Research Article

Comparison between Pulsed and Static Magnetic Treatment for Enhancement of Germination Characteristics in Differentially Aged Maize Seeds

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Abstract

Magnetic treatment is one of the seed enhancement treatments which are a non-invasive and non-aqueous technique that is advantageous over traditional chemical processes or priming due to the absence of toxic residues and avoidance of hydration. Magnetic field treatment is two types viz, pulsed and static magnetic treatment but which one is better among them is still poor known. A study was done in spring-summer 2013 at IARI research farm to compare pulsed and static magnetic treatment for enhancement of germination characteristics in differentially aged maize seeds. Two differentially aged seed lots of Pusa composite-3 (*kharif* 2009 and 2011 produce) was subjected to pulsed [100 mT for 2 h with 6 min. interval (T_1)], and static magnetic treatment [100 mT for 2 h (T_2)] for optimization of dose for enhancement of germination characteristics and one without exposing the seeds into magnetic field known as untreated (T_0). Both magnetic field treatments showed beneficial effects on total emergence, speed of emergence, seedling weight (fresh and dry weight), leaf area and vigour index to varying degrees over control. Both the magnetic treatments showed positive effect and the enhancement in low vigour lot was more as compared to high vigour lot. The effect of magnetic treatment was more pronounced in pulsed magnetic field treatment as compared to static magnetic field. It is concluded that both pre-sowing magnetic treatment can be effectively used for improving field performance on low vigour lots of maize.

Keywords: Maize, Pulsed and Static Magnetic treatment, Field performance, Leaf area, Vigour index

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Introduction

Maize (*Zea mays* L.) is third most important cereal crop after wheat and rice in the world and has multiple uses in food, feed and industrial sectors. In India, maize is cultivated throughout India under a wide range of agro-ecological conditions, both rainfed and irrigated. Rapid and uniform field emergence is essential to optimize stand establishment under all environmental conditions. The overall performance of the crop is based on the quality of the seed sown. High germination and vigour of the seed are important for uniform field emergence, better crop stand and high yield. Physiological constraints like poor germination and vigour, low seedling emergence and establishment result in uneven and low plant stand.

Various seed treatments have been devised to improve the rate and uniformity of emergence as well as seed viability in a number of crop species [1-4]. Magnetic treatment is a non invasive physical stimulant used for improving vigour and field emergence in seeds. Numerous reports are available on the stimulating effects of magnetopriming on plant growth and yield under non-stressed condition [5-7]. These were supported by response of magnetic field exposure on enhanced level of assimilatory pigments, chlorophyll and average nucleic acids in plants [8]. Increase in the amount of chlorophyll a, b and total chlorophyll contents of the primary and secondary leaves, both in 10 and 14 days old seedlings were observed in fresh paddy seeds exposed to Pulsed Magnetic Field [9]. Radhakrishnan *et al.*, [7] reported that pretreatment of pulsed magnetic treatment (PMF) plays important roles in improvement of crop productivity of soybean through the enhancement of protein, mineral accumulation and enzyme activities which leads to increase the growth and yield. Vashisth and Nagarajan [10] observed the effect of pre-sowing exposure of maize seeds to static magnetic field and found increased seedling growth, especially the root length. Alternating magnetic field exposure of 35, 50 and 80 mT in wheat accelerated the metabolic rate in comparison with non-exposed seeds [11]. Exposure of dry seeds to both static and pulsed magnetic field improved the germination and vigour in a number of crops [12].

Materials and Methods

Seeds

Two differentially aged seed lots of Pusa composite-3 (*kharif* 2009 and 2011 produce) was subjected to pulse and static magnetic treatment for optimization of dose for enhancement of germination characteristics.

Magnetic field generation

An electromagnetic field generator "Testron EM-60" with variable horizontal magnetic field strength (50–300 mT) with a gap of 10 cm between poles was used for seed treatment. The pole pieces were cylindrical in shape, 15 cm in diameter, 35 cm in length. The number of turns per coil was 1600 and the resistance of the coil was 16 Ω. A DC power supply (80 V/10 A) with a continuously variable output current was used for the electromagnet. A digital Gauss meter model DGM-30 (Testron Instruments, India) operating on the principle of the Hall Effect monitored the field strength produced in the pole gap. The probe was made of indium arsenide crystal and encapsulated to a non-magnetic sheet of 5 mm x 4 mm x 1 mm could measure 0–2 T with full-scale range in increments of 5 mT.

