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Could magnetic field minimize wheat grains insects without affecting its quality?

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Abstract: The present work focus on studying the insecticidal activity of 180 millitesla (mT) magnetic field (MF) against adults of *S.* & *R. dominica* and *T. castaneum* using contact method and their effect on seeds viability (germination%, SVI, seeds component %, soil microflora and plant pigments).

Results showed that the four MF exposure periods (one day, two days, three days and four days) exhibited a significant toxic effect (df, F and P< 0.5) against *Sitophilus oryzae* and *Rhyzopertha dominica* the four days exposure period while *Triboleum castaneum* indicated resistance against the four MF exposure periods

At the end of the experiment (10 days for *Sitophilus oryzae* & *Rhyzopertha dominica* and 21 days for *Triboleum castaneum*), the highest MF exposure period (four days) recorded mortality 8.3, 8.3, 16.6, 20, 33.3, 41.6 and 55% of *Sitophilus oryzae*, 1.6, 3.3, 6.6, 8.3, 15, 21.6, 21.6, 33 and 40% for *Rhyzopertha dominica*. 3.3, 5, 8.3, 8.3, 11.3 and 16.3% for *Triboleum castaneum* , also caused high reduction in F1-progeny % with the three tested insects.

Treatment of wheat seeds with the highest MF exposure period (4 days) for 6 months storage and planting for 45 days exhibit improvement in shoot & root length and water percentage comparable to that of control with significant enhancements in fresh and dry weights also, plant chlorophyll significantly increased compared to untreated grains. The soil microflora illustrates that, treatments with 4 days MF exposure period cause appearance or disappearance of some fungi and bacteria.

keywords: Wheat; magnetic; insects; storing; microflora.

1.Introduction

Wheat is an important staple crop in the global food chain[1]**.** Insect infestation is one of the leading factors accounting for the postharvest loss of wheat grains during storage, and it is paramount to the nutritional status and economy of many countries[2]**.**

The major stored grain insect pests attacking on stored wheat include *Sitophilus granarius* L., *Rhyzopertha dominica* Fabr, *Tribolium castaneum* Herbst., *Prostephanus truncates* Horn, *Sitophilus oryzae* L., *Sitotroga cerelella* Olivier and Plodia interpunctella Hubner[3]**.**

Up to date, the control of stored product insects is generally based on the use of chemical insecticides and fumigants, such as pyrethroids, neonicotinoids, organophosphates, and phosphine[4]**.** However, the frequent use of high doses of these substances has been associated with several problems, such as harmful effects on environment and increased resistance of insects and non-target species including humans[5]. Antimicrobial and insecticidal properties offer the view of using them as natural pesticides with a commercial value, having social approval due to its sustainability and being environmentally friendly[6].

Current study was aimed to evaluate the insecticidal efficiency of 180 millitesla (mT) magnetic field (MF) against adults of rice weevil, *Sitophilus oryzae* (L.); lesser grain borer *Rhyzopertha dominica* (Fabricius) and red flour beetle, *Tribolium castaneum* (Herbst.) and its effect of wheat quality.

2. Materials and methods

This investigation includes two sets of experiments; A: Laboratory insects experiments and B: Pot experiments; these experiments conducted to study the effects of 180 (mT) MF on wheat grains storage for 6 months. The first sets (A) study the response of the used insects to the used MF; preliminary: to select the most effective exposures period and the main storage experiment: to follow up the used insects during 6 months. The second sets (B) study the reflection of the most effective MF exposure period on the grains after storage period; 1: to examine initial data about the constituents of wheat grains before and after storage for 6 months and 2: the main pot experiment: to investigate the response of the magnetized wheat grains for 6 months storage after planting for 45 days.

Materials:

A pure strain of *Triticum sativum* L. (wheat) was obtained from Agricultural Research Center, Ministry of Agriculture, Giza, Egypt. Target insects were obtained from Plant Protection Research Institute, Mansoura Branch. A magnetic field apparatus of about 100 mT was obtained from Delta water company, Cairo, Egypt.

Insects rearing

Adults of both *Sitophilus oryzae* and *Rhyzopertha dominica* were reared on wheat grains while *Tribolium castaneum* were reared on wheat flour in a glass jars (each of approximately 500 ml). Each jar was covered with muslin cloths and fixed with rubber bands. The used insects were selected based on their economic significance as harmful and destructive pests to stored gains and other food products worldwide

To have an initial population of insect adults homogenous in age, about 500 adults were introduced into jars containing wheat grains or flour then kept in an incubator at 30±2°c and 65±5 % relative humidity (R.H.). After three days, all insects were removed from the media and the jars were kept again at controlled conditions. Adults of (1-2 weeks old) were used for the experiments.

