSTRACT

Agricultural sciences take an interest not only in the common and valued crop-forming factors, but also in those less expensive, safe environmentally and generally underestimated. The technology of magnetic water has been developed and subsequently used widely in the field of agriculture in many countries such as Australia, USA, China and Japan. Desperate its importance, it is not yet explored in Egypt. Therefore, the present work was carried out to study the response of some food crops using magnetized water for irrigation purpose under green house condition. Monocotyledonous such as wheat and flax and dicotyledonous such as chick-pea and lentil plants were selected for the present study. Based on the results of our experiments revealed all the plants which were irrigated with magnetic water exhibited a remarkable increase in vegetative growth and biochemical constitutions. Further the results indicated that the number of protein bands got increased in plants treated with magnetized water when compared to untreated control plants. Moreover, the magnetized water treatment increased yield and yield component traits of all crops. Over two seasons, the increases in seeds yield/plant in monocotyledonous crops reached to 9.10% and 31.33% for flax and wheat, respectively and in dicotyledonous crops reached to 24.92% and 38.46%, for lentil and check pea, respectively compared with crops irrigated with tap water. It may be concluded that the preliminary study upon the utilization of magnetized water could led to improve the quantity and quality of crop production under Egyptian condition.

Keywords*:* Magnetized water; Growth; Chemical constituents; Yield.

1. Introduction

Till 1980 a little were known about how the magnetic field (MF) can stimulate plant growth or even prevent it. Wojcik [1995] reported that in the beginning of 1980s Japanese called Fujio Shimazaki working in Shimazaki Seed Company was the first who reported that stationary magnetic fields can improve the germination of seeds and speed up the growth of plants. It has been reported that the magnetic field influenced the maximal seed germination and yield potential [Aladjadjiyan, 2002]. The reason of this effect can be searched in the presence of paramagnetic properties in chloroplast which can cause an acceleration of seeds metabolism by magnetic treatment [Aladjadjiyan and Ylieve, 2003]. MF increased yield parameters of crops like cereal, sunflower and soybean [Özalpan *et al*., 1999; Yurttas *et al*., 1999 and Oldacay, 2002].On the other hand, it has been recorded that MF affected various characteristics of plants like germination of seeds, seedlings growth and reproduction including the growth of meristematic cells and chlorophyll development [Namba *et al*., 1995; Atak *et al*., 1997 and Reina *et al*., 2001].

The effect of magnetic field on the productivity of different crops has been studied by many authors [Phirek et al., 1996; Pietruszewski, 1999 a, b and c and Aladjadjiyan, 2002]. It has been established that the proper combination of magnetic field induction and exposure accelerates the early stages of plant development and improves the productivity. Consequently, the magnetic field effect can be used as an alternative to the chemical methods of plant treatment for improving the production efficiency Aladjadjiyan [2003]. Investigations of MF on biological systems have demonstrated generalized increases in gene transcription and changes in the levels of specific mRNAs [Celik et al., 2008].

2. Material and Methods

Two pot experiments were conducted under green house condition at Agronomy Department, National Research Centre, Dokki, Giza, Egypt during one successive winter season to evaluate magnetized water using monocotyledonous crops such as wheat (var.

Sakha-93) and flax (var. Sakha-2)] and dicotyledonous crops such as check pea (var. Giza-4) and lentil (var. Sena-1)]

Grains of the respective crops were obtained from Field Crop Research Department, Field Crops Institute, Agriculture Research Centre, Giza, Egypt. Grains of each crop without visible defect, insect damage and malformation were selected and planted in ten pots (30 cm in diameter and 50 cm depth) containing a mixture of clay and sandy soil [2:1]. Half of the pots were irrigated twice on a week interval with tap water, while the other 5 pots were irrigated with the tap water after magnetization through a one inch Magnetron [U.T. 3, Magnetic Technologies LLC PO Box 27559, Dubai, UAE]. The recommended NPK fertilizers for each crop were applied through the period of experiment.

After 60 days from sowing plant height, fresh and oven dry weight of 6 plants from each crop were determined. Photosynthetic pigments such as chlorophyll a, chlorophyll b and carotenoids) of leaves were estimated spectrophotometrically as the method described by Moran [1982]. Total indole acetic acid (IAA) [Larsen et al., 1962], and total phenol [Malik and Singh, 1980], were estimated in the fresh leaves. Electrophoresis protein profile of leaves was analyzed according to sodium dodocylsulphate polyacrylamide gel electrophoresis [SDS-PAGE] technique [Sheri, et al., 2000]. Molecular protein markers, percentage of band intensity and molecular weight of each polypeptide were related to standard markers using gel protein analyzer version 3 [MEDIA CYBERNE TICE, USA].

