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Pre-sowing seed magnetic field stimulation: A good option to enhance bitter gourd germination, seedling growth and yield characteristics

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ABSTRACT

Effect of pre-sowing magnetic field (MF) treatments on germination, seedling growth and yield attributes in bitter gourd (*Momordica charantia* L.; cv Faisalabad Long) was investigated. Genetically uniform seeds were exposed to 25, 50, and 75 mT generated by an electromagnet (rectified sinusoidal non-uniform) for 15, 30 and 45 min each. The treated seeds were sown and grown under field conditions in experimental plots (2.4 m^2) according to standard agricultural practices along with control. The germination, growth, and yield parameters were measured by standard methods and for mineral contents, laser induced breakdown spectroscopy (LIBS) was used. The enhancements in germination, emergence index, mean germination time (MGT) and vigor index I and II were recorded up to 54.52%, 50.92%, 35.98%, 24.93% and 47.21%, respectively. The growth parameters i.e., growth rate (56.98%), leaf area (64.61%), root fresh weight (55.77%), root dry weight (76.16%), shoot dry weight (45.26%), shoot fresh weight (23.35%), shoot length (29.39%) and root length (17.78%) were also enhanced significantly in plants, raised from magnetically treated seeds. The chlorophyll contents (35.41%), fruit length (18.11%), fruit weight (14.93%), yield (29.16%) and mineral contents were also recorded to be higher in MF treated plants versus control. Results suggest that pre-sowing MF treatment could possibly be used to improve the productivity by enhancing germination and seedling growth since this treatment is eco-friendly, affordable and applicable at cultivator level.

1. Introduction

Bitter gourd (*Momordica charantia* L.) or Karela (Pakistan), which belongs to family *Cucurbitaceae*, is used as a food and also has medicinal importance. Bitter gourd grows in various tropical regions of the world i.e., India, Malaya, China, tropical Africa, Middle East, America (Kubola and Siriamornpun, 2008) and it is one of the most important summer vegetables in Pakistan as well. Generally, bitter gourd growing season in Pakistan and India is January to June and now-a-days, it is usually grown as an annual crop (Saleem et al., 2014). Optimum temperature of 25 – 28 °C is required for the germination of bitter gourd seeds and in Pakistani region temperature remains high except short winter season. The mildew that often occurs during germination is responsible for uneven and low germination rates (Peter et al., 1998). Biological and chemical pre-sowing seed treatments have been used for better seed germination and these treatments are considered cost effective and also harmful to the environment (Iqbal et al., 2012a) and the environmental safety is also an important issue worldwide, which already has been contaminated and polluted with toxic agents due to urbanization and industrialization (Abbas et al., 2015; Adesola et al., 2016; Babarinde and Onyiaocha, 2016; Bilal et al., 2014; Iqbal et al., 2013, 2014; Iqbal, 2016; Iqbal and Bhatti, 2014, 2015; Iqbal and Khera, 2015; Iqbal and Nisar, 2015; Jamal et al., 2015; Manzoor et al., 2013; Qureshi et al., 2015; Sayed, 2015; Ukpaka, 2016; Ukpaka et al., 2015; Ullah et al., 2013; Younas et al., 2015). Therefore, it is important to adopt sustainable agricultural practices i.e., environmental friendly, affordable and safe methods (Iqbal et al., 2013; Majkowska-Gadomska et al., 2015; Maqsood et al., 2013).

Modern agricultural efforts are now in search of a competent ecological tool based on physical treatment of seeds to enhance the germination, seedling strength and crop yield and recently,

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pre-sowing MF seed treatment has attracted the attention of agricultural community (Iqbal et al., 2012a; Jamil et al., 2012; Kowalyszyn and Konyk, 2015; Naz et al., 2012; Zia ul Haq et al., 2012). Various researchers have studied and reported that vegetable and grain crops seed treated by magnetic field showed high performance in terms of germination, plant growth, height, seed mass per spike as well as shoot and root length and total fresh and dry masses, chlorophyll contents, enzymatic activities and yield (Iqbal et al., 2013; Iqbal et al., 2012a; Jamil et al., 2012; Jamil et al., 2013; Naz et al., 2012; Perveen et al., 2011; Zia ul Haq et al., 2012). There are numerous hypotheses explaining cellular responses of MF on biological systems; however, precise mechanism is not well known. Based on research conducted in this field, particles having ferromagnetic properties in living organism, energy level amendment and changes in electron spins in atom and molecules are considered important. Different researchers presume that MF can effect chemical reactions by altering electron spin location and in this way they have potential to cause biological effects (De Souza et al., 2014; Iqbal et al., 2012a). Electromagnet induced physiological and biochemical changes in biological objects. Water assimilation and intensified photosynthesis collectively enhance the seed germination and growth (Podleoeny et al., 2004). In view of importance of bitter gourd, nevertheless attention has been paid to evaluate the effect of MF of germination, growth and yield since it is a common vegetable in Pakistan. Therefore, the principal objective of the present study was to appraise the MF pre-sowing seed treatment effect on germination, seedling growth, mineral contents (by LIBS) and yield characteristics of bitter gourd native to Pakistani soil.