Sets A of Experiments

***Preliminary experiment**

Bioassay tests:

An experiment was conducted to test the insecticidal activity of different treatments (one day, two days. three days and four days days). (on *S.* oryzae, Rhyzopertha dominica and T. castaneum (1-2 weeks old)

The insecticidal efficacy of magnetic field against the used pests

An experiment was conducted using a magnetic field apparatus of about 100 mT, where twenty adults of either *S. oryzae* or *R. dominica* or *T. castaneum* (1–2 weeks old) infested 10 gm of either wheat grains for *S. oryzae* and *R. dominica* or wheat flour for *T. castaneum* then, exposed to 100 mT MF for the four previously mentioned MF. Each treatment was replicated three times. After the exposure period, the mortality percentage was recorded.

Percent of insect mortality was calculated using the corrected Abbot's formula[7]Reduction percentage in progeny of offspring was calculated according to[8] after45 days for *S. oryzae* & *R. domonica* and 60 days for *T. castaneum*.

***Storage experiment**

A laboratory experiment was conducted to study the efficiency of the highest effective MF period (4 days) in protecting wheat grains for 6 months of storage. Thus, one kg of wheat grains was exposed to MF of 100 mT magnet twice intervals; before storage and three months later then stored for 3 months (6 months total storage period) and one kg of untreated grains was used to serve as control. The first emergence of insects in treated and untreated grains was recorded.

***Sets B Experiment**

1- Biochemical aspects of the dry stored wheat grains:

***wheat component analysis**

This experiment was carried out at the Soil, Water and Environment Research to study the effect of the highest MF exposure period on wheat grains components % (moisture%, crude fats%, crude protein%, ash% and carbohydrates %) before and after 6 months of storage.: Total ash content: 2 gram of grains sample were added into previously weighed porcelain crucible, place in muffle furnace for 2 hours at 600OC then placed in desiccators and weigh. The weight of the residue was calculated and expressed as percent ash[9]**.** Crude Fat (Ether Extract): 10 gram of each powdered grains sample were extracted using (Soxhlet) with a solvent of petroleum ether (b.p.60-80OC) for 16 hours. Each extract was dried over anhydrous Na2SO4 and evaporated to dryness. The residue was dried at 80OC for 10 minutes, cooled, weighed and expressed as percent lipid[9]**.** Crude Fiber Contents: 2 gram of each sample defatted powder were boiled with 1.25% sulfuric acid for 30 minutes and filtered. The residue was dried at 100OC to constant weight the difference between the weight of residue after drying at 110OC and the of powder represents the weight of crude fiber[9]. Crude Protein: calculated by multiplying the total nitrogen by the factor 6.25. According to[9]. Moisture Contents: Five g air-dried powder sample were accurately weighed and dried in an oven until constant weight was obtained. The loss in weight was calculated according to[9]. Determination of total carbohydrate was given by: 100 – (percentage of ash + percentage of moisture + percentage of fat + percentage of protein.[10]**.**

*** The main field experiment**

After storing the of wheat grains for six months, the grains divided into 4 groups as follow:

Group (1): stored + 0 treatment (C).

Group (2): stored with magnetic treated grains (M).

Group (3): C+ irrigation with magnetic water (C +MW).

Group (4): M + irrigation with magnetic water (M + MW).

Grains of the 4 groups were cultivated in the green house of the Faculty of Science, Mansoura University, Egypt. At 12 December 2021, one hundred grains were sown in each group divided in to 10 replicates and watered as usual practice by adding equal amounts of water to each group of pots when required. The 4 groups were exposed to normal day night conditions. At the end of planting period, sampling was takes place; five replicas for each.

The collected samples were used for assessment of growth parameters (shoot length, shoot fresh & dry weights, shoot water percentage, root length, root fresh & dry weights and root water percentage). Photosynthetic pigments content, in treated and untreated plant was determined. In addition, soil microflora was also detected.

