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Research Article

Effect of Static Magnetic Field on Germination and Seedling Attributes in Tomato (*Solanum lycopersicum)*

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ABSTRACT

An experiment was conducted at Indian Agricultural Research Institute, New Delhi to study the effect of pre-sowing seed treatment using different combinations of magnetic field intensities and time duration, on germination and seedling attributes in North Indian variety of tomato (var. Pusa Ruby). Seeds were exposed to static magnetic fields (SMF) of strength 50, 100 and 120 mT for 5, 10, 15, 20, 25 and 30 min and subjected for germination test along with control (untreated) at 25 °C. The germination and seedling attributes were recorded on 8 days-old seedlings. Results showed that SMF application significantly enhanced seed performance in terms of laboratory germination, seedling length, seedling dry weight and vigour. Among the combinations, 100 mT SMF for 30 min exposure performed best.

Key words: Magnetic field, Tomato, Germination, Seedling vigour

Introduction

Performance of crop growth, yield and quality of produce are determined by the seed quality. Some physical and chemical pre-sowing treatments have been used to improve the seed quality. The effect of magnetic field on germination of seed and growth of the plant had been the object of numerous researches. Exposure of maize seeds to stationary magnetic field (MF) enhanced the germination and early seedling growth; the greatest increase was when the seeds exposed to a static field of 125 or 250 mT (Florez *et al*., 2007). Significant enhancement in shoot and root length of 1-month old maize, chickpea and sunflower plants with seeds exposed to combinations of strength of MF and duration (Vashisth and Nagarajan, 2008a, 2008b; 2010). Numerous studies have demonstrated enhanced growth and yield when tomato seeds were treated with MF (Boe *et al.*, 1968; De Souza *et al*., 2006; Martinez *et al.*, 2009; Feizi *et al.*, 2012). However, there is no consensus on the most effective strength-duration combination. In this study, we explored the possible effect of static magnetic field (SMF) of three different strengths with same duration of exposure, on the seedling characteristics in North Indian variety of tomato (Pusa Ruby).

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Materials and Methods

An electromagnetic field generator 'Testron EM-20' with variable horizontal field strength (50 to 500 mT) with a gap of 5 cm between pole pieces was used. A DC power supply (80V/10A) with variable outputs was used for the electromagnet. A digital gauss meter (model DGM-30, Testron Instruments, India) operating on the principle of Hall Effect monitored the field strength. The probe could measure 0-2 tesla with full-scale range in increments of 5 mT.

Tomato seeds were exposed to SMF of 50, 100 and 120 mT for 5, 10, 15, 20, 25 and 30 min in a cylindrical shaped sample holder of 42 cm^3 capacity, made of non-magnetic thin transparent plastic sheet. The required strength was obtained by regulating the current in the coils of the electromagnet. At low field (50 mT), from centre to end of the poles, the variation was 0.6% in the horizontal direction and 1.6% in the vertical direction of the applied field. At high field (250 mT), they were 0.4 and 1.2% of the applied field respectively.

The germination test was carried out following the method of ISTA (1985). Four replications each with 25 seeds were placed between two layers of moist germination papers, rolled carefully and wrapped in a sheet of wax paper to reduce surface evaporation. They were placed in the germination incubator at 25°C in an upright position. After 8 days, germination percentage was calculated based on normal seedlings. Ten such seedlings from each replicate were randomly taken for measuring shoot and root length in cm, oven-dried overnight at 90°C and kept in desiccators till room temperature is reached and the dry weights were measured. Seedling vigour was calculated following Abdul-Baki and Anderson (1973) as:

Vigour index I = Germination % x Seedling length (Root +Shoot)

Vigour index II = Germination % x Seedling dry weight (Root +Shoot)

Results and Discussion

Exposure of tomato seeds to different magnetic field intensities increased significantly all of its germination related characters, such as, germination percentage, shoot and root length, seedling dry weight and calculated vigour indices (Table 1). The improvement in germination percentage was 2-16%. The shoot and root length increased by 0-16 and 2-33%, while total seedling length increased by 6-19%. The seedling dry weight had 0-17% increase. The calculated vigour indices I and II also increased by 12-39 and 4-32%, respectively in different treatment combinations compared to control. However, the percent enhancement of the parameters was not linearly related to the field strength. Among the combinations, 100 mT for 30 min was found most effective in improving most of the parameters. Magnetic field exposure time of 5 to 30 min increased germination characteristics significantly, irrespective of the field strength.

