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ORIGINAL ARTICLE

Effect of electric field on seed germination and growth parameters of chickpea *Cicer arietinum* L.

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Cicer arietinum (L.) seeds were exposed to electric field in the soil via electrodes. Four different EF were 3, 6, 9, and 12 V induced 10 minutes after 24 hours for 100 days, each treatment consisted g of an isolated gathering of plants. The rate of seed germination was better in experimental groups. Plant height, root length, number of leaves, number of flowers, plant dry weight, and seed weight were measured after the harvesting. Plant heights significantly increased under the influence of 3, 6, 9 and 12 V by 25.5%, 30.5%, 11.8%, and 17.1% respectively. Similarly, root length was significantly increased under 3, 6 and 12V by 28.6%, 24.0%, 3.0% respectively; whereas it was retarded by 3.0% under 9 V. Leave numbers were significantly higher by 25.3%, 25.2%, 15%, and 19.3% under the treatment by 3, 6, 9 and 12 V respectively. There was no significant increase in flower number, plant dry weight and seed weight.
Keywords: Electric field; seed germination; variety Parbat

Introduction

It is a technique in which plants are grown in the influence of electricity, and found to be significant in the growth of plant yield. (Nelson and Robert, 1982; Electroculture, 2013). Electric field induced in plant growth initiated form seed germination to yield. *Cicer arietinum* var: Parbat 2003; a desi type, was choose and acquired from Crop Sciences Institute National Agriculture Research Centre Islamabad. The physical method has least damage to the plants (Das and Bhattacharya, 2006; Aladjaadjiyan, 2010). The treatment has increased the rate of seed germination (Aksyonov et al., 2000) as well as stimulated the plant growth (Murr, 1964; Muraji et al., 1998; Stenz et al., 1998). The potato plants experiment by W. Ross in 1840 and Holdenfliess in 1844 reported possible results favoured in an increase of yield up to 25% along with the voltage provided by battery (Ross, 1844). Researchers have found that electric field had boosted the growth and the output of plants (Li, 2003; Wang, 2004). The exposure of electric field (EF) can affect the plants, inducing a series of physiological and biochemical responses (Scopa et al., 2009; Berghoefer et al., 2012; Vallverdu-Queralt et al., 2013). The observation was that plants were greener, lengthen and often showed an increase in yield. However, these observations were not common for all plant species (Lemström, 1904; Goldsworthy, 2006).

The experimental studies began in 1746, when Dr. Maimbary treated myrtle plants with electrical source and found an increase in growth. Many investigators have studied that yield was increased (Blackman, 1923; Monahan, 1904; Stone, 1909). Some of them found a decrease in growth rate, (Murr, 1964, 1965; Russell, 1920). While others found that electrical energy did not affect plant growth (Dorchester, 1935; Hendrick, 1918; Solly, 1845). In 1783, Abbot Breatholon found that plants have shown in acceleration in the rate of germination and increased in crop yield (George, 1898).

M. Spyeshneff and M. Karvekoff (1900) had found on electrified seeds, germination happen more rapidly, and yield better as compare to the naturally growing. Beginning in 1885, Finnish Scientist Selim Laemstrom experimented on the aerial part of the plant and found an efficient growth of plants such as potato, and carrots for an average increase of about 40-70% within 60 days. The yield of electrified rice seeds was possibly 5-10% increase in yield, but it did not affect seed germination (Kerdofag et al., 2002). Cotton seeds have shown an increase in the seed germination in the electric field (Pietruszewki, 1999). In Pissum sativum rate of seedling depended on the intensities and exposure duration (Podlesny et al., 2003). The experiment on citrus tree connected with the negative end of the source, it can be helpful in fruit ripening (Singh, 1932; Moliterisz, 1965). The electric field can also be a fertilizer in soils (Wang and Wang, 2004). Plants may respond to electric stress by changing physiological adaption either in postive or negative way (Wawrecki and Zago, 2007).

Materials and Methods

The research work was conducted at Laboratory of Botany Department, Govt. Post Graduate College No 1 Abbottabad. During the spring-summer season of 2019. The soil for experiment acquired form field site at the location (34.162036, 73.238233). NPK tests were performed before experimentation (Table 1). The selected variety is the earliest known variety of chickpea (Kupicha, 1977). Material and methods based on the electrical circuit using diodes, resistors, conducting plates and batteries, i.e. 12, 9, 6, and 3 V respectively.

Table 1. Chemical and physical properties of soil.