Estimation of photosynthetic pigments:

The plant photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) were determined in leaves of the seedlings via the method recommended by[11] for chlorophylls and[12] for carotenoids as accepted by[13]**.**

A known fresh weight of plant leaves (0.1 g) was cut into small pieces in an ice-cold porcelain mortar, some quartz sand was added and MgCO3 powder to reduce acidification. The leaves were ground with 80 % acetone for 5 minutes. At the end of the grinding the extract stirred in the mortar then quantitatively transferred to a centrifuge tube. The mortar was washed several times with cold 80 % acetone and the volume completed to 8 ml, mixed well and the tube covered for the protection of the evaporation of acetone during centrifugation, which continue for 3 min at 1000 rpm. After centrifugation the volume was adjusted and color was measured within a short time or the extracts were stored closed in a cold dark place but not more than 24 hrs. The extract was measured against a blank of pure 80 % aqueous acetone at 3 wave lengths of 480, 644 and 663 nm using (BHF 80B biology spectrophotometer). Taking into consideration the dilutions made, the concentration of the pigment fractions was calculated as µg/ml using the following equations:

Chlorophyll a = $10.3E_{663} - 0.918\ E_{644}$ = µg/ml

Chlorophyll b = $19.7\ E_{644} - 3.87\ E_{663}$ = µg/ml

Carotenoids = $5.02\ E_{480}$ = µg/ml

Then, the fractions were calculated as µg / g fresh weight of the differently treated plant leaves.

Estimation of water percentage:

The water percentage was estimated according to method described by[14]**.**

Dry shoot tissue samples, obtained by put a known weight of shoot tissue in an oven at 80°C for 48 hrs or for constant weight.

Water percentage = (fresh weight - dry weight) / (fresh weight) x 100

Soil microflora

For isolation of bacteria, nutrient agar containing 0.015% (w/v) nystatin (to inhibit fungi growth) was prepared. 10g of rhizospheric dry soil sample was taken for serial dilution series up to 10^{-9} by using saline water (0.85%) according to[15]. The bacteria were originally isolated by direct technique on TSA (Ttypticase soy agar) and incubated for 24 hours at 37°C. The developed colonies were purified by streaking on nutrient agar for bacterial identification according to colony and cellular characterization[16] (Hanirah *et al.*, 2015).

For isolation of fungi, PDA (Potato dextrose agar) to which 0.05% (w/v) chloramphenicol has been added; to inhibit bacteria growth was prepared. 10g of rhizospheric soil sample was taken for serial dilution series up to10^{-9} by sterile distilled water. Fungi were isolated by inoculating 0.1ml of the dilutions of the rhizosphere soil samples on PDA plates and incubated for 4 days at 28°C, then as in case of bacteria the appeared colonies were picked and identified[16].

Statistical Analysis

Data were statistically analyzed and comparison among means was carried out using COHORT/ COSTAT program (798 Lighthouse Ave. PMB 329, Monterey, CA, 93940, USA). The treatments were applied to subjects where ANOVA (analysis of variance) procedure could determine if the treatments had a significant effect on the observed values. The one way completely randomized type was adopted as the type of the experimental design. After ANOVA, mean tests were carried out to compare the means in each group of treatments to detect which were significantly different. The least significant difference (LSD) test was chosen as a mean test with significance level at $P \leq 0.05$.

3. Results and Discussion

As previously mentioned, this study includes two sets of experiments; **A**: Laboratory insects' experiments (to study the response of the tested insects to the used MF; preliminary and the main storage experiment during 6 months.) and **B**: Pot experiments (to study the echo of the pest MF exposure periods on dry grains, seedlings and vegetative after storage the grains for 6 months; preliminary and the main pot experiment).

Experiments A

Preliminary experiment

Effect of magnetic field for different exposure periods on mortality percentage of *S. oryzae* adults on wheat during 10 days and reduction percentage in F1 progeny.

The toxicity of four magnetic field periods (1, 2, 3 and 4 days) on the stored wheat insect *S. oryzae* is presented in **table (5).** Accumulative mortality percentage increased with increasing of exposure period.

At the end of this experiment (after 10 days) insect mortality percentage recorded 8.3, 28.3, 40, and 55% with 1, 2, 3 and 4 days, respectively, in relation to control. According to recorded data, exposure to 4 days magnetic field period caused mortality percentage 8.3, 8.3, 16.6, 20, 33.3, 41.6 and 55% after 1, 2, 3, 4, 5, 7 and 10 days from treatment respectively corresponding to control.

After incubation period (month) until adult emergence, four tested magnetic field periods caused reduction percentage in F1 progeny 23, 40, 70.3, and 73.3% with 1, 2, 3 and 4 days magnetic period, respectively.

Insecticidal toxicity bioassay of *S. oyzae* by Abbot's method.

At the end of experiment, mortality percentage of *S. oryzae* recorded 5.1% with one day magnetic field while mortality percentage recorded 25.1% with 2 days magnetic period

In case of three days magnetic period, mortality percentage recorded 36.8% while Mortality percentage recorded 51.8% with 4 days magnetic period.

