EFFECTS OF MAGNETIC SEED TREATMENT ON YIELDS OF BARLEY, WHEAT, AND OATS IN SOUTHERN ALBERTA

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Received 11 Dec. 1975, accepted 30 Sept. 1976.

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PITTMAN, U. J. 1977. Effects of magnetic seed treatment on yields of barley, wheat, and oats in southern Alberta. Can. J. Plant Sci. 57: 37–45.

Preseeding magnetic treatment of barley seed (*Hordeum vulgare* L.) resulted in seed yield increases in 13 of 19 field tests in southern Alberta from 1972 and 1975. Similarly, treatment of spring and winter wheat seed (*Triticum aestivum* L.) resulted in yield increases in 14 of 23 tests. Otas (*Avena sativa* L.) showed no yield response to magnetic treatment of the seed. Within specified limits, date of treatment before seeding, strength of magnetic field, make or model of the magnetic treater used appeared to have no appreciable effect on the response elicited by the seed and the resultant plant.

De 1972 à 1975 dans le sud de l'Alberta, le traitement magnétique en présemis de semences d'orge (*Hordeum vulgare* L.), de blé de printemps et d'hiver (*Triticum aestivum* L.), ainsi que d'avoine (*Avena sativa* L.) a accru le rendement grainier dans 13 essais au champ sur 19 pour l'orge, 14 sur 23 pour le blé, mais n'a donné aucun résultat pour l'avoine. Dans les conditions des essais, la date du traitement, la force du champ magnétique, la marque de commerce ou le modèle du magnétomètre semblent n'avoir eu aucun effet significatif sur la réaction manifestée par les semences et les plants engendrés.

A magnetic field applied to dormant seed was found to increase the rate of subsequent seedling growth of barley, corn, beans, wheat (Pittman 1963; Mericle et al. 1964; Pittman and Anstey 1967), certain tree fruits (Chao and Walker 1967), and other tree species (Maronek 1975). Exposure of corn and soybeans to magnetic fields (Moustafa 1973) indicated that environmental factors such as temperature and soil moisture content around the seed may affect the response obtained.

This paper described the effects of magnetic treatment of dormant seeds on subsequent growth and yield of barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L. and *T. durum* Desf.), and oats (*Avena sativa* L.).

MATERIALS AND METHODS

The following commercial and experimental machines were used to expose wheat, oats, and barley seed to a magnetic field. Not all machines were used each year on each cultivar. (Use and mention of these and other magnetic seed treaters does not imply endorsement by Agriculture Canada.)

Commercial Machines

(1) A SeedXciter™ made by Agro Enterprises Incorporated, Owasso, Michigan;
(2) A Seed Enagizer™ manufactured by Agro Tronics Incorporated, Des Moines, Iowa;
(3) A Zapper™ made by Agronetics Incorporated, Calgary, Alberta;
(4) A Magna 90™ manufactured by Hagen Electric Lethbridge Limited, Lethbridge, Alberta;
(5) A Booster™ manufactured by Willaul Marketing Limited, Calgary, Alberta.

Experimental Machines

(1) A *Starter Unit* that consisted of an electric auto starter from which the end plates had been removed and the armature replaced with a 25-cm length of 6.5-cm-diam PVC pipe. When the unit was activated with 12 volts DC at 3 amps, a field

of 50 gauss developed at the midpoint between the two opposite field coils. (All quoted magnetic inductions were measured with a Model 1890 Gauss Meter manufactured by Radio Frequency Lab Incorporated, Boonton, New Jersey, U.S.A.)

(2) A *Two-Magnet Unit* consisted of two 6-kg horseshoe magnets mounted 10 cm apart on opposite sides of a wooden chute. A magnetic field of 650 gauss existed at the midpoint between the magnets, which were mounted to attract one another.

(3) A *Dummy Unit* was identical to the magnet unit except that dummy aluminium "magnets" were used and there was, therefore, no magnetic field.

