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# Magnetic field as a save alternative protectant for wheat grains during storage period and its influence on seeds viability

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**Abstract**
Current study was conducted to investigate the efficiency of magnetic field (MF) to protect wheat grains during storage period from insect infestation furthermore, studying its influence on seeds viability and seeds components after 6 months storage period. According to observed results, exposure twice at the beginning and middle of storage period (2nd group) to MF for 36&48 h was the most effective in protecting stored wheat grains from insect infestation for 6 months comparing with other tested exposure periods and untreated seeds while exposure once at the beginning of storage period (1st group) for 36&48 h was able to protect wheat for 15&19 weeks. Exposure for MF for 6&12 h wasn't effective comparing with untreated seeds while exposure for 24h was able to protect wheat for only 11 weeks. Magnetic field negatively affected the percent of seeds germination. Using of magnetic water improves germination % of magnetic wheat grains comparing with tap water with all exposure periods. Magnetic field has positive effect on seeds viability in both 1st & 2nd tested groups as it increases seedling length and improve seedling vigor index. Exposure for MF for 36&48 h in both groups increased total carbohydrate, crude protein, total fats & crude fiber % which are important for seed germination while it highly decreased ash percentages. The moisture content % was slightly increased but still under limited which useful for safe storage.

**Keywords:** magnetic field, wheat, storage, germination, water properties

## Introduction
Most of wheat losses during storage due to insect's infestation.Damaged kernels caused by insects are the result of the direct feeding of insects on the endosperm, grain embryos and also the pollution caused by their droppings and flayed skins that are make grains lighter in weight and result in discounts when marketed. Also there's increased exposure of grain to rot because of scratches and damage which create unpleasant odors. the rot can infect the grain delivered which can't be accepted by humans and animals [1] Healthy wheat grains should take its way from field to consumer through successful storage system. Protecting stored grains from pest infestation depends mainly on chemical pesticides and fumigants like phosphine and Ecofume which have harmful effect on non-target organisms and has fostered environmental and human health concerns [2, 3] therefore, there's an urgent need to develop safe, effective, economic and convenient alternative methods that have the potential to exchange toxic fumigants [4]. Other than a source of radiation, MFs (a physical control method) has attracted the attention of researchers thanks to their biological effects, low cost and safety. Physical control means make environmental changes by physical means to make it hostile or inaccessible to the pest insects [5].Many advantages of using physical agents in stored product insects control can be noticed like stored foods products without toxic or undesirable chemical residues, no resistance development of pest insects, saving nutritive value, avoiding physicochemical changes of the treated products and cheap applications [6, 7].
Investigations on the influence of magnetic fields on seeds and plants over a few years suggest that they cause better plant growth and yield than chemical fertilizers and contributed to the development of the crop productivity and protection. Additionally, there are been developed magnetic technologies in several countries that are ecologically friendly and non-polluting to the soil and are potentially attractive as being affordable to farmers [8,9].
Seed germination is enhanced by pre-sowing treatments through chemical or physical methods which protect the seeds against pest and diseases. Treatment with magnetic field (MF) may provide a viable alternative for improving seed vigor [10]. Currently, there's real evidence that magnetic pre-germination treatment of seeds before sowing allows for reduced costs of planting as germination rates are increased substantially, furthermore the plant growth being promoted [11,12].

The aim of this work is to investigate the ability of magnetic field to protect wheat during storage period from insect infestation also study its influence on seeds viability and seeds components at the end of storage period.

## Material and methods
The present study was conducted at Plant Protection Research Institute, Agriculture Research Center, Egypt.

### Magnetic device
A magnetic device of about 1000 gauss (100 mT) [13] was provided by Delta Water Company, Alexandria, Egypt.

### Storage experiment
This experiment was conducted to investigate the ability of magnetic field to protect wheat seeds during 6 months storage period. To start this experiment, 2 groups of wheat were used. **1st** group was exposed to magnetic field once at the beginning of the storage period for 6, 12, 24, 36&48 h.

**2nd** group was exposed to magnetic field twice at the beginning of storage period for 6, 12, 24, 36&48 h. and after 3 months for only 36&48 h. 1kg of wheat grains was used for each time exposure. 1kg of untreated grains was used as control group. The experiment was observed weekly to record 1st insect infestation for each treatment.