After the incubation period, the reduction percentage in F1 progeny ranged from 23 to 73.3% with 4 magnetic field exposure periods. **(Table 2).**

Table 1: Effect of magnetic field on mortality percentage of *S. oryzae* adults infesting wheat and reduction percentage in F1 progeny.

Treatment	% Adult mortality after indicated days							Reduction % in F1 progeny
	1	2	3	4	5	7	10	
Control	0±0^{c}	0±0^{b}	0±0^{c}	0±0^{c}	0±0^{e}	0±0^{e}	1.6±1.6^{e}	0%
1 days	0±0^{c}	0±0^{b}	0±0^{c}	0±0^{c}	5±0^{d}	8.3±1.6^{d}	8.3±1.6^{d}	23%
2 days	0±0^{c}	1.6±1.6^{b}	1.6±1.6^{c}	5±0^{bc}	11.6±1.6^{c}	20±2.8^{c}	28.3±4.4^{c}	40%
3 days	5±0^{b}	6.6±1.6^{a}	6.6±1.6^{b}	6.6±1.6^{b}	16.6±1.6^{b}	28.3±3.3^{b}	40±2.8^{b}	70.3%
4 days	8.3±1.6^{a}	8.3±1.6^{a}	16.6±1.6^{a}	20±2.8^{a}	33.3±1.6^{a}	41.6±1.6^{a}	55±2.8^{a}	73.3%

*Means within a column followed by the same lower-case letter are not significantly different (P<0.05)

Table 2: Effect of magnetic field on mortality percentage of *S. oryzae* adults infesting wheat and reduction percentage in F1 progeny by Abbot.

Treatment	% Adult mortality after indicated days							Reduction % in F1 progeny
	1	**2**	**3**	**4**	**5**	**7**	**10**	
Control	_	_	_	_	_	_	_	0%
1 days	0±0^{c}	0±0^{b}	0±0^{c}	0±0^{c}	5±0	8.3±1.6	5.1±1.6	23%
2 days	0±0^{c}	1.6±1.6^{b}	1.6±1.6^{c}	5±0^{bc}	11.6±1.6	20±2.8	25.1±4.4	40%
3 days	5±0^{b}	6.6±1.6^{a}	6.6±1.6^{b}	6.6±1.6^{b}	16.6±1.6	28.3±3.3	36.8±2.8	70.3%
4 days	8.3±1.6^{a}	8.3±1.6^{a}	16.6±1.6^{a}	20±2.8^{a}	33.3±1.6	41.6±1.6	51.8±2.8	73.3%

*Means within a column followed by the same lower case letter are not significantly different (P<0.05).

Effect of magnetic field for different exposure periods on mortality percentage of *R. dominica* adults on wheat during 10 days and reduction percentage in F1 progeny.

The toxicity of 4 magnetic field periods (1, 2, 3 and 4 days) on the stored wheat insect *R. dominica* are showed in **table (3).** Data tabulated from the second day. Accumulative mortality percentage increased with increasing of magnetic field exposure period.

At the end of this experiment (after 10 days), Insect mortality percentage recorded 15, 20, 31.6 and 40 % with 1, 2, 3 and 4 days, respectively in relation to control. According to recorded data, exposure to 4 days magnetic field period caused mortality percentage 1.6, 3.3, 6.6, 8.3, 15, 21.6, 21.6, 33 and 40% after 2, 3, 4, 5, 6, 7, 8, 9 and 10 days from treatment respectively corresponding to control.

After incubation period (month) until adult emergence, four tested magnetic field exposure periods caused reduction percentage in F1 progeny was 36, 48.4, 60, and 76.2% with 1, 2, 3 and 4 days magnetic period, respectively. Mortality percentage of *Sitophilus oryzae* (L.) and *Rizopertha dominica* F increased with increasing of MFs levels and time exposure[17] **.**

Insecticidal toxicity bioassay of *R.dominica* by Abbot's method.

At the end of experiment, mortality percentage of *S. oryzae* recorded 8.4% with one day magnetic field while mortality percentage recorded 13.4 with 2 days magnetic period

In case of three days magnetic period, mortality percentage recorded 25% while mortality percentage recorded 33.4 with 4 days magnetic period.

After the incubation period (month), the reduction percentage in F1 progeny ranged from 36 to 76.2% with 4 exposure periods **(Table4)**.