Statistical analysis was carried out using SPSS program Version 16. A student test (Independent *t*-test) was also carried out to find the significant differences between magnetic and nonmagnetic water treatments.

3. Results and Discussion

3.1. Growth parameters:

The growth characters such as plant height, fresh and dry weight of the plants exposed to magnetic field are shown in Table [1]. It is obvious that, magnetic treatment increased the growth [plant height, fresh and dry weights/plant and water content] significantly over the untreated control plants in both monocotyledonous and dicotyledonous plants. Over two seasons, the percent of increments in fresh weight/plant of monocotyledonous plants reached to 17.06 and 48.36% and reached to 10.48 and 39.25% in dry weight/plant of wheat and flax plants, respectively (Fig 1). The percent of increments in fresh and dry weight/plant of dicotyledonous plants reached to 12.51 – 18.18% and 5.76 – 15.05% in chick pea and lentil plants, respectively as compared with plants irrigated with tap water (Fig 1). Water content was found to be least affected parameters in both crops where the percent of increase ranged between 1.13 – 2.07% in all four crops. It is worthy to mention that, the percent of increases in growth parameters which reflected in fresh and dry weight/plant in this study showed that, monocotyledonous plants [wheat and flax] surpassed dicotyledonous plants [chick pea and lentil] in their response to irrigation with magnetized.

The stimulatory effect of magnetic water may be attributed to their role in increasing absorption and assimilation of nutrients consequently increasing plant growth. These results are in good harmony with several investigators, who found that in studied paulownia tissue cultures and showed the positive effect of magnetic field on regeneration percentage [Yaycılı and Alikamanoğlu, 2005]. Also, Alikamanoğlu et al. [2007] suggested that, magnetic water treatment improved seed inhibition, vigor and germination rate, and seedling treatment promoted NPK absorption and increased root no, stem thickness, dry weight/100 plants and tillers number. Moreover, Celik *et* al. [2008] and Nasher [2008] concluded that, magnetized water increased growth and consider an important factor for inducing chick pea plant growth. The stimulatory effect of MW on growth criteria of this study may be also attributed to the increase in photosynthetic pigment, endogenous promoters (IAA), total phenol [Table 2] and increase in protein biosynthesis [Table 4]. In this connection, Shabrangi and Majd [2009] concluded that, biomass increasing needs metabolic changes particularly increasing protein biosynthesis.

3.2. Chemical constituents:

Photosynthetic pigments (chlorophyll a, chlorophyll b, total chlorophyll a+b and carotenoids), total phenols and IAA contents in plant shoots exhibited remarkable increase in response to the irrigation with magnetized water when compared to untreated control plants [plants irrigated with tap water] as shown in Table [2] and Fig [2&3]. Over of both seasons, the stimulation percent over control reached by 17.60 and 17.46% in chlorophyll a, 11.37 and 67.80% in chlorophyll b and 3.03 and 8.55 in carotenoids for monocotyledon plants [wheat and flax, respectively] and reached by 26.57 & 13.58%, 21.82 & 44.67, 0.45 & 2.70% for the above mentioned characters in dicot [chick- pea and lentil], respectively [Fig 2]. Total phenol content was increased by 18.2 – 33.59 % in monocot and by 20.0 – 39.02 % in dicot, respectively [Fig 2]. The results also showed that, total indole acetic acid content of monocot plants irrigated with magnetic water was increased by 33.35 – 233.5 %, while their content in dicot plants was increased by 8.66 – 148.19 % [Fig 3].

