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Effect of static magnetic field on physiological and biochemical seedling vigour activities of wheat seed

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ABSTRACT A laboratory experiment was conducted to find out the effect of electromagnetic field on physiological growth and biochemical seedling vigour activities of wheat seed. Seeds of wheat (*Triticum aestivum L.*) variety UP 2565 were exposed to static magnetic fields of different strength from 100-250 mT at an interval of 50 mT for different duration from 1-4 hour in steps of 1 hour. Exposure to static magnetic field significantly increased shoot length, root length, germination index, germination rate, seedling dry weight, seedling vigour index and dehydrogenase enzyme activity of wheat seed over control seeds, whereas difference in seed germination was non-significant. Seed coat membrane permeability of treated seeds was significantly improved by magnetic field over control seeds. The exposure duration did not significantly influence seed germination, physiological and biochemical seedling vigour parameters of the seeds.

Keywords: Wheat, magnetic field, germination, seedling vigour and biochemical enzyme activity

Seed vigour is one of the important parameters of seed quality, which can potentially influence crop yield through affecting seedling establishment, particularly under adverse environmental conditions. Seed vigour is maximum at physiological maturity thereafter begin to deteriorate on the mother plant or during storage. The rate of seed deterioration is positively related to ambient temperature, relative humidity and seed moisture content. Membrane disruption is one of the main reasons of seed deterioration. Nowdays, agricultural scientists around the world are trying to find out eco-friendly seed invigoration technologies based on physical and biological treatments to enhance the seedling vigour of seed for uniform emergence and better crop establishment of a crop. Seed quality enhancement treatments might be able to enhance the vigour of low quality seed. There are various physical, physiological and biochemical treatments used to improve seed vigour of poor quality seed. Among them, exposure of seeds to magnetic field is safe and cost effective method to increase physiological growth and biochemical seedling vigour activities of seed for uniform crop establishment and sustainable crop production [1]. It was reported that, an aquatic plant (*Hydrolase verticiliata*) showed an accelerated streaming of cell-protoplasm when exposed to violin music [2]. Singh and his group continued these pioneering stimulation experiments with classical Indian music using other plant species like asters, petunias, onions, sesame, sweet potatoes and radish. Similar successful plant studies have been carried out on onion and rice seeds [3] and it was concluded that rice seed exposed to a magnetic field for 12 hours showed significantly increased germination as well as shoot and root length of seedlings. Exposure of maize seeds to a 150 mT magnetic field stimulated shoot development and also led to an increase in germination, fresh weight

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and shoot length of maize plants [4]. Response of static magnetic field to plant depends on magnetic field intensity, the time of exposure to magnetic field, species and varieties of crop plant. It has been stated that positive effect of magnetic treatment may be due to paramagnetic properties of some atoms in plant cells and pigments such as chloroplasts. Magnetic properties of molecules determine their ability to attract and then change the energy of magnetic field in other type of energy and to transfer this energy afterward to other structures in plant cells, thus activating them [4]. The present study was carried out to study the effect of different magnetic fields of varying strength and duration on germination and physiological and biochemical seedling vigour parameters of wheat seed.

MATERIALS AND METHODS

Wheat seed of variety UP-2565 was obtained from Breeder Seed Production Centre, GBPUA&T, Pantnagar. Seeds were exposed to the magnetic field of 100-250 mT in steps of 50 mT for 1-4 hour in steps of 1 hour. Five hundred sound seeds were kept in the plastic container between the N-S poles of the electromagnet having a stationary magnetic field for the required duration (Fig.1). The required strength of the magnetic field was obtained by regulating the current and voltage in the DC power supply unit (Table 1). Gauss meter was used to measure the strength of the magnetic field between the north and south poles. A unit of 10^{-4} gauss measures one Tesla Strength.

After magnetizing seed with different strength for different duration, standard germination test was conducted in four

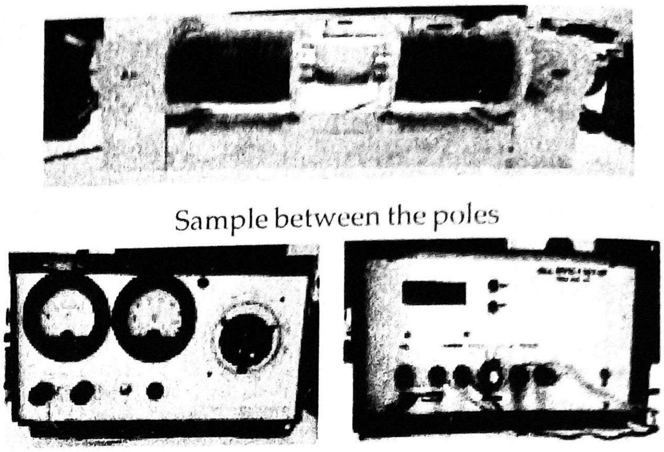


Fig. 1. Experimental setup for static magnetic field

Table 1. Current and voltage supplied to produce required strength of magnetic field