Table 3: Effect of magnetic field on mortality percentage of *R. dominica* adults infesting wheat and reduction percentage in F1 progeny.

Treatment	% Adult mortality after indicated days									Reduction % in F1 progeny
	1	2	3	4	5	6	7	8	9	10	
Control	0±0	0±0^{a}	0±0^{b}	0±0^{b}	0±0^{bc}	0±0^{b}	0±0^{d}	0±0^{c}	1.6 ±1.6^{d}	3.3 ±1.6^{c}	0%
1 days	0±0	0±0^{a}	0±0^{b}	0±0^{b}	1.6±1.6^{b}	5 ±2.8^{b}	5±2.8^{c}	6.6 ±3.3^{b}	10±1.6^{c}	15 ±2.8^{b}	36%
2days	0±0	0±0^{a}	5±0^{a}	5±0^{a}	5±0^{ab}	5 ±0^{b}	5±0^{c}	8.3 ±1.6^{b}	16.6 ±1.6^{c}	20 ±2.8^{b}	48.4%
3 days	0±0	3.3±1.6^{a}	5±0^{a}	5±0^{a}	5±0^{ab}	6.6 ±1.6^{b}	11.6±1.6^{b}	20 ±2.8^{a}	25±1.6^{b}	31.6 ±1.6^{a}	60%
4 days	0±0	1.6±1.6^{a}	3.3±1.6^{a}	6.6±1.6^{a}	8.3±1.6^{a}	15 ±2.8^{a}	21.6±0^{a}	21.6 ±1.6^{a}	33.3±1.6^{a}	40 ±2.8^{a}	76.2%

*Means within a column followed by the same lower case letter are not significantly different (P<0.05)

Table 4: Effect of magnetic field on mortality percentage of *R. dominica* adults infesting wheat and reduction percentage in F1 progeny by Abbot.

Treatment	% Adult mortality after indicated days										Reduction % in F1progeny
	1	2	3	4	5	6	7	8	9	10	
Control	_	_	_	_	_	_	_	_	_	_	0%
1 days	0±0	$0±0^{a}$	$0±0^{b}$	$0±0^{b}$	$1.6±1.6^{c}$	$5±2.8^{b}$	$5±2.8^{c}$	$6.6±3.3^{b}$	$6.8±1.6^{d}$	$8.4±2.8^{d}$	36%
2days	0±0	$0±0^{a}$	$5±0^{a}$	$5±0^{a}$	$5±0^{b}$	$5±0^{b}$	$5±0^{c}$	$8.3±1.6^{b}$	$13.4±1.6^{c}$	$13.4±2.8^{c}$	48.4%
3 days	0±0	$3.3±1.6^{a}$	$5±0^{a}$	$5±0^{a}$	$5±0^{b}$	$6.6±1.6^{b}$	$11.6±1.6^{b}$	$20±2.8^{a}$	$21.8±1.6^{b}$	$25±1.6^{b}$	60%
4 days	0±0	$1.6±1.6^{a}$	$3.3±1.6^{a}$	$6.6±1.6^{a}$	$8.3±1.6^{a}$	$15±2.8^{a}$	$21.6±0^{a}$	$21.6 ±1.6^{a}$	$31.1±1.6^{a}$	$33.4±2.8^{a}$	76.2%

*Means within a column followed by the same lower case letter are not significantly different (P<0.05)

Table 5. Effect of magnetic field on mortality percentage of *T. castaneum* adults infesting wheat flour and reduction percentage in F1 progeny.

Treatment	% Adult mortality after indicated days							Reduction % in F1 progeny
	2	4	6	8	10	14	21	
Control	0±0	$0±0^{b}$	$0±0^{b}$	$0±0^{b}$	$0±0^{c}$	$0±0^{b}$	$0±0^{b}$	0%
2 days	0±0	$0±0^{b}$	$0±0^{b}$	$0±0^{b}$	$0±0^{c}$	$1.6±1.6^{b}$	$3.3±1.6^{b}$	17%
3 days	0±0	$0±0^{b}$	$0±0^{b}$	$1.6±1.6^{b}$	$3.3±1.6^{bc}$	$3.3±1.6^{b}$	$5 ±0^{b}$	25.1
4 days	0±0	$0±0^{B}$	$1.6±1.6^{b}$	$6.6±1.6^{a}$	$6.6±1.6^{ab}$	$6.6±1.6^{ab}$	$10±0^{a}$	33.2%
5 days	0±0	$3.3±1.6^{a}$	$5±0^{a}$	$8.3±1.6^{a}$	$8.3±1.6^{a}$	$11.3±0^{a}$	$16.6±1.6^{a}$	57%

*Means within a column followed by the same lower case letter are not significantly different (P<0.05)

Effect of magnetic field for different exposure periods on mortality percentage of *T. castaneum* adults on wheat flour during 21 days and reduction percentage in F1 progeny.