(4) A *Four-Magnet Unit* consisted of four 7.6 × 1.2-cm bar magnets mounted quadrilaterally on the outside of a 9-cm-diam cardboard tube. At the midpoint between the magnets, there was a field of 50 gauss.

(5) A *Bolus Unit* consisted of an 8 × 1.5-cm cylindrical rumen magnet centrally suspended in a 6.5-cm plastic tube. Midway between the magnet and the tube wall there was a magnetic field of 130 gauss.

Grain to be treated in either the SeedXciter or the Seed Enagizer was moved through the machine at a rate of 18 q/h by an electrically driven auger. Grain was allowed to "free-fall" through all other treaters.

To provide seed for check plots, grain was passed through the Dummy Unit or through the SeedXciter with the electromagnet inactivated. No magnetic field, other than of terrestrial origin, was detected in the SeedXciter except when the coil was activated. The following grains were included in the experiments: wheat (*Triticum aestivum* L.) cvs. Neepawa, Glenlea, and Sundance; wheat (*Triticum durum* Desf.) cvs. Wakooma and Wascana; barley (*Hordeum vulgare* L.) cvs. Galt, Betzes, and Conquest; and oats (*Avena sativa* L.) cv. Sioux.

General Experiments at Lethbridge, Alberta

From 1972 to 1975, 100-kg lots of wheat, oats, and barley seed were treated shortly before sowing. The SeedXciter was used each year. In addition, the Seed Enagizer was used from 1973 to 1975 and the Zapper in 1975.

Time of Treatment Experiment

In 1974 and 1975, Galt barley and Neepawa wheat seed that was grown and harvested at the Agriculture Canada Research Station at Lethbridge, Alberta, was treated in an activated Seed Enagizer at weekly intervals, 1–42 days before planting. Seed for check plots was passed through the Enagizer before the electromagnetic collar on the machine was activated. After treatment, seed was stored at room temperature away from the treating area and sway from known electrical circuits until it was sown.

Treater Experiments

Experiments in 1974 and 1975 were designed to test the effects of several commercially available and experimental magnetic seed treaters on the yield of Galt barley and Neepawa wheat.

Location Experiments

In 1974 or 1975, or both, Galt barley and Glenlea spring wheat seed treated in the SeedXciter or the Seed Enagizer were sown at several locations in southern Alberta to sample a range of weather and soil conditions.

Field Culture

At seeding time, experiments using magnetically treated seed were placed on clean fallow land at the Agriculture Canada Research Station at Lethbridge and at several other locations in southern Alberta. Field plots were arranged in randomized blocks or split blocks with four to eight replicates depending on available land. Each plot contained 6 or 12 rows, 8 to 18 m long, spaced 22 cm apart. All grains were sown at a rate of 67 kg/ha with a powered plot drill equipped with double disc furrow openers preceded and followed by packing wheels to ensure uniform depth of seeding and compaction of soil around the seed. No consideration was given to row orientation except that all rows in any test were oriented in the same geographical direction. Broadleaf weeds were controlled, where necessary, with an application of appropriate herbicide to the entire experimental plot area. All tests were examined periodically to determine general conditions of plant growth, development, and maturity. Grain yields were determined by harvesting the center four or eight rows of each plot after the plot ends had been suitably trimmed to length. All data were analyzed statistically (Goulden 1952).

RESULTS

General Tests at Lethbridge

Yields of grain from all crops and cultivars showed the year-to-year variability common to dryland crops in southern Alberta. Although yields of Neepawa spring wheat were increased ($P < 0.05$ or $P < 0.01$) by magnetic treatment in only three of the five tests conducted (Table 1), in none of the experiments did the treated grain yield significantly less than the untreated check. In 1975, seed treatment had no effect on the yield of Neepawa wheat in an early seeded test, but tended to increase yields ($P < 0.10$) in another test shown 1 wk later in somewhat less fertile soil. Both tests received about the same amount of precipitation.