These results may be due to the effect of MT on alteration the key of cellular processes such as gene transcription which play an important role in altering cellular processes. It also may be due to the increase in growth promoters [Table 2]. The same result was obtained by Tian et al. [1991] and Atak et al.[2000] who found an increase in chlorophyll contents specifically appeared after exposure to a magnetic field for a short time. Moreover, Atak et al. [2003] suggested that, increase all photosynthetic pigments through the increase in cytokinin synthesis which induced by MF. They also added cytokinin play an important role on chloroplast development, shoot formation, axillary bud growth, and induction of number of genes involved in chloroplast development nutrient metabolism. Atak et al. [2003] showed that, the increase in shoot regeneration, chloroplast rate, root formation and fresh weight were accompanied by the increase in auxin synthesis which induced by MF treatment of soybean plants. Moreover, Goodman et al. [1995] and Atak et al. [2003] described the role of MF in changing the characteristics of cell membrane, affecting the cell reproduction and causing some changes in cell metabolism. So the increase in total phenol under this study may be attributed to the role of MT in changing the cell membrane properties. Also, Carimi et al. [2002] and Celik et al. [2008] conclude that, MF stimulates protein synthesis via increase cytokinins and auxins and they can promote the maturation of chloroplast. Moreover, magnetic fields are known to induce biochemical changes and could be used as a stimulator for growth related reactions including affecting photosynthetic pigments [Dhawi and Al-Khayri, 2009].

3.3. Protein electrophoretic pattern:

The changes in protein electrophoretic pattern of plant leaves treated with magnetic water is analyzed and recorded in Table [3]. In the control leaves the separation of 12, 13, 15 and 11 protein bands were appeared in wheat, flax, chick pea and lentil, respectively. Their molecular weights ranged between 346 K Da. and 20 K Da. Magnetic water treatment of plants showed an increase in the number of protein bands to 16, 21, 22 and 16 bands in wheat, flax, chick pea and lentil, respectively. These results indicate that the leaves of plants treated with magnetic water characterized by disappearance of certain bands and the appearance of new ones as compared with that of the control plant [Table 3]. The six new protein bands appeared in wheat at molecular weights 340, 194, 116, 88, 57 and 22 KDa. The nine new protein bands appeared in flax at molecular weights 301, 267, 223, 210, 113, 107, 98, 59 and 45 KDa. Also, the new protein bands appeared in chick pea at molecular weights 314, 248, 235, 226, 192, 135, 49 and 32 KDa. While in lentil, the new protein bands appeared at molecular weights 332, 307, 301, 93, 75, 55 and 38 KDa.

On the other hand, the protein bands at molecular weights 51 and 37 K Da in wheat, at 56 K KDa in chick pea and at 127 and 20 K Da. In lentil were disappeared in response to magnetic water treatment. The induction of new protein bands in response to MWT may be as a result of the effect of MFs in increases proliferation, gene expression and protein biosynthesis [Tenford, 1996]. Also, Celik *et al.* [2008] found that the increase in the percentage of plant regeneration is due to the effect of MF of cell division and protein synthesis in paulownia node cultures, and concluded that, investigations of MF on biological systems have demonstrated generalized increases in gene transcription and changes in the levels of specific mRNAs. Moreover, Shabrangi and Majd [2009] concluded that, biomass increasing needs metabolic changes particularly increasing protein biosynthesis. They also add magnetic field is known as an environmental factor which affects on gene expression. Therefore, by augmentation of biological reactions like protein synthesis, biomass would increase too.

3.4. Yield and yield component:

With respect to the effect of MT on the yield and yield component of monocot and dicot plants data in Table [4a and 4b] cleared that MT increased all yield characters in all crops over the untreated controls. Over two seasons, the percentage of increase reached to 3.89 & 11.88% in plant height, 3.64 & 6.72% in 100-seed weight and 9.10 & 31.33% in seed yield/plant for monocotyledonous crops [flax and wheat, respectively] and to 17.98 & 26.48%, 6.24 & 2.54% and to 24.98 & 38.64% in above mentioned parameters for dicotyledonous crops [lentil and chick pea, respectively] over the untreated controls [Fig 4].