The toxicity of 4 magnetic field periods (1, 2, 3 and 4 days) on the stored wheat insect *T. castaneum* is showed in **table (9)** and. *T. castaneum* was non-significantly affected by magnetic field. Data tabulated from the fourth day cleaned that accumulative mortality percentage increased with increasing of magnetic field exposure period.

At the end of this experiment (after 21 days). Insect mortality percentage recorded 3.3,5, 10 and 16.6 % with 1, 2, 3 and 4 days, respectively in relation to control. According to recorded data, exposure to 4 days magnetic field period, mortality percentage recorded 3.3, 5, 8.3, 8.3, 11.3 and 16.3% after 4, 6, 8, 10, 14 and 21 days from treatment respectively corresponding to control.

At the end of experiment the four tested magnetic field periods caused reduction percentage in F1 progeny where reduction percentage in F1 progeny was 17, 25.1, 33.2 and 57% with 1, 2, 3 and 4 days magnetic period, respectively. After incubation period (month and a half) until adult emergence, all tested magnetic field exposure periods caused reduction percentage in F1 progeny was 17, 25.1, 33.2 and 57% with 1, 2, 3 and 4 days magnetic period, respectively. The mortality percentage of *T. castaneum* increased with increasing of MF time exposure[18].

Storage experiment

The efficiency of 4 days MF exposure period in protecting wheat grains for 6 months of storage.

Residual toxicity experiment:

As mentioned before, previous results indicated that magnetic field exposure period for 4 days are more effective than other treatments so the residual toxicity were tested for six months storage in protecting wheat grains against *S. oryzae*, *R. dominica* and *T. castaneum* (latter insect was more tolerant than the rest). As recorded in **table (6)**, data indicated high effect thus, up to the six month there were no appearance of the three tested insects in all treatments.

Table 6: Adult mortality percentage of S. oryzae and R. dominica and T. castanium during 6 months storage of magnetized wheat grains and wheat treated with spearmint and lemon grass EOs.

Treatment	Tested insect	Adults number during storage period					
		1 month	2 months	3 months	4 months	5 months	6 months
Control	S. oryzae	0	0	0	0	0	0
	R. dominica	0	1	1	3	4	4
	T. castanuim	0	0	0	0	0	0
Magnetic	S. oryzae	0	0	0	0	0	0
	R. dominica	0	0	0	0	0	0
	T. castanuim	0	0	0	0	0	0

Experiments B

Preliminary experiment

Wheat grains components % before and after storage for 6 months with the most effective MF exposure period (4 days).

Table (7) and represented the percentage of some components of the stored grains (moisture contents, crude protein, crude fat, total ash and total carbohydrates) of untreated and treated wheat grains with 4 days magnetic field period after 6 months storage; control grains were used for comparison. Results showed significant differences between the components of treated and untreated wheat grains as follow:

Moisture%:

Examination of **table (7)** is cleared that moisture% before storage recorded 9.49 of wheat grains and after storage this percentage decreased significantly to 9.13 in control and significantly increased in magnetized wheat gains to 9.72 corresponding to control.

Crude Protein%:

As regards crude protein% the recording data cleared that this parameter record 10.13 before storage of wheat grains and after storage this percentage decreased significantly in control to 9.75 and in magnetized wheat to 9.81 as compared to control **(Table 7).** Electric or magnetic treatments enhance seed vigour by influencing the biochemical processes, which stimulate the activity of proteins and enzymes[19].

Total Fat%:

Concerning the percentage of total fat, the data in **table (7)** showed that wheat grains before storage recorded 2.15 and after storage this percentage significantly decreased in control to 2.10 while significantly increased in magnetic field treated wheat grains to 2.25 as regarded to control.

Fiber%

Regarding fiber%, the data in **table (7)** revealed that wheat grains before storage recorded 3.43 and after storage this percentage significantly decreased to 3.03 while it significantly decreased in magnetized wheat grains to 3.19 as compared to control.

Total Carbohydrates%:

Total carbohydrates% before storage recorded 72.88 in wheat grains and after storage this percentage increased significantly to 73.2 and 73.4 in control and magnetized wheat grains, respectively **(Table 7)**.