The response of non-bread wheats (Glenlea, Wakooma and Wascana) to magnetic seed treatment was erratic (Table 1).

In 2 of 3 yr, yields of Sundance winter wheat were increased ($P < 0.05$) by magnetic seed treatment. In 1975, a patchy distribution of an infection with a mosaic-like disease caused within-plot variability, and although treatment did not affect yields ($P > 0.05$), differences in plant size, development, and maturity were visible.

In tests on three barley cultivars, yields were increased by magnetic seed treatment. Galt barley yields were not affected by seed treatment in this series of tests in 1974 or 1975. Although dates of maturity were not recorded, barley grown from treated seed usually turned green to buff color 2–4 days earlier than that grown from check seed. Concomitantly, the awns on the more mature barley heads assumed a more open position and the heads tended to nod earlier.

Preseeding magnetic treatment had no effect ($P > 0.05$) on the yield of Sioux oats. There were no apparent differences in height, plant population, or time of maturity of the oat plants grown from treated and untreated seed.

Time of Treatment

Magnetic treatment increased ($P < 0.05$) yields of Galt barley and Neepawa wheat in 1974 and 1975 (Table 2), but the main effect of time of treatment was not significant ($P > 0.05$) except in 1975 when the average yield of Galt barley grown from seed treated 29 days before seeding was lower than that grown from untreated seed. Similarly, in 1975, the yield of Neepawa wheat grown from seed treated immediately before, or 29 days before, seeding was the same as that of the untreated grain. There was no difference ($P > 0.05$) in yield response to the two different treaters used.

Treater Experiments

In 1974 and 1975, Galt barley yields were increased ($P < 0.05$ or $P < 0.01$) as a result of magnetic seed treatment, irrespective of the treater used (Table 3).

Yields of Neepawa wheat were increased ($P < 0.01$) in 1974 by using seed treated in either of two experimental treaters. These results are similar to those obtained in the time of treatment test. Conversely, in 1975, yields were not affected by treatment ($P > 0.05$) in this test, although treatment had increased yields in the date of treatment test which was sown about 1 wk earlier.

Yield response appears to be independent of the strength of the imposed magnetic field, since about the same magnitude of response was obtained from treaters generating fields of from 50 to 650 gauss at the point of measurement.

Location Experiments

Yields of Galt barley were increased by 2.8–6.5 q/ha ($P < 0.01$ or $P < 0.05$) by treatment in 1974 and 1975. Magnetic treatment did not affect ($P > 0.05$) yields at Milk River in 1974 or at Carseland in 1975 (Table 4). At Carseland, however, barley grown from magnetically treated seed lodged earlier than that grown from untreated seed (Fig. 1). Though no measurements were taken, visual comparisons indicated that barley grown from treated seed was about 5–8 cm taller than that from untreated seed.

Table 1. Effects of magnetic seed treatment on yield (q/ha) of cereals at Lethbridge, Alberta, 1972-1975

	1972			1973				1974				1975				
Cultivar	T_2‡	C	% CV	T_1	T_2	C	% CV	T_1	T_2	C	% CV	T_1	T_2	T_3	C	% CV
								Wheat								
Neepawa	28.7*	26.9	2.2	16.9*	16.9*	15.1	4.5	17.3	17.7	17.2	2.0	30.8		32.6	31.6	7.9
Neepawa												25.5†			24.2	1.1
Glenlea				13.4*	13.7*	11.1	7.4	18.3	19.9	19.2	4.0	30.4		31.9	31.4	7.0
Wakooma								18.1**	17.9**	17.1	0.8	33.1		33.9	33.5	4.8
Wascana												29.0*			28.1	1.5
Sundance					18.5*	17.3	3.8	22.7**		21.6	1.3	32.9	32.8		30.6	5.6
								Barley								
Galt	41.7**	40.3	2.8	26.8**	26.2**	23.8	6.9	25.8	24.8	24.9	1.7	43.8		44.0	43.0	2.8
Betzes								23.1*	23.3*	22.5	1.5					
Conquest												35.2*			33.6	2.0
								Oats								
Sioux	33.4	33.0	3.6	18.2	17.0	17.6	4.4	18.4	18.1	18.5	2.5	40.4		40.7	41.6	2.6
Sioux												30.6			30.3	2.8

†*,**, Treatments differ from control at $P < 0.10$, $P < 0.05$, or $P < 0.01$.
‡T_1, seed treated in Seed Enagizer; T_2, in SeedXciter; T_3, in Zapper; C, control.

