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Effect of Magnetic Field on the Growth of *Vigna unguiculata*

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Authors' contributions

This work was carried out in collaboration between two authors. Author NOA designed the study, author OFO performed the statistical analysis, wrote the protocol, and the first draft of the manuscript. Author OFO also managed the analyses of the study and the literature searches. The two authors read and approved the final manuscript.

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ABSTRACT

The effect of low frequency electromagnetic field on cowpea yield was considered in a laboratory by exposing viable cowpea seeds to low frequency electromagnetic field producing magnetic strength of values; 50 mG, 100 mG, 150 mG and 250 mG at a constant exposure time of 30 minutes. Seeds of nearly equal weight were used. These seeds were placed in water for 3 minutes for imbibition and later uniformly put in petri dishes. The experiment had three replicates and five