Magnetic field strength (milli Tesla)	Current (Ampere)	Voltage (Volt)
100	2.1	23
150	2.7	38
200	3.8	42
250	4.2	46

replications as per International Rules for Seed Testing [5]. Daily germination counts were made for recording number of seeds with visible radical protrusion (~2 mm) through the seed coat. At the 8th day, final count was taken and seedlings were evaluated into normal seedlings, abnormal seedlings and dead seed categories. At the end of the standard germination test, ten normal seedlings were randomly selected for measuring average root length and shoot length, separately and seedlings were dried at 70±2^{0}C for 72 h until the weight became constant for measuring seedling dry weight. Seedling vigour indices were also computed [6]. Time taken for 50% germination (T_{50}) [7]

and Mean germination time (MGT) was calculated [8]. Germination index was calculated by the formula described in Handbook of seed Testing [9]. Electrical conductivity of seed leachate was measured with the help of an electrical conductivity meter, by soaking 5 g seed in 50 ml distilled water for 17 h at 25±1^{0}C temperature. After 17 h, seeds were removed from water with the help of forceps and electrical conductivity of water was measured and expressed in µS/cm/g of seed.

Dehydrogenase enzyme activity was measured following the standard method [10] and expressed in OD/10 seed. The study was set up in completely randomized design with four replications and the data was analyzed by using STPR-2 programme, designed and developed by Department of Mathematics and Statistics of College of Basic Science and Humanities (CBSH), Pantnagar. Standard error of means (SEm ±) was computed and critical differences (CD) at 5% level of probability were worked out for comparing treatments in case of significant 'F' test [11].

RESULTS AND DISCUSSION

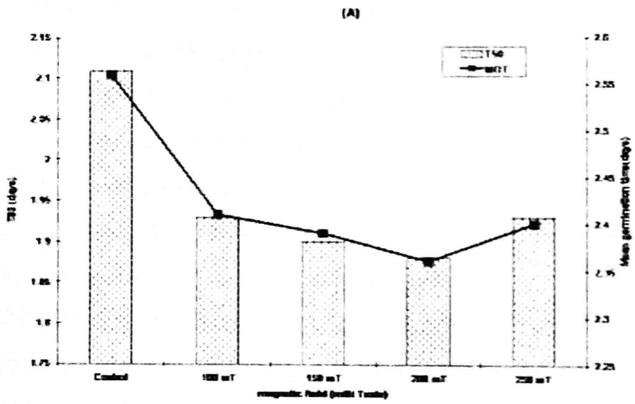
Exposure of wheat seeds to different magnetic field strengths significantly improved physiological and biochemical seedling vigour indices over control (Table 2). However, the effects of exposure durations on these parameters were non-significant. In the present study, earlier and uniform germination was observed in treated seeds over control (Fig. 2A). The increased germination rate in treated seeds was indicated by lower value of T_{50} and mean germination time and higher speed of germination. A significant decrease in time taken to 50% germination in magnetic field treated maize seed was also observed [12]. The increased germination rate and seedling vigour parameters may be attributed due to increased dehydrogenase enzyme activity in the treated seeds (Table 2). The seed coat membrane stability of treated seeds was also higher, which resulted in reduced leaching of solutes from the seeds. In treated seeds shoot length, root length and seedling dry weight were 15-16%, 7-9% and 4-11% higher than control seeds respectively (Fig. 2B). The increased vigour parameters consequently resulted in increased seedling vigour index-I (9-12%) and seedling vigour index-II (5-12%) over untreated seeds (Table 2). Mean germination time and time taken to 50% germination decreased by 6-8% and 8-10%, respectively; whereas germination index increased by 7-8 % over control. It may be because of increase in the root growth of plants (Fig. 2B). Roots of plant contain starch molecule that determine the effect of the earth's magnetism [13]. Our results are in agreement with previous studies [3], wherein they noted that the application of an external magnetic field as a pre-germination treatment improved the germination and seedling vigour of low viability rice and onion seeds. However, seed germination was not significantly influenced by energy treatments. It was also reported by that the differences in final germination percentage of the magnetically treated rice seeds and the control were non-significant when exposed to various magnetic frequencies [14].