Generally, the stimulatory effect of magnetic treatment may be attributed to their role in increasing growth [Table 1], photosynthetic pigment and growth promoters [Table 2] consequently increasing yield characters. These results are in agreement with those obtained by Tian et al. [1991] who indicated that, MW increased yield of rice by 13.23%. This was accompanied the stimulation effect of MW on leaf chlorophyll content. Kordas [2002] found that, the exposure of green tops and root systems of wheat plant to MF increased quantity of coarse grain by 10.6% and 6.3% respectively. In this connection, Dodlesny et al. [2004, 2005] suggested that, the gain in seed yield resulting from the pre-sowing treatment of seeds with MF for broad bean and pea was due to the higher number of pods per plant and the fewer plant losses in the unit area in the growing season. Moreover, Souza et al. [2006] showed that, MT on tomato increased significantly the mean fruit weight, the fruit yield/plant, the fruit yield per area and the equatorial diameter of fruits in comparison with the controls. Moreover, MF was shown to induce fruit yield per plant and average fruit weight [Celik et al., 2008]. Exposure of plants to MW is highly effective in enhancing growth characteristics. This observation suggests that there may be resonance-like phenomena which increase the internal energy of the seed that occurs. Therefore, it may be possible to get higher yield [Vashisth *et al.*, 2008 and Shabrangi and Majd, 2009] on chickpea and lentil respectively.

4. Conclusion

In summary, growth parameters, biochemical components and yield components of tested plants is concomitantly increased when plants are treated with magnetic water. Biochemical components such as photosynthetic pigments, endogenous total indole; total phenol and protein contents were also increased significantly in plants treated with magnetic water. The variation in the response of plants should need continuous efforts from researchers to explore the mode of magnetic treatment action in monocot and dicot crops.

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Table 1. Response of moncot and dicot crops growth at 60 days after sowing for irrigation with magnetic and normal water under green house conditions.

Treatment	Monocotyledons crops											
	Wheat						Flax					
	2008/09 season		*t*-sign.	2009/2010 season		*t*-sign.	2008/09 season		*t*-sign.	2009/2010 season		*t*-sign.
Character	Tap water	Magnetic water		Tap water	Magnetic water		Tap water	Magnetic water		Tap water	Magnetic water	
Plant height (cm)	20.75	24.12	**	26.20	29.20	**	24.00	25.00	ns	26.20	28.26	**
Fresh weight (g plant $^{-1}$)	0.68	0.98	**	0.79	1.21	**	0.61	0.71	**	0.79	0.93	**
Dry weight (g plant $^{-1}$)	0.17	0.23	**	0.21	0.29	**	0.15	0.16	ns	0.21	0.24	ns
Water contents (%)	75.00	76.53	ns	74.04	75.60	ns	75.47	77.09	ns	74.10	74.19	ns
	Dicotyledonous crops											
	Lentil						Chick-pea					
Plant height (cm)	15.20	18.40	*	17.16	21.00	**	20.40	23.60	*	24.20	26.20	ns
Fresh weight (g plant $^{-1}$)	0.56	0.66	**	0.67	0.79	*	1.39	1.58	**	1.55	1.73	**
Dry weight (g plant $^{-1}$)	0.17	0.19	**	0.24	0.27	ns	0.32	0.35	ns	0.37	0.38	*
Water contents (%)	70.12	70.61	ns	64.18	65.49	ns	76.98	77.85	ns	75.93	77.93	**

***, ** t is Significant at the 0.05 and 0.01 levels, respectively, ns: non significant.**

Table 2. Effect of magnetic water on chemical constituents of some monocot and dicot plants at 60 days after sowing.

Treatment		**Monocotyledons crops**						**Dicotoyledons crops**					
		Wheat			**Flax**			**Chick-pea**			**Lentil**		
Character		**Tap water**	**Magnetic water**	***t*-sign.**	**Tap water**	**Magnetic water**	***t*-sign.**	**Tap water**	**Magnetic water**	***t*-sign.**	**Tap water**	**Magnetic water**	***t*-sign.**
Photosynsetic pigments (mg 100 g fresh weight $^{-1}$)	**Chlorophyll a**	8.23	9.68	**	6.13	7.20	**	5.72	7.24	**	3.71	4.21	*
	Chlorophyll b	4.97	5.54	**ns**	2.36	3.96	**	3.07	3.74	**	1.25	1.80	*
	Chlorophyll a+b	13.21	15.22	**	8.49	11.16	**	8.79	10.98	**	4.96	6.02	*
	Carotoneiods	5.67	5.84	**ns**	4.60	4.99	**ns**	4.48	4.50	**ns**	4.77	4.90	**ns**
	Total pigments	26.42	30.45	**	16.98	22.32	**	13.27	15.48	**	9.92	12.04	**ns**
Total phenol (mg 100 g fresh weight $^{-1}$)		215.62	288.05	**	208.19	246.07	**	312.29	434.13	**	179.18	215.02	**
Total indols (µg 100 g fresh weight $^{-1}$)		2.94	9.80	**	1.19	1.59	**	1.26	1.37	**	0.83	2.05	**