Ash%:

The tabulated data **(Table 7)** illustrated that wheat grains before storage recorded 5.35 and after storage this percentage significantly decreased to 5.23 while increased significantly in magnetized wheat grains to 5.45 comparing to control.[18] reported that the MF of (180 mT) caused a slight increase in the percent of total carbohydrate, ash and crude protein while slightly decrease the percent of moisture, total fats and crude fiber.

Table 7: Wheat components before and after storage for 6 months with the tested MF (4 days)

ParameterTreatment	Moisture,%	Protein,%	Fat,%	Fiber,%	Carbohydrates,%	Ash,%
0 Time Initial	9.49b	10.13a	2.15b	3.43a	72.88c	5.35b
Control After 6 storing months	9.13c	9.75c	2.10c	3.03c	73.2b	5.23c
Magnetized wheat grains (4 days)	9.72a	9.81b	2.25a	3.19b	73.4a	5.45a

Field experiment

Changes in growth parameters of storage wheat after planting for 45 days.

a- Shoot

The effect of the used treatments on shoot growth parameters of wheat plant after grains storing for 6 months are represented in **table (8).**

Shoot length increased either non significantly by M +MW or significantly by C+MW as regards to control value (35.8) thus, the maximum value was (38.5) recorded by C + MW.

In case of shoot fresh weight, it decreased non significantly with M while decreased significantly with C +MW in relation with control value (0.85).

About wheat dry weight of shoot, this parameter non-significantly increased by M, but decreased non-significantly with C + MW as regard to control (0.15).

Water percentage of shoot increased significantly with C + MW (83.72) which recorded the maximum value but decreased non-significantly with M + MW and significantly with M, in respect to control value (81.9). Magnetic field application improved seed performance in terms of laboratory germination, speed of germination, seedling length and seedling dry weight significantly comparing to unexposed control [20]. Pulsed magnetic field enhanced soybean seedling growth by regulation of enzyme activities[21]. [22]stated that, magnetic field alters the membrane structure of the plant cells so that the plants absorb more water and nutrients.

Table 8: Effect of the used treatments on shoot growth parameters of wheat after planting for 45 days.

ParameterTreatment Mean	Shoot length	Shoot Freshweight	Shoot Dry weight	Waterpercentage
C	35.8[b]	0.85[a]	0.15[ab]	81.9[b]
M	35.8[b]	0.83[ab]	0.16[a]	79.8[c]
C + MW	38.5[a]	0.82[b]	0.13[b]	83.78[a]
M + MW	36[b]	0.85[a]	0.15[ab]	81.76[b]

*C: stored + 0 treatment, M: stored with magnetic treated grains, C +MW: C+ irrigation with magnetic water, M + MW: M + irrigation with magnetic water.

b- Root

Table (9) showed that root length increased non significantly in M and M +MW and increased significantly by C +MW to 24 which recorded the maximum value as regards to control value (20.12) .

In case of fresh weight, it decreased non-significantly with C + MW, but increased non-significantly by M + MW which recorded the maximum value (0.08), in respect to control value (0.06)

Root dry weight decreased non significantly by M, C+ MW and increased non significantly by M + MW, as compared to control value (0.03) so, the maximum value was (0.04) recorded by M + MW.

Water percentage increased significantly by all treatments as regards to control value (49.15), where the maximum value was (62.7) recorded by C +MW.[17]approved that pre-sowing low-magnetic field treatment has the potential to enhance seed germination and seedling vigor traits of wheat verities infected with stored grain insects *(S. oryzae* or *R. dominica*) by reduction in F_1- progeny and increasing mortality percentage. [23] showed that MF may have, a mostly temporary, negative and positive effect on early wheat seedling growth, which is strongly dependent on the applied exposure time

Table 9: Effect of the used treatments on root growth parameters of wheat after planting for 45 days.

ParameterTreatment Mean	Root Length	Fresh weight	Dry weight	Water percentage
C	20.12[b]	0.06[a]	0.03[a]	49.15[d]
M	20.36[b]	0.06[a]	0.02[a]	51.6[c]
C + MW	24[a]	0.05[a]	0.02[a]	62.7[a]
M + MW	20.5[b]	0.08[a]	0.04[a]	56.62[b]

*C: stored + 0 treatment, M: stored with magnetic treated grains, C +MW: C+ irrigation with magnetic water, M + MW: M + irrigation with magnetic water,

Changes in pigments content

The changes in the determined pigments (chlorophyll a, chlorophyll b, total chlorophylls, and chlorophyll a / chlorophyll b, carotenoids & total pigments) in leaves of wheat in response to different treatments (C, M, C + MW, M + MW) are given in **table 10**.