Table 2. Yield (q/ha) of Galt barley and Neepawa wheat grown from seed exposed to a magnetic field at various intervals before sowing, Lethbridge, Alberta, 1974-1975

Treatment to sowing interval (days)	Galt Barley					Neepawa Wheat				
	1974		1975			1974		1975		
	T†	C	T	M	C	T	C	T	M	C
43.5±1.5	26.3	26.0	45.4	43.0	44.2	19.2	18.0	32.9	32.3	31.2
36.5±1.5	28.4	26.7	45.8	46.6	39.9	18.0	18.3	33.9	34.6	32.9
29.5±1.5	27.3	26.4	44.8	46.2	46.2	19.5	18.9	33.7	33.3	33.3
22.5±1.5	27.0	26.5	43.4	45.7	43.6	18.8	18.5	33.4	34.5	32.6
16.0±1.0	26.4	26.3	46.6	46.3	44.3	19.1	18.9	34.7	35.9	33.4
1.5±1.5	27.1	26.2	44.2	46.1	43.5	19.8	19.5	33.5	33.7	33.3
Avg yield	27.1*	26.4	45.1*	45.7*	43.6	19.0*	18.5	33.7*	34.1*	32.8
% CV for treatment	3.44		5.69			8.14		5.69		
Treatment	*		*			*		*		
Interval	NS		NS			NS		NS		
Interval × treatment	NS		*			NS		*		

*Treatments differ from control at $P < 0.05$.
†T, seed treated in Seed Enagizer; M, seed treated in Magnet Unit; C, control.

Galt barley yields were decreased ($P < 0.01$ or $P < 0.05$) by treatment at one location (Grassy Lake) in both test years. In 1975, barley grown at Grassy Lake from treated seed matured 3–5 days earlier (Fig. 2), but weighed 0.96 kg/hl (6.71 vs. 7.67) less than that grown from untreated seed.

Yields of Glenlea spring wheat were increased ($P < 0.01$ or $P < 0.05$) as a result of magnetic seed treatment in tests at two of three locations in 1974 and 1975. Treatment had no effect ($P > 0.05$) on yield of Glenlea at Carseland in either test year.

At all locations, the yield response obtained was independent of the type of treater used.

Table 3. Effects of various commercial and experimental magnetic seed treaters on yield (q/ha) of Galt barley and Neepawa spring wheat at Lethbridge, Alberta, 1974-1975

Treater†	Galt barley			Neepawa Wheat	
	1974	1975	1975	1974	1975
Enagizer (c)		43.6**	47.1**		26.6
Booster (c)		42.7**			26.8
Zapper (c)		43.1**			27.1
Magna 90 (c)		42.7**			26.3
1 Magnet Unit (e)	26.7*	42.2**		22.2**	26.9
4 Magnet Unit (e)			46.8**		
Starter (e)	26.0*			22.6**	
Bolus (e)			46.4**		
Control	24.9	40.1	45.2	20.6	26.1
% CV	4.03	3.16	1.85	4.22	5.43

*,**Treatments differ from control $P < 0.05$ or $P < 0.01$.
†c, commercial units, and e, experimental units.