*, ** t **is Significant at the 0.05 and 0.01 levels, respectively, ns: non significant.**

Table 3: The relative area percentage of protein bands in leaves at 60 days after sowing of some monocot and dicot plants irrigated with magnetized and normal water

M wt. K.Da.	Monocot				Dicot			
	Wheat		Flax		Chickpea		Lentil	
342	4.54	2.24					1.76	1.83
339		5.28	2.54	3.58				
327	5.07	4.16			3.54	2.51		2.44
323					3.61	1.47	2.72	2.58
322					16.97	1.46		
316			4.49	3.03		2.32		
307				3.42				2.00
301								1.27
286	8.73	8.21	2.43	3.03				
267				3.22				
253	8.21	7.34	2.37	3.26				
245						7.80	10.23	12.75
233			4.61	3.15		1.31		
224				3.65		2.51		
204		10.32		2.40		2.68		
189					2.32	2.32		
146	13.79	6.80	7.40	7.60	4.23	5.38	8.60	4.97
135						1.99	4.55	2.15
125					2.06	2.06	6.17	
114		6.11		3.86				
107				2.56				
95				5.49				10.35
87		4.55	15.70		4.27	5.24		
73			6.21	2.75				7.85
66	9.67	9.81			6.89	7.70	17.32	2.85
56		3.92		6.77	6.15			6.05
52	8.08		10.61	6.03	2.76	5.69	8.11	4.73
47			11.22	10.44		5.08	13.30	14.96
45	15.47	12.84		5.96	10.45	7.76		
41			11.36	4.75	8.80	7.17		
37	5.16		7.26	2.45	8.79	6.15		6.59
35					5.34	2.25		
33	11.67	9.23	13.80	12.60		10.68	18.31	16.63
30					5.60	8.47		
22		4.24						
20	9.61	4.95					8.93	
Band number	**11**	**15**	**13**	**21**	**15**	**22**	**11**	**16**
Number of new band		**6**		**9**		**8**		**7**

Table 4a. Response of wheat and flax yield and its components at harvest for irrigation with magnetic and normal water.

Treatment / Character	Wheat 2008/09 season Tap water	Wheat 2008/09 season Magnetic water	*t*-sign.	Wheat 2009/2010 season Tap water	Wheat 2009/2010 season Magnetic water	*t*-sign.
Plant height (cm)	39.80	47.00	*	56.40	59.60	*
Spike length (cm)	5.00	6.60	**	8.50	9.20	**
Spike weight (g)	0.48	0.53	**	0.64	0.75	**
Spikeletes no. spike $^{-1}$	9.00	12.00	**	14.40	16.00	**
100-grain weight (g)	4.04	4.31	ns	4.14	4.42	ns
Grain yield (g tiller $^{-1}$)	0.30	0.40	**	0.75	0.97	**
Straw yield (g tiller $^{-1}$)	0.59	0.80	**	0.93	1.06	**
Biological yield (g tiller^{-1})	0.89	1.20	**	1.68	2.03	**
HI (%)	33.63	33.33	ns	44.64	47.78	ns
			Flax			
Plant height (cm)	56.80	58.20	*	58.30	61.40	**
Tecenical length (cm)	43.40	48.80	*	48.50	51.60	**
Based branches (number plant^{-1})	2.40	2.80	ns	2.60	2.84	ns
Fruit Branches (number plant^{-1})	5.60	6.00	ns	6.20	6.44	ns
Cabsules (number plant^{-1})	9.20	10.80	ns	10.40	11.60	ns
Cabsules weight (g plant^{-1})	0.44	0.53	*	0.53	0.57	ns
Seed (number cabsula^{-1})	8.00	8.40	ns	8.26	9.28	**
Seeds (number plant^{-1})	73.60	90.72	**	85.68	107.46	**
100-seed weight (g)	0.68	0.70	ns	0.69	0.72	ns
Seed yield (g plant^{-1})	0.32	0.35	*	0.34	0.37	ns

***, ** t is Significant at the 0.05 and 0.01 levels, respectively, ns: non significant**.

Table 4 b. Response of lentil and chick-pea yield and its components at harvest for irrigation with magnetic and normal water.