Magnetic seed treatments

Differentially aged maize seeds were given following magnetic treatments with an electromagnetic field generator "Testron EM-60". The seeds were held in the sample holder with a gap of 10 cm between the two poles of the electromagnet having a uniform magnetic field for the desired duration. The required strength of the magnetic field was obtained by regulating the current in the coils of the electromagnet. The variation in temperature during the course of seed exposure was 25 $\pm$ 0.5°C. For parallel control, seeds from the same lot used for magnetic field exposure were kept under conditions which had no influence of the induced magnetic field, as magnetic field generator was housed in a separate chamber. Following treatments were used for this studied;

Untreated = Control (T_0)
Pulsed magnetic treatment = 100 mT for 2 h with 6 min. interval (T_1)
Static magnetic treatment = 100 mT for 2 h (T_2)

Efficacy of magnetic field treatments on seed germination, rate and uniformity of emergence, seedling establishment, and vegetative growth in maize was evaluated under Delhi conditions. Four replications of 200 seeds from control and each treatment were sown in the DSST field during spring summer 2013. Experiment was laid in randomized block design with four replications. 200 treated and control seeds were sown on ridges in plots of 5mx3m length with four rows maintaining a row to row and plant to plant distance of 75 cm and 25cm respectively. Sowing was done on 1st Feb 2013. Emergence count of the seed were taken under for two week and total seedling emerged were counted. The emergence was expressed as percentage of seedling emerged which was counted as:

Percent emergence = (no. of seedling per 4 rows/200*) x 100

*Total number of seeds sown in four rows per replication

Speed of Emergence was computed as per Maguire [13]

$$\text{Speed of germination} = \sum n/t$$

Where n is number of seeds newly germinated at time t and t is days from sowing

After taking the final count on seedling emergence, five plants from each replication were used for taking fresh weight and dry weight. Seedlings from each replication were washed, and dried at 80 $\pm$ 1°C for 24 hrs for dry weight. Seedling fresh and dry weight was expressed in g/five seedling.

Results and Discussion

The performance of the spring season maize crop is reported to be better than *kharif* [14], though the poor stand establishment due to low soil temperature is a problem. Hence, several priming/enhancement treatments have been tried to improve field emergence in winter/spring maize [14, 15]. The results indicated that both the pulsed and static magnetic treatments enhanced germination and field performance in terms of field emergence (4.67-4.82%) (**Table 1**), speed of emergence (11.42-18.57%) (**Table 2**), seedling fresh weight (26.3-40.49%), seedling dry weight (18.36-24.19%), leaf area (23.8-29.13%) and vigour index (25.82-46.24%) under spring sowing condition with mean maximum and minimum temperatures of 21.4 and 7.9°C (**Table 3**).

Table 1 Effect of pulsed and static treatments on field emergence of differentially aged maize seeds in spring summer season

Genotype	Vigour level	T_0	T_1	T_2	Mean
Pusa Composite-3	High	80.00 (63.44)	85.00 (67.21)	84.00 (66.44)	83.00 (65.80)
	Low	80.25 (63.58)	82.75 (65.42)	84.00 (66.42)	82.33 (65.13)
	Mean	80.13 (63.64)	83.87 (63.27)	84.00 (65.98)	
C.D. (0.05)	Vigour level (A)	NS			
	Treatment (B)	2.263			
	A x B	NS			

Table 2 Effect of pulsed and static magnetic treatments on speed of field emergence of differentially aged seeds in spring summer season

Genotype	Vigour level	T_0	T_1	T_2	Mean
Pusa Composite-3	High	10.50	11.74	11.20	10.55
	Low	9.10	11.49	10.64	11.41
	MEAN	9.80	11.61	10.92	
C.D. (0.05)	Vigour level (A)	0.372			
	Treatment (B)	0.463			
	A x B	0.654			

Table 3 Effect of pulsed and static magnetic treatments on vegetative growth characteristics of differentially aged maize seeds in spring summer season