Table 4. Effects of magnetic seed treatment on yield (q/ha) of Galt barley and Glenlea wheat at several locations in southern Alberta, 1974-1975

		Galt barley				Glenlea wheat			
Location	Year	T_1†	T_2	C	CV (%)	T_1	T_2	C	CV (%)
Arrowwood	1974	33.8*	33.8*	30.8	6.8	31.0*		28.2	4.5
	1975		48.1**	42.7	4.7	29.9*		27.5	4.0
Carseland	1974	48.1*	46.7*	43.9	4.5	22.1	21.0	21.4	6.0
	1975		52.9	50.9	7.5	34.3		35.8	7.8
Chin	1974	36.7*	34.0*	31.0	5.7				
Glenwoodville	1974		23.5**	16.8	16.1	15.7**	17.2**	13.1	9.8
Grassy Lake	1974		23.5**	27.8	5.0				
	1975		34.2*	40.4	8.3				
Indus	1974	35.6**	34.5**	31.3	6.0				
Milk River	1974	14.1	13.4	12.0	11.6				

*,**Treatments differ from control at $P < 0.05$ or $P < 0.01$.
†T_1, seed treated in Seed Enagizer; T_2, seed treated in SeedXciter; c, control.

DISCUSSION

Field experiments on crop plants, in which yield is used as the sole or primary criterion for measuring the effect of a treatment seldom provide consistent results from year to year or crop to crop. When the treatment is applied to the seed before it is sown, all of the uncontrollable environmental conditions that occur during the growing season have an opportunity to affect final seed yield. If any of the uncontrolled factors has a different effect on the "treated" than on

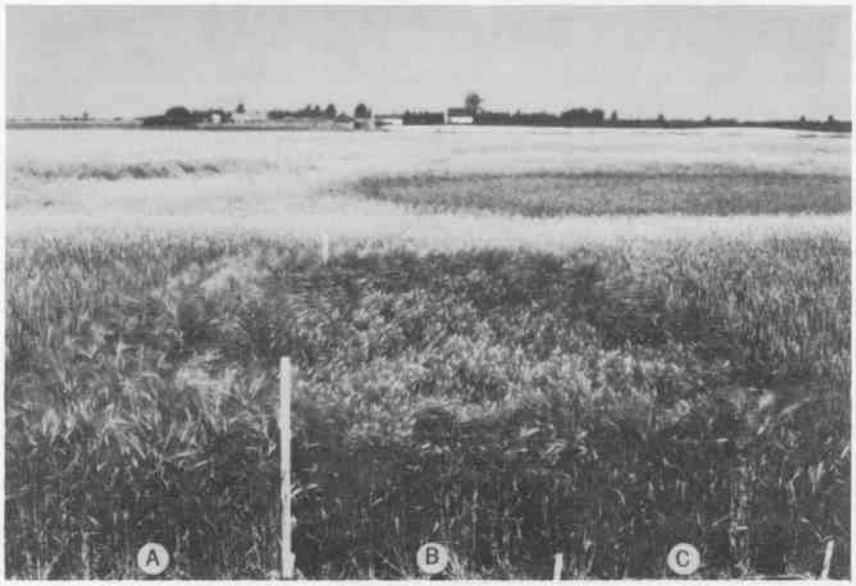

Fig. 1. Galt barley grown from magnetically treated seed (B and C) lodged earlier than that grown from untreated seed (A), Carseland, 1975.

Fig. 2. Galt barley grown from mangnetically treated seed (A and B) matured earlier than that grown from untreated seed (C), Grassy Lake, 1975.

the ''untreated'' plants, the real effect of original treatment may be partially masked. For example, it has been shown that fungicidal dressings applied to wheat generally increased the yield of wheat; but in some years and at some locations, yield decreases were recorded after treatment (Das Gupta and Austenson 1973). Similarly, it has been shown that plant density and yield were related only at low and high levels and that plant density had no measurable effect on yield when stands were intermediate (Pelton 1969). Environmental conditions undoubtedly also affected our results.