Treatment	Lentil						Chick-pea					
	2008/09 season		*t*-sign.	2009/2010 season		*t*-sign.	2008/09 season		*t*-sign.	2009/2010 season		*t*-sign.
Character	Tap water	Magnetic water		Tap water	Magnetic water		Tap water	Magnetic water		Tap water	Magnetic water	
Plant height (cm)	16.40	20.60	**	23.20	25.60	*	28.40	35.20	**	32.40	41.80	**
Branches (number plant^{-1})	2.71	3.60	*	3.32	3.92	*	2.47	3.23	**	3.20	4.40	**
Pods (number plant^{-1})	4.78	6.40	**	6.76	8.40	**	6.60	8.81	ns	7.60	11.50	**
Pods weight (g plant^{-1})	0.63	0.72	*	0.74	0.88	**	1.86	2.59	**	1.96	2.76	**
Seeds (number plant^{-1})	8.75	10.50	**	10.66	12.34	**	6.89	9.50	**	7.13	10.20	**
100-seed weight (g)	5.20	5.62	**	5.45	5.69	**	18.16	19.03	**	19.13	19.17	ns
Seed yield (g plant^{-1})	0.52	0.66	**	0.63	0.78	**	1.36	1.77	**	1.43	2.10	**
Straw yield (g plant^{-1})	0.54	0.71	**	0.75	0.91	*	1.43	1.91	**	1.98	2.94	**
Biological yield (g plant^{-1})	1.06	1.37	**	1.38	1.69	**	2.79	3.68	**	3.41	5.04	**

***, ** t is Significant at the 0.05 and 0.01 levels, respectively, ns: non significant.**

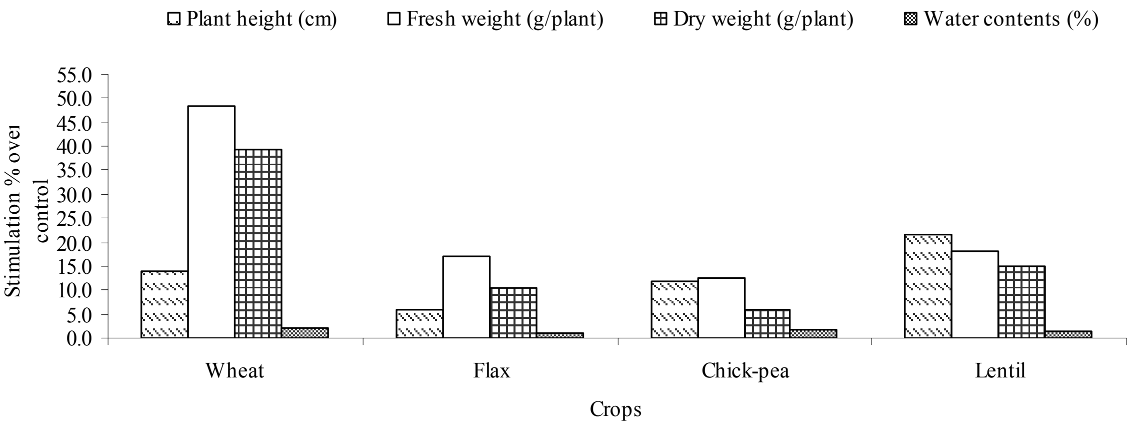

Fig 1. Stimulation % over control in some growth parameters of moncot and dicot crops at 60 days after sowing.