Similar improvement in germination and growth in tomato crop was also observed by Martinez *et al*. (2009) and De Souza *et al.* (2006). Vashisth and Nagarajan (2008a & b, 2010) reported significant increase in germination, seedling vigour and shoot growth in maize, chickpea and sunflower seeds exposed to SMFs. Tomato seed treatment by AC electric and AC magnetic fields for short periods accelerated germination (Moon and Chung, 2000). Florez *et al*. (2007) reported that exposure of maize seeds to SMF enhanced the germination and early growth reduced of 10 days-old seedlings. The highest increases was obtained when maize seeds were exposed to 125-250 mT.

It is postulated that the ion-cyclotron resonance may interfere with the Ca^{2+} ion sequestering and thereby enabling the raise in free Ca^{2+} concentration in the system (Rajendra *et al*., 2005). The increased Ca^{2+} concentration may signal the cell to enter into early mitotic cycle. Also, increased uptake of Ca^{2+} ions in rice seedlings grown from seeds exposed to pulsed magnetic field was found responsible for better leaf growth, meristematic tissues in stems and roots (Saktheeswari and Subrahmanyam, 1989). Kavi (1983) reported that in ragi (*Eleusine coracana* Gaertn) seeds, exposure to 100 mT MF changed its internal potential energy and suggested that by selecting suitable combination of MF and exposure time, it may be possible to get higher yields. Vashisth *et al*. (2012) showed evidence for re-arrangement of cellular water in chickpea seeds exposed to SMF and in un-exposed controls. The NMR relaxation time of seed water and its analysis indicated early appearance of structural (hydration) water and greater amount of cytoplasmic bulk water and hydration water in magnetically exposed seeds. Also, in these treated seeds, molecular mobility

Table 1. Effect of static magnetic field on seedling attributes in tomato (8 days-old seedlings)

Magnetic field strength (mT)	Germination (%)	Length of seedlings (cm)			Dry weight (g seedling^{-1})	Vigour	
		Shoot	Root	Total		I	II
Control	84	9.3	7.2	16.5	0.0017	1386.0	0.141
50 (5min)	96	9.9	8.3	18.3	0.0017	1756.9	0.163
50 (10min)	98	10.0	9.0	19.0	0.0017	1857.1	0.166
50 (15min)	91	10.2	8.6	18.8	0.0018	1714.2	0.161
50 (20min)	95	10.5	8.9	19.4	0.0018	1841.4	0.174
50 (25min)	95	9.5	8.2	17.6	0.0017	1676.3	0.162
50 (30min)	86	10.7	8.2	18.9	0.0017	1624.2	0.146
100 (5min)	86	10.4	8.9	19.3	0.0018	1656.8	0.153
100 (10min)	96	10.2	7.4	17.6	0.0018	1687.2	0.171
100 (15min)	93	10.8	8.1	18.9	0.0019	1753.2	0.176
100 (20min)	94	10.4	8.3	18.8	0.0018	1764.8	0.165
100 (25min)	89	9.6	7.9	17.5	0.0018	1556.7	0.161
100 (30min)	98	10.1	9.6	19.7	0.0019	1933.9	0.186
120 (5min)	88	10.2	9.5	19.7	0.0017	1730.3	0.152
120 (10min)	93	9.5	9.1	18.6	0.0017	1726.4	0.158
120 (15min)	95	9.3	9.6	18.9	0.0018	1795.5	0.171
120 (20min)	94	10.4	9.2	19.6	0.0020	1844.1	0.183
120 (25min)	86	9.9	9.4	19.3	0.0018	1655.0	0.158
120 (30min)	87	10.3	9.2	19.5	0.0020	1699.4	0.172
CV %	*6.7*	*6.4*	*9.6*	*5.3*	*7.4945*	*8.6*	*10.143*

of cytoplasmic bulk water and hydration water of macromolecules were higher as indicated by their respective relaxation times. This may be responsible for early germination and higher seedling vigour of these seeds over untreated controls. A highly significant correlation between the relaxation time of cytoplasmic bulk water and the activities of germination related enzymes in general emphasised the fact that this fraction of water is vital for metabolic activities taking place during germination process. The increased physiological activity due to greater absorption of moisture by treated seeds may be responsible for overall increase in seedling length, seedling dry weight and vigour indices but there is no definite pattern of increasing field and/or time duration with changes in seedling characteristics.

Conclusions

The exposure of tomato seed (North India tomato variety – Pusa Ruby) to SMF increased germination, seedling length and dry weights significantly compared to unexposed control. Among the combinations of field strength and duration, 100 mT for 30 min exposure resulted in the best performance of tomato.

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