Texture	Clay-loam
Soil depth	0-30 cm
E.C $d.Sm^{-1}$	0.98
pH	7.39
SOM %	1.2
T.O.C %	0.69
T.O.N %	0.06
AP (mg kg^{-1})	21.4
AK (mg kg^{-1})	120
Saturation %	50

Electric field application and culture conditions

The electric contact was made through the soil via stainless copper electrodes placed one of each end of the seedbed (Pot). The Electric field was passed through the trial plots from one electrode to the other (Stone, 1904). The seeds were sown in plastic pots (165 x 105 x 70 mm) under controlled climatic conditions. Chickpeas were cultivated in two groups, treated and control. Treated plants were exposed to Electric fields on units as A, B, C, D (Table 3) respectively, while E group is Non-electrified as Control Group. The duration of exposure was repeated for 10 minutes every 24 hours and applied for 100 days.

Table 2. Seed germination and voltage supply to the units.

Units	Treatment	Voltage Supply	Seed Germination in Days
A	T1	3V	17
B	T2	6V	15
C	T3	9V	16
D	T4	12V	18
E	T0	Control Group	18

Plants were harvested on 130 days. Morphological analysis such as plant height, number of leaves, number of flowers was carefully performed. The plant roots and shoots were separated and shady dried. The experimental design is based on CRD with three replication with three seeds per replicate. Data were analyzed using software package SPSS v. 23 with ANOVA and post hoc LSD significant differences test at $p < .05$.

Results and Discussion

The rate of seed germination was enhanced as compare to the control groups. Seeding was appeared early in some electrified groups, while slightly delayed in control group (Table 3), the order of rate of seed germination: T2<T3<T1<T4=T0. There was a significant increase in three parameters i.e., Plant height, root length and number of leaves while no significant difference in number of flowers, dry weight, and seeds weight (Table 2). The increase per cent of the different parameter in unit A, B, C, and D, are compared with the mean value of control group percentage were measured form the difference of their mean values (Table 3).

Table 3. Mean percent (%) of parameters in Unit A, B, C and D compared with control group.

Units	Plant Height (%)	Root length (%)	Number of leaves (%)	Number of flowers (%)	Dry weight (%)	Dry weight of 10 seeds (%)
A	+25.5	+28.6	+25.3	+3.4	+11.0	+19.0
B	+30.5	+24.0	+25.2	+10.2	+14.0	+24.1
C	+11.8	-3.0	+15.0	+8.0	+15.0	+20.0
D	+17.1	+ 3.0	+19.3	+9.0	+13.0	-1.0

The rate of seed germination was improved the results were in accordance with George, (1898); Nature Publication, (1900); Podlesny et al. (2003). The seeds were germinated 24 hours earlier than the control group in some treatments. Electrified plants were more green than non-electrified (Lemström, 1904; Goldsworthy, 2006).

The best response was found in the influence of weak DC electric fields; most significant results were recorded in 3V and 6V. It seems that plants were stimulated by an electric field, however, when treatment was reduced they turned into their natural way as a control group. Pietruszewki, rate of seed germination was enhanced the result was similar to Aksyonov et al. (2000). The results of electrification in plants were similar in the growth of vegetative parts such as plant height that was similar with Costanzo (2008) that electric field of different intensities is found in increasing of plant height (Lemström, 1904; Goldsworthy, 2006; Costanzo, 2008). Supposed, that electrical field may not only act on the ion accumulation mechanism but also internal auxin production. It was suggested by Lemström (1904) and Goldsworthy (2006), the effect of the electric field is not similar to all plants equally, especially in terms of increase in yield, which was quite similar to them, there was no significant increase in yield of the crop were found.

The root length in treated plants was found in increased in (A) by 28.6%, (B) by 24.0%, (C) by -3.0% and in (D) by 3%, the results were accordance to Wawrecki and Zago (2007). Increasing in root length also confirmed the hypothesis of Brayman and Miller (1989) found a significant increase in the root length in different treatments.

The rate of seedling in chickpea was improved in electrified plants, which was similar to seedling in wheat, soybean and corn reported by Rochalska (2002) and Podlesny et al. (2003).

Number of leaves were increased, in our finding the results was similar in number of leaves in different treatments as in (A) by 25.3%, (B) by 25.2%, similarly in (C) by 15% and in (D) by 19.3%. that was similar to the result of Moore (1972) who confirmed increase in foliage and number of leaves by 300%, increase in foliage is due to the accumulation of ions and minerals in the plants, so that they were looking dark green in colour. The number of flowers, dry weight of plant and weight of dry seeds were not increased significantly due to the shortening of the plant life cycle; they were sowed at the ending of the season.