Among magnetic field intensities, exposure of seeds to 100 mT intensity

Table 2. Effect of different magnetic field strength on germination, germination index, seedling length, seedling vigour index (SVI-I), seedling dry weight, seedling vigour index (SVI-II), dehydrogenase activity and electrical conductivity (EC) on wheat seed

Treatments	Germination (%)	Germi nation index (per day)	Seedling length (cm/ seedling)	SVI-I	Seedling dry weight (mg/ seedling)	SVI-II	Dehydro -genase activity (O.D./ 10 seed)	Electrical conductivity (µS/cm/ g of seed)
Control	98.0	19.67	22.03	2161	15.10	1480	0.103	33.75
100 mT*	98.9	21.11	24.36	2408	16.74	1655	0.178	30.82
150 mT	98.6	21.18	24.21	2388	16.20	1597	0.159	32.05
200 mT	98.0	21.13	24.03	2355	16.38	1606	0.143	29.78
250 mT	99.0	21.16	24.24	2400	15.73	1557	0.131	29.93
SEm±	0.4	0.27	0.26	29	0.31	32	0.016	0.51
CD (p=0.05)	NS	0.77	0.73	83	0.87	81	0.045	1.45

*mT= milli Tesla



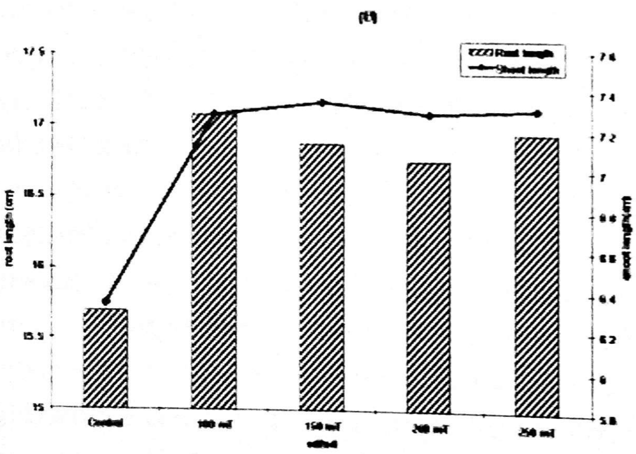


Fig. 2. Effect of different magnetic field strength on time taken to 50% germination (T_{50}), mean germination time (MGT) (A) , shoot length and root length (B) of wheat seed

recorded higher values of 17.07 cm, 16.74 mg/ seedling, 1655 and 0.178 OD/10 seeds for root length, seedling dry weight, seedling vigour index-II and dehydrogenase activity, respectively which was significantly higher than 250 mT magnetic field intensity and at par with 150 and 200mT intensities. Similarly, 200mT magnetic field intensity recorded significantly lower values of 29.78, 1.88 and 2.36 for electrical conductivity of seed leachate, T50 and MGT compared to control seeds. The results obtained in our study regarding seedling vigour parameters are in agreement with the previous results [12], wherein they reported higher seedling growth in maize seeds exposed to 125 and 250 mT magnetic field. A considerable improvement in shoot length and seedling length was reported in maize seeds when seeds were magnetically treated [4]. The magnetically treated seeds had significantly higher vigour indices than that of control [15]. These results clearly indicate that exposure of seeds to magnetic field intensity of 100mT to 200mT produce some stimulatory effect on various seed quality parameters. Further, increase in intensity to 250mT recorded significant reduction in seedling dry weight (15.73mg/seedling), seedling vigour index–II (1557) and dehydrogenase enzyme activity (0.131 OD/10 seed). It shows that further increase in magnetic field intensity had a deleterious effect on seedling vigour parameters. The harmful effect of high magnetic intensity was also reported earlier [16].

The probable reasons for the improved performance of magnetized seeds may be attributed to change in the respiration rate of the plant in the constant magnetic field [17]. It was suggested that, magnetic field modulate the rate of recombination of free radicals during normal plant metabolism [18] and other author suggested that magnetic field might affect activity of ion channels [19] or ion transport within a cell. The magnetic field enhanced germination rate of sunflower seeds [1], that earlier germination led to improvement of seed vigour and superior root traits may be due to more activity of hydrolyzing enzymes. However, according to the present state of knowledge, it is difficult to say precisely how these energy treatments help in improving physiological and biochemical process of seeds, but several theories have been proposed, including biochemical changes or altered enzyme activities [19]. On the basis of, these results, it can be summarized that exposure of wheat seeds to different static magnetic field significantly improved germination index, shoot length, root length, seedling vigour index and dehydrogenase enzyme activity compared to control seeds. Among various combinations of magnetic field and exposure duration, 100mT for 1h yielded superior root length, mean germination time, time taken for 50 percent germination, seedling vigour index and enzyme activity. Increase in the magnetic field intensity above 200mT had a deleterious effect on seedling vigour parameters. Therefore, exposure of seeds to static magnetic field at 100 for 1h duration could be a way of seed invigoration treatment for improving stand establishment under adverse environmental conditions for wheat crop. However, these results need to be validated through further studies.

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