2. Material and methods

2.1. Soil description and experimental area

The experiment was conducted in March, 2013 at the Postgraduate, Agriculture Research Station, University of Agriculture, Faisalabad (31°.26′ N, 73°.06′ E). The soil was of sandy clay loam in texture, pH 8.1, pH water 6.67, organic matter (0.87%) and electrical conductivity (2.6 dSm^{-1}). The meteorological data regarding rainfall, relative humidity and temperature were recorded from meteorological observatory cell in the immediate vicinity of the field during the experimental period. The average temperature, relative humidity, PAN evaporation, sun shine and wind speed values were recorded to be 20 °C, 59.9%, 03.5 mm, 8.4 h and 5.8 km/h, respectively (March, 2013), whereas these values were 25.1 °C, 47.0%, 05.9 mm, 9.3 h, and 7.2 km/h, respectively (April, 2013).

2.2. Seed collection and MF treatment

The bitter gourd (*Momordica charantia* L, cv Faisalabad Long) authentic seeds were obtained from Ayyub Agriculture Research Institute, Faisalabad, Pakistan. Uniform seeds were selected by hand picking for MF treatment. Seeds having visible defects, insect damage or malformation were discarded and selected seeds were stored in desiccators over 70% (v/v) glycerin. The procedure and electromagnet specification has already been reported in detail elsewhere (Iqbal et al., 2013; Naz et al., 2012). Total nine different MF doses (strength and exposure time) were selected for seed treatment i.e., T_1=25 mT for 15 min, T_2=25 mT for 30 min, T_3 =25 mT for 45 min, T_4=50 mT for 15 min, T_5=50 mT for 30 min, T_6=50 mT for 45 min, T_7=75 mT for 15 min, T_8=75 mT for 30 min, T_9=75 mT for 45 min and T_0=Control (untreated seeds).

2.3. Seed sowing and culture practices

The experiments were carried out in Randomized Complete Block Design (RCBD) in triplicate. The plot size was kept 1.5 m x 2 m (4.5 m^2). Row to row and plant to plant distance was 1.5 m and 60 cm, respectively. Seeds were seeded in pit at 2.5–3.0 cm depth. First irrigation was applied after 10 days and then, regularly on weekly basis in such a way that the moisture contents remained > 80%. Three hoeing were given to keep plots free from weeds during the early stage of growth. All treatments in the experiments were run simultaneously along with control under similar conditions.

2.4. Germination measurement

For germination, ISTA (ISTA, 2004) guidelines were adopted. The germination percentage of bitter gourd was measured following the reported method (Carbonell et al., 2000) and percentage germination was calculated using the relation shown in Eq. 1.

$$\text{Germination}(\%) = \frac{\text{Seed germinated}}{\text{total seeds}} \times 100 \tag{1}$$

Emergence rate index (ERI) was calculated as described in the association of official seed analysts (Grewal and Maheshwari, 2011) using the relation shown in Eq. 2, where X_1, X_2, …X_n are the number of seedling emerged on 1st, 2nd,… nth day after sowing, N is the days taken for germination and n_p is presenting germinated seed.

$$\text{ERI}(\%) = \sum \left\{ \frac{X_1 + X_2 + X_3 \ldots + X_n}{N(n_p)} \right\} \tag{2}$$

Mean germination time (MGT) was measured using the relation shown in Eq. 3, where n is the number of seeds germinated on day D, D is the number of days counted from the beginning of germination and Σ_n is the final germinated seed. Vigor indices I and II of the seeds were calculated by relations (Eqs. 4–5) (Vashisth and Nagarajan, 2010).

$$\text{MGT} = \frac{\sum D_n}{\Sigma_n} \tag{3}$$

$$\text{Vigor Index I} = \text{Germination}(\%) \times \text{seedling length}(\text{root+shoot}) \tag{4}$$

$$\text{Vigor Index II} = \text{Germination}(\%) \times \text{seedling dry weight}(\text{root+shoot}) \tag{5}$$

2.5. Growth parameter measurements

The growth rate was calculated using the relation shown in Eq. 6. Leaf area was measured by using portable leaf area measurement meter (Model YMJ-A, China) and averages were computed by statistical analysis. The root lengths (cm), root fresh and dry weight (g), shoot fresh and dry weight (g) were calculated after 45 days of sowing. Dry weights (root and shoot) were determined after heating at 105 °C for 15 min, followed by incubation at 80 °C for 24 h. The root length was determined by scale from root neck to tip (Iqbal et al., 2013; Iqbal et al., 2012a; Iqbal et al., 2012b; Zia ul Haq et al., 2012). All measurements were performed in triplicate and data thus, obtained was averaged.

$$\text{Growth rate}(\%) = \frac{\text{Plant height at maturity}}{\text{Number of days taken}} \tag{6}$$