**Seed germination experiment**

Germination experiments were carried out under laboratory conditions. A germination test was performed on the 1st&2nd groups magnetized wheat grains after 6 months of storage. For this assay, ***50*** seeds were randomly picked from each treated and untreated groups and placed on 15 cm filter paper inside disposable dishes at the rate of ***10*** seeds per plate. All treatments were arranged in a randomized design with five replicates. Tap and magnetized water was used with the treated and untreated seeds as described in Table 1 at 22± 2°C to study the following parameters:

**Germination percentage**: Was calculated 10 days later according to [14, 15]

**Seedlings length (cm):** it was measured of randomly 10 normal seedlings at 10 days after planting in which Root length + Shoot length (cm) measured with measuring tape and their averages were recorded.

**Seedling vigor index (SVI):** It was calculated according to [16] as; Vigor index = Germination (%) x Seedling length (Root +Shoot)

**Table 1:** Description of tap and magnetized water used with the treated and untreated seeds

| | | | | | |
|---|---|---|---|---|---|
| Untreated seeds + tap water | Treated seeds 24h + tap water | Treated seeds 36h once + tap water | Treated seeds 48h once + tap water | Treated seeds 36h twice + tap water | Treated seeds 48h twicw + tap water |
| Untreated seeds+ magnetized water | Treated seeds 24h + magnetized water | Treated seeds 36h once +magnetized water | Treated seeds 48h once +magnetized water | Treated seeds 36h twice+magnetized water | Treated seeds 48h twice +magnetized water |

A home-made magnetic device was built with neodymium permanent magnets N52 for treating tap water fig. (1) as designed by [17] which consisted of a series of pairs permanent magnets with north and south poles facing each other, which can be associated alternately. The water to treat passed through a glass cylinder (D=1 in) inserted between the polar pieces in opposition of polarity with MF about 34 mT for 12 h. The magnetic pieces fixed by adhesive tape fig. (2) were perpendicular to the water flow. Each polar piece is the assembling of circular permanent magnets (13 mm diameter and 2mm thick). The various pairs were separated by 5 mm.

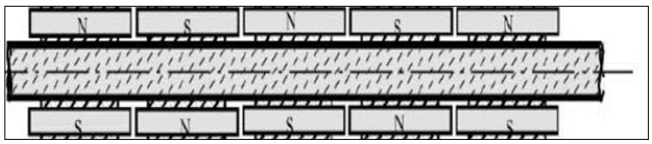


**Fig 1:** inverted permanent magnets

**Fig 2:** A home-made magnetic device was built with neodymium permanent magnets N52

**Seed component analysis**

This experiment was carried out at the Soil, Water and Environment Research Institute to study the effect of magnetic field for 24, 36&48 h exposure on the 2 groups magnetized wheat seed components (moisture, crude fats, crude protein, ash and carbohydrates %) after 6 months of storage. The control seeds were used for comparison.

**Results and discussion**

**Storage experiment**

**Table 2:** Efficiency of MF in protection of wheat grains from insect infestation during 6 months storage.

| (1st group) Exposure time | 1st insect infestation | (2nd group) Exposure time | 1st insect infestation |
|---|---|---|---|
| ctrl | 7 weeks | ctrl | - |
| 6 h | 7 weeks | 6 h | - |
| 12 h | 8 weeks | 12 h | - |
| 24 h | 11 weeks | 24 h | - |
| 36 h | 15 weeks | 36 h | 24 weeks |
| 48 h | 19 weeks | 48 h | 24 weeks |

1st group: treated once with MF 2nd group: treated twice with MF

A laboratory experiment was conducted to study the efficiency of MF in the protection of wheat grains from insect infestation during storage.

According to observed results in Table 2, exposure twice at the beginning and middle of storage period (2nd group) to MF for 36&48 h was the most effective in protecting stored wheat grains from insect infestation for 6 months comparing with other tested exposure periods and untreated seeds while exposure once at the beginning of storage period (1st group) for 36&48 h was able to protect wheat for 15&19 weeks.

Exposure for MF for 6&12 h wasn't effective comparing with untreated seeds while exposure for 24 h. was able to protect wheat for only 11 weeks.

These results indicated that MF represented a safe, powerful alternative in protecting stored seeds. A few studies have investigated the efficiency of MF during the storage period. [18] used a magnetic field among and between stored grains and seeds for 9 months in which each treatment was

provided with 80 similar small magnet pieces. Each magnet was 1.5 cm long with a 14–18 mT magnetic power. These magnets lowered insect and mite infestation by four fold compared to the control seeds. Another study performed by [19] recorded that, exposure to 180 mT MF for 48 h was very effective in protecting stored wheat from insect infestation up to 8 months compared to untreated seeds which became infested after 3 months of storage.