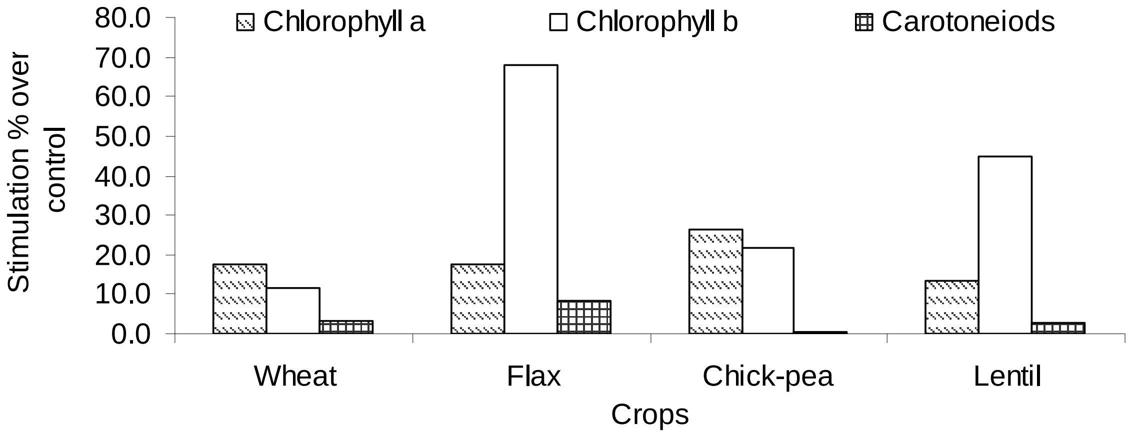

Fig 2. Stimulation % over control in photosynsetic pigments (mg 100 g fresh weight $^{-1}$) of moncot and dicot crops at 60 days after sowing.

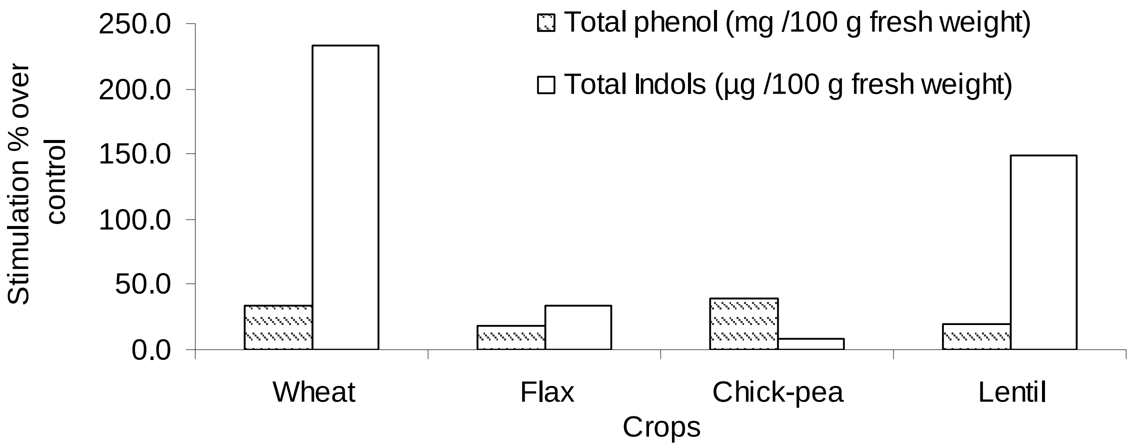

Fig 3. Stimulation % over control in total phenols and total indoles of moncot and dicot crops at 60 days after sowing.

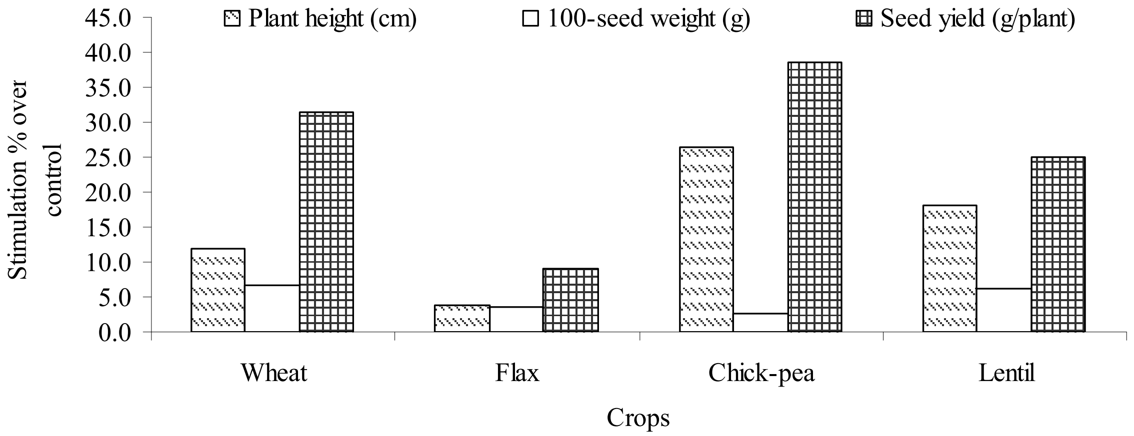

Fig 4. Stimulation % over control in some yield parameters of moncot and dicot crops at 60 days after sowing.