After 45 days from planting wheat plant, chlorophyll a increased significantly by all treatments in relation to control (0.648),where the maximum value was (0.875) recorded by M +MW.

Chlorophyll b, increased significantly by all treatments related to control value (0.372) so, the maximum value was (0.670) recorded by M +MW.

Chlorophyll a/b decreased significantly by all treatments corresponding to control value (1.74) so, the maximum value was (1.36) recorded by M.

Total chlorophyll increased significantly with all treatments in relation to control value (1.02) so, the maximum value was (1.54) recorded by M +MW.

The tabulating increment in carotenoids content of wheat leaves was non-significant by all used treatments M, C +MW, M +MW as compared to the control value (0.300), where the maximum value was (0.337) recorded by M +MW.

Total pigments are increased in response to the used treatments significantly by all treatments M, C +MW, M +MW related to control value (1.32), in which the maximum value (1.88) was recorded by M +MW. Moreover, MFs have the ability to change the properties of water; MW increases chl content in leaves[24].

Table 10: Chlorophyll and carotene content of wheat seedlings after storage for 6 months and planting for 45 days (mg/g FW).

ParametersTreatment	Chlorophyll a	Chlorophyll b	Chlorophyll a/b	Total chlorophyll	Carotene	Total Pigments
C	0.648d	0.372d	1.74a	1.02d	0.300a	1.32c
M	0.803c	0.589c	1.36b	1.39c	0.313a	1.705b
C + MW	0.845b	0.630b	1.34b	1.47b	0.325a	1.8ab
M + MW	0.875a	0.670a	1.30b	1.54a	0.337a	1.88a

*C: stored + 0 treatment, M: stored with magnetic treated grains, C +MW: C+ irrigation with magnetic water, M + MW: M + irrigation with magnetic water.

Changes in the soil microflora

a- Changes in soil fungi

The data resulted from the analysis of the soil sample by dilution method showed in **table 11** and cleared that, the soil where the untreated cultivated wheat have *Asparagillus niger* which appeared in all treatments except in M + MW while *Asparagillus fumigatus* which also appeared only in C and disappeared by all other treatments.

In case of *Asparagillus flavus*, it disappeared in all treatments and about *Asparagillus A.ochraceus* it appeared only in M while disappeared by all other treatments. The way Magnetically treated water (MTW) affects plants is not clear and one possibility is that MTW affects a plant indirectly through its effect on the soil microflora] fauna population. This theory was investigated with pepper and melon, plants which have specific (and contradictory) responses to soil disinfection. Response to MTW was observed in both crops unless soil was disinfected, thus supporting the theory of the soil microflora/fauna being involved in the MTW effect.[25].

Effect of the tested MF on the soil microflora of *Triticum aestivum* plant.

Table 11: Effect of the tested EOs and MF on the soil fungi of *Triticum aestivum* plant after 45 days.

Sample name	Asparagillus niger	A.fumigatus	A.flavus	A.ochraceus
C	+	+	-	-
M	+	-	-	+
C + MW	+	-	-	-
M + MW	-	-	-	-

*C: stored + 0 treatment, M: stored with magnetic treated grains, C +MW: C+ irrigation with magnetic water, M + MW: M + irrigation with magnetic water.

b-changes in soil bacteria

The data resulted from the analysis of the soil sample by dilution method showed in **table 12** and cleared that, the soil where the untreated cultivated wheat have *Psedeumonas* sp. appeared in C and M while dissappered in C

+MW and M +MW while *Micococcus* sp appeared in untreated and treated samples.

In case of *Bacillus* sp., it appeared in all treatments except in M and about *Xanthomonas* sp. it detected only in C and M + MW while disappeared in M and C + MW

As regards to *Erwinia* sp. appeared only in M while, disappeared in all other treated and untreated samples. Pulsed magnetic field (10 Hz) pretreated soybean plants did not affect the microbial population in rhizosphere soil [21].

Table 12: Effect of the tested MF on the soil bacteria of *Triticum aestivum* plant after 45 days.

Sample name	Pseudomonas sp.	Micrococcus sp.	Bacillus sp.	Xanthomonas sp.	Erwinia sp.
C	+	+	+	+	-
M	+	+	-	-	+
C + MW	-	+	+	-	-
M + MW	-	+	+	+	-

*C: stored + 0 treatment, M: stored with magnetic treated grains, C +MW: C+ irrigation with magnetic water, M + MW: M + irrigation with magnetic water.

4. References

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