**Seeds viability experiment**

The effect of magnetic field on plant seed germination has been researched over a very broad range of values of magnetic induction. This experiment was conducted to study the effect of tap water and magnetized water on magnetized wheat seeds viability after 6 months storage.

Results in Tables 3&4 showed that magnetic field negatively affected the percent of seeds germination. Using of magnetic water improves germination % of magnetic wheat grains comparing with tap water with all exposure periods. Magnetic field has positive effect on seeds viability in both 1st & 2nd tested groups as it increases seedling length (root & shoot) fig.(3) & fig.(4) also improves seedling vigor index. Similar results have been reported by many other researchers such as a study by [20] demonstrated that a magnetic field of 50 Hz, 30 mT, applied on wheat seeds stimulated the growth of roots and sprouts. [21] recorded that, the influence of a magnetic field on wheat germination for magnetic induction is 35, 50 and 80 mT Also 35mT magnetic field has the strongest positive effect and Magnetic fields influence germination in the initial 50h of the process. [22] Observed that the application of magnetic field doses of 4 mT and 7 mT promoted germination ratios of bean and wheat seeds. [23] Reported that the root length of wheat seeds increases by 10 % and the radicle length of the wheat seeds plantlets increases by 14 % at 50 mT/0.5h compared with the control. [24] Concluded that magnetic treatment improves the germination rate of triticale seeds. In general, most of the triticale seeds parameters recorded with all tested doses were better than control values. In addition, seedlings from magnetically treated seeds grew taller than the control. [25] Found that magnetic field positively affected all germination parameters (seed germination %, seed and seedling vigor traits) compared to untreated seeds. [26] Reported that 125 mT magnetic field has positive effect on percentage and rate of germination in rice, wheat, maize and barley seeds [19]. Recorded that exposure to 180 mT magnetic field for 48 h had no negative effect on seeds germination (%) after 8 months storage. also, the germination (%) was accelerated by 6 h compared to non-magnetic seeds.

**Table 3:** Effect of magnetic field treatments (1st group) on germination %, seedling length (SL) and seedling vigor index (SVI) of wheat.

| Treatment | | Ctrl+ TW | | Ctrl+ MW | | Group 1 (magnetized once) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 24h+TW | | 24h+MW | | 36h+TW | | 36h+MW | | 48h+TW | | 48h+MW | |
| Mean Germ. (%) | | 100 | | 100 | | 96 | | 98 | | 96 | | 98 | | 92 | | 94 | |
| Mean SL (cm) | Mean Shoot length(cm) | 11 | 6 | 11.7 | 6.5 | 11.8 | 5.5 | 12.4 | 5.8 | 12.7 | 6.9 | 13.3 | 5.9 | 12 | 5.2 | 13.5 | 6 |
| | Mean Root length(cm) | | 5 | | 5.2 | | 6.3 | | 6.6 | | 5.8 | | 7.4 | | 6.8 | | 7.5 |
| SVI | | 14.4 | | 16.4 | | 14.6 | | 17.1 | | 14.6 | | 17.8 | | 13 | | 16.8 | |

**Table 4:** Effect of magnetic field treatments (2nd group) on germination %, seedling length (SL) and seedling vigor index (SVI) of wheat.

| Treatment | | Ctrl+ TW | | Ctrl+ MW | | Group 2 (magnetized twice) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 36h+TW | | 36h+MW | | 48h+TW | | 48h+ MW | |
| Mean Germ. (%) | | 100 | | 100 | | 98 | | 100 | | 96 | | 98 | |
| Mean SL (cm) | Mean Shoot length(cm) | 11 | 6 | 11.7 | 6.5 | 12.6 | 6 | 13.8 | 6.2 | 11.6 | 6 | 12.4 | 6.3 |
| | Mean Root length(cm) | | 5 | | 5.2 | | 6.6 | | 7.6 | | 5.6 | | 6.1 |
| SVI | | 14.4 | | 16.4 | | 15.7 | | 18.2 | | 13.9 | | 16.6 | |