Genotype	Vigour level	Fresh weight				Dry weight				Leaf Area				Vigour Index-I			
		T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean
Pusa Composite-3	High	276.56	367.47	325.82	323.30	60.80	74.11	65.16	66.69	331.36	406.14	394.94	377.48	4879.2	6224.8	5391.2	5498.5
	Low	170.99	289.29	264.74	241.70	25.96	49.38	42.57	39.30	275.58	377.81	356.47	336.62	2070.0	3937.7	3352.0	3119.8
	MEAN	233.77	328.43	295.27		43.38	61.74	53.86		303.47	391.90	375.71		3474.5	5081.2	4371.6	
C.D. (0.05)	Genotype (A)	32.924				11.968				NS				1082.673			
	Vigour level (B)	40.329				NS				50.976				NS			
	Treatment (C)	20.29				12.64				39.4				709.2			

T_0 =Control, T_1 = 100 mT for 2h/6min interval (Pulse), T_2 = 100 mT for 2h (Static)

Saktheeswari and Subrahmanyam, [9] reported shortening of the germination time, increased germination percentage, root and shoot length and hastened starch hydrolyzation in paddy due to exposure to pulsed magnetic field (PMF) of low frequencies. It also increased the total number of leaves with better plant growth and reduced maturity time. Dominguez *et al.*, [16] observed that the irradiating maize seeds at magnetic induction levels of 160 and 560 mT also produced an increment in seed emergence rate and seedling emergence. Vashisth and Nagarajan [10, 17] reported that maize and chickpea seeds exposed to magnetic field showed increased laboratory germination, speed of germination, seedling length and dry weight as compared to untreated seeds.

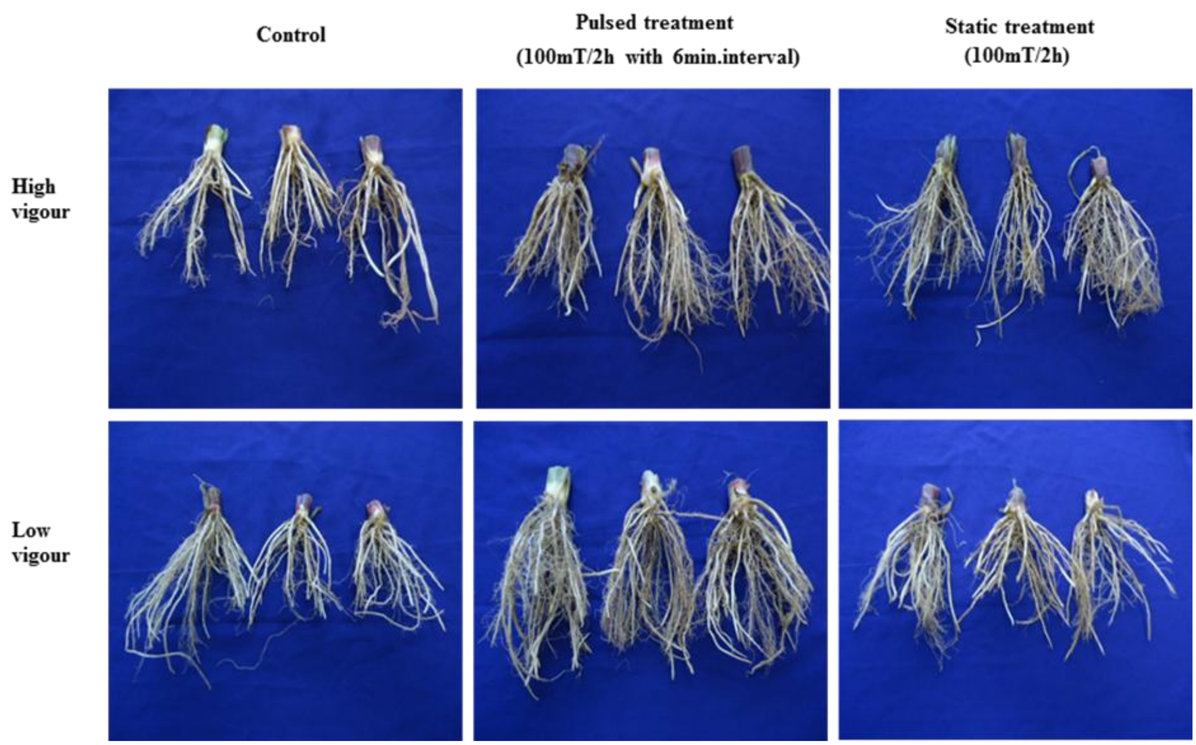

Figure 1 Effect of pulsed and static magnetic field on root growth of differentially aged maize seeds of Pusa composite-3 (45DAS) in spring-summer season