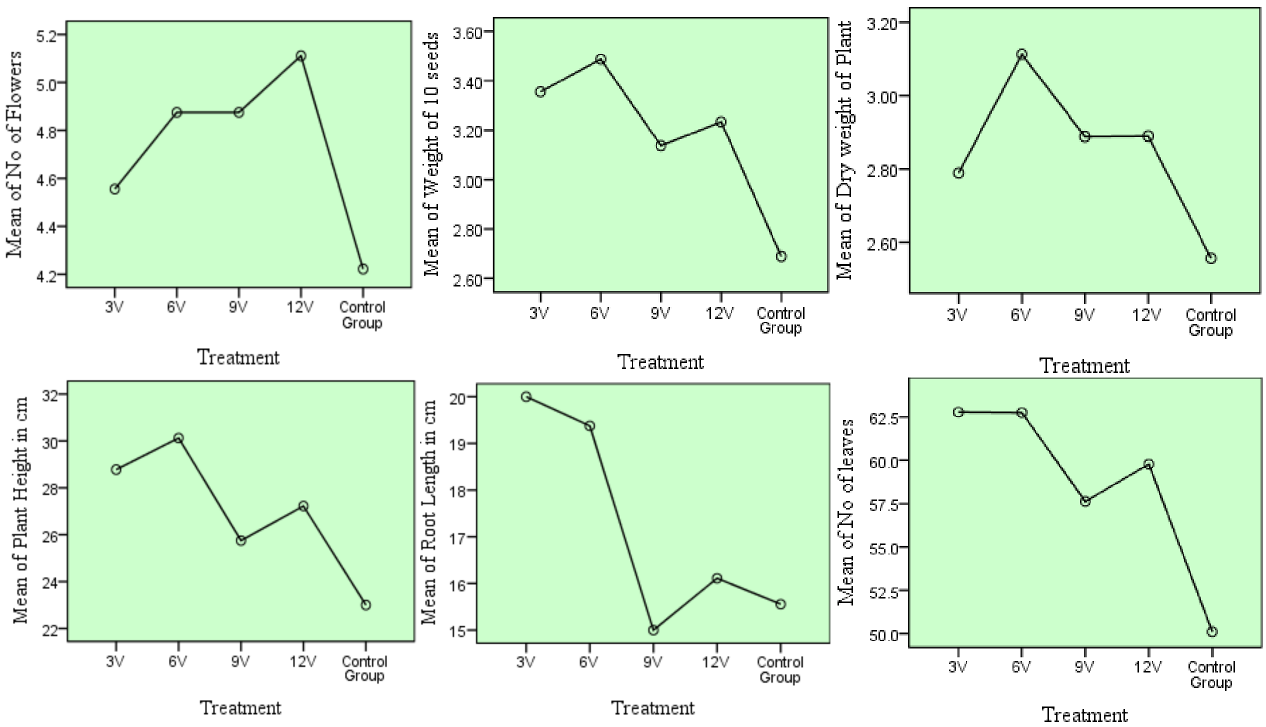

Fig. 1. The plots of parameter mean values.

Fig. 2. Different parts of chickpea plant (seeds, leaves, flowers, and pods).

Fig. 3. Units, A, B, C, D and E.

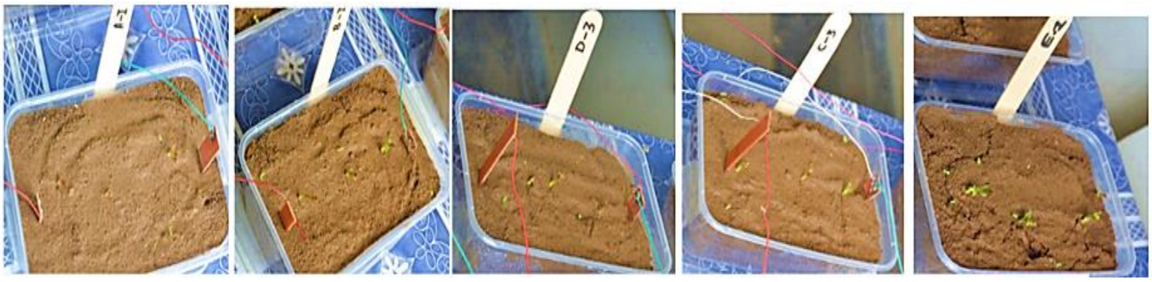

Fig. 4. Growth rate of Chickpeas in units A, B, C, D and E after 30 Days.

Fig. 5. Growth rate in units A, B, C, D and E after 45 days.

Fig. 6. Flowering at 75 days in different Units A, B, C, D, and E.

Fig. 7. Maturation of Pods at 105 days in Units A, B, C, D, and E.

Conclusion

We suggested that the electric field influenced on the growth of plants. We observed that the rate of seed germination was improved. The results of our study proved that cellular metabolism can be positively increased by the application of appropriate intensities of the electric field. So, that we registered the positive effect of 3, 6, 9 and 12 V intensities of the electric field in some parameters, namely plant height, root length, and leave number in chickpea plants (Figs 1-7).

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