TW: tap water MW: magnetic water

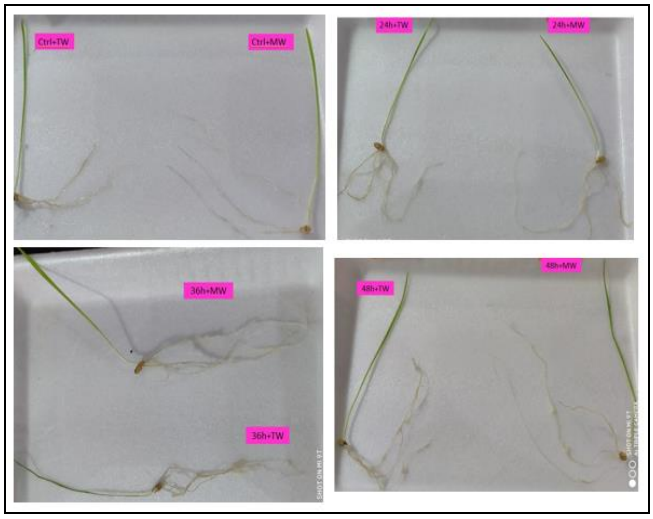


**Fig 3:** effect of Magnetic Water (MW) and Tap Water (TW) on root length of 1st group magnetized wheat seeds

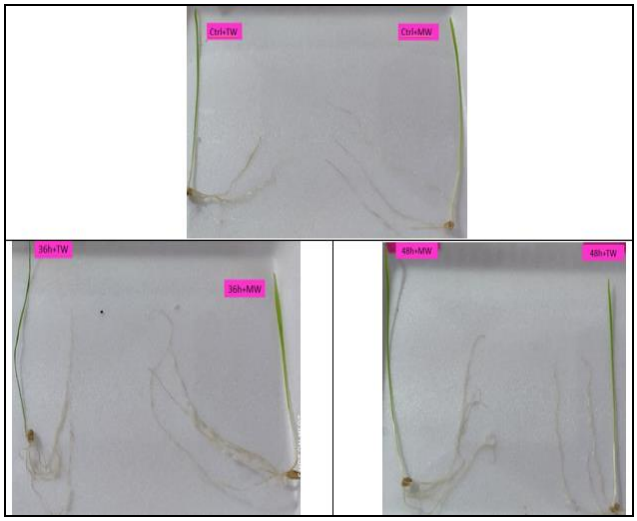


**Fig 4:** effect of Magnetic Water (MW) and Tap Water (TW) on root length of 2nd group magnetized wheat seeds

### Seeds components analysis

**Table 5:** Effect of magnetic field on wheat seed components after 6 months storage

| Content % | Control | Group 1 (magnetized once) | | | Group 2 (magnetized twice) | |
|---|---|---|---|---|---|---|
| | | 24 h | 36 h | 48 h | 36 h | 48 h |
| Moisture | 10.26 | 10.18 | 10.87 | 11.41 | 11.06 | 11.48 |
| Protein | 10.93 | 11.23 | 11.66 | 11.89 | 12.03 | 12.10 |
| Fat | 2.33 | 2.16 | 2.64 | 2.73 | 2.51 | 2.78 |
| Fiber | 3.68 | 3.41 | 4.16 | 4.22 | 4.37 | 4.51 |
| Carbohydrates | 70.67 | 71.90 | 72.18 | 72.63 | 72.57 | 72.93 |
| Ash | 5.81 | 4.53 | 2.65 | 1.34 | 1.83 | 0.71 |

The effect of MF after 6 months storage on means of wheat grains components treated once for 24, 36&48 h and twice for 36&48h including moisture content, crude fats, crude protein, ash and carbohydrates percentages are shown in Table 5. Control seeds were used for comparison.

Results showed that exposure for MF for 36&48 h in both groups increased total carbohydrate, crude protein, total fats & crude fiber % which are important for seed germination while it highly decreased ash percentages. The moisture content % was slightly increased but still under limited which useful for safe storage. Based on certification standards it is recommended that for good quality, long duration storage, prior to storage, the seeds should not have moisture content above 14 or below 5% [27]. Seeds stored at moisture content above 14% begin to exhibit increased respiration, heating and fungal invasion that destroy seed viability more rapidly while below 5% causes seed deterioration. [23] Reported that the protein percentage of the wheat seeds increase by 8 % at a dose rate of 50 mT/0.5h compared with the control. [25] recorded that, exposure wheat seeds for 60 mT MF slightly increase moisture content (%) and total carbohydrate (%) while slightly decrease crude protein (%), total fats (%) and crude fiber (%) after 12h exposure. [19] Recorded that, exposure of wheat seeds to180 mT MF for 48 h caused a slight increase in the percent of total carbohydrate, crude protein and ash while slightly decrease the percent of moisture, total fats and crude fiber after 8 months of storage.

### Conclusion

Exposed wheat grains for 36h magnetic field at the beginning and middle of storage period is sufficient to protect grains from insect infestation without affecting seeds germination% also improves seeds viability when used magnetic water with magnetic seeds.

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