In 13 of 19 tests conducted from 1972 to 1975 on non-irrigated lands in southern Alberta, yields of barley were increased substantially as a result of magnetic seed treatment. Morphological differences in plants grown from treated and from untreated seed were occasionally visible. In each of 2 yr at Grassy Lake, yields of barley grown from treated seed were significantly lower than those of barley grown from untreated seed. That this decrease in yield may be related to the lack of adequate soil moisture during the later stages of development of the earlier-maturing plants grown from treated seed is indicated by the lower test weight of the crop produced by the treated seed. The more sparsely spaced plants on the control plots (22.8 and 38.2 plants/m of row in 1974 and 1975, respectively) probably withstood the severe summer droughts (3.1 and 4.1 cm precipitation, 1 July to 15 August in 1974 and 1975, respectively) better than the more dense plant populations (31.7 and 45.0 plants/m of row in 1974 and 1975, respectively) that prevailed where treated seed was used. This hypothesis is supported by research (Pelton 1969) that showed that soil moisture was available over a longer period to crops seeded at low rates than where high seeding rates were used, and also that low seeding rates of wheat resulted in heavier kernels where soil moisture was limited during the growing season. While advanced maturity in grain grown from magnetically treated

seed may be, in part, a response to earlier limitations in soil moisture, it may also be a direct response to the magnetic seed treatment. It has been reported (Pittman 1963, 1965; Khvedelidze et al. 1968; Moustafa 1973) that rate of germination or seedling growth, or both, of cereals, beans, and corn was increased after magnetic treatment of the seed.

Whether all barley cultivars react the same as Galt to magnetic treatment is unknown. Limited testing with Betzes and Conquest indicated that their response was similar to that of Galt.

Yields of spring wheat were increased ($P < 0.01$ or $P < 0.05$) in only 12 of 20 tests from 1972 to 1975 as a result of magnetic seed treatment. Yields of this crop were never decreased as a result of seed treatment. Failure to obtain additional positive yield reponses to magnetic seed treatment in spring wheat may be an indication that spring wheats are affected differently by environmental conditions prevailing during the growing season than is barley, possibly because they require a longer growing season.

Although magnetic treatment led to increased yields ($P < 0.01$ or $P < 0.05$) in Sundance winter wheat in only 2 of 3 yr, it is highly probable that a positive response occurred also in the 3rd yr, but that disease obscured any meaningful yield data.

Under the environmental conditions of southern Alberta, Sioux oats did not respond to magnetic seed treatment in any of five tests conducted from 1972 to 1975. Research showing that magnetic treatment may affect the permeability of the cell membrane (Lebedev et al. 1975) suggests that the structure or permeability of the oat cell membrane may differ from that of wheat or barley.

Within limits, neither time of treatment nor strength of magnetic field appeared to affect the magnitude of the response elicited in the seed and the resultant plant. Previous research (unpublished data) showed that magnetically treated Campana barley seeds that were held in sealed jars for 11 yr after treatment had a higher rate of germination and grew more in a 48-h test than similarly stored untreated seeds. That field strength may not be critical is in agreement with earlier research on cereal seedling growth rate (Pittman 1967). Earlier research (Ssawostin 1930) indicated that fields of low intensity may affect some biological processes as much as those of higher intensity. Low intensity fields increased growth rate of rye, lupins, beans, cucumber, and maize (Strekova et al 1965), but higher fields had no effect on rye plants.

Although these experiments indicate that similar yield responses to seed treatment in a small selection of electromagnetic and permanent magnet seed treaters were obtained in most grains, there may be ineffective treaters. More research is needed to define optimum field strengths for treating various grains, optimum date of treatment before seeding, and optimum rates of treatment.

Similarly, post-treatment handling of seed may affect the growth and yield response obtained and should be investigated. Information is needed on the interaction of seed treatment, crop fertilization, and soil moisture utilization. Additional research is also required to determine the response mechanism within the seed and plant to delineate the precise environmental conditions under which responses to magnetism may or may not occur, since preliminary research (personal communications) at other locations in Canada tends to provide fewer positive results.

ACKNOWLEDGMENTS

I thank Dr. F. R. Harper for his assistance in preparing this manuscript.

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