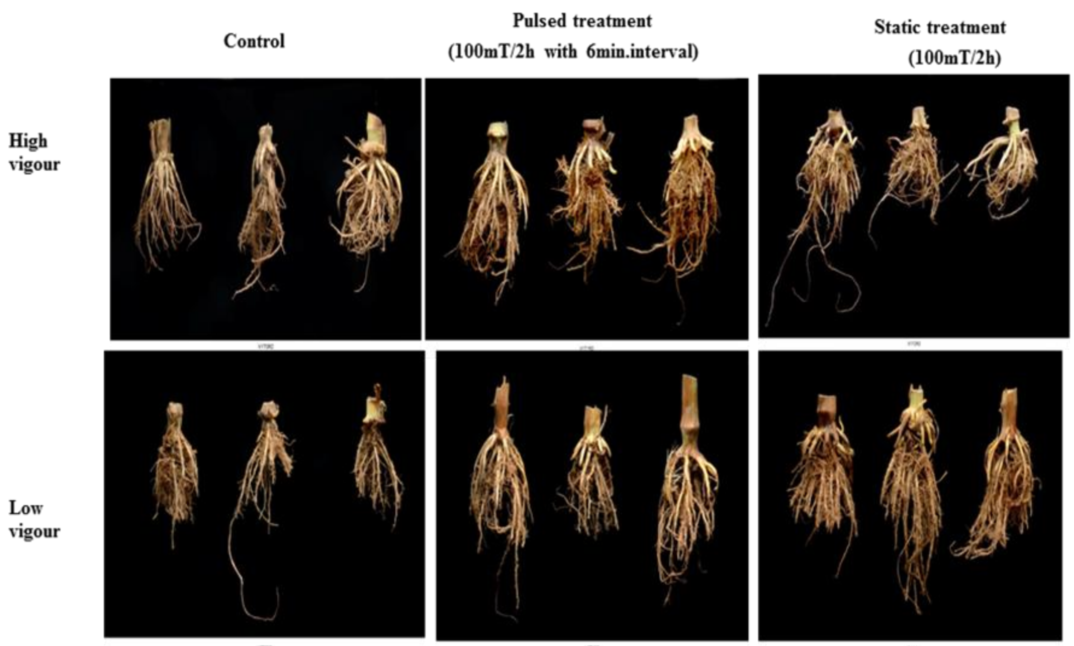

Figure 2 Effect of pulsed and static magnetic field on root growth of differentially aged maize seeds of Pusa composite-3 (60DAS) in spring-summer season

Seed enhancement treatments significantly improved root growth over the control in terms of surface area, length and volume (**Figures 1** and **2**). The present study conclusively showed both at laboratory and field conditions, the benefits of magnetopriming in spring maize. Vashisth and Nagarajan [10] also observed the effect of pre- sowing exposure of maize seeds to static magnetic field and found increased seedling growth, especially the root length. Radhakrishnan *et al*., [7] showed that pretreatment of pulsed magnetic treatment (PMF) plays important roles in improvement of crop productivity of soybean through the enhancement of protein, mineral accumulation and enzyme activities which leads to increase the growth and yield. Among genotypes, low vigour lots showed better root growth than high vigour lots. The magnetically treated seeds had more surface area and volume due to greater development of fine root hairs which could provide the seedling better anchorage and potential to absorb moisture from greater depth under water deficit conditions.

Conclusion

From our study it can be concluded that, both static & pulsed magnetopriming treatments enhanced the germination and vigour characteristics significantly, which resulted in better field emergence. However, the pulsed magnetic treatment is superior compared to static magnetic field treatment under field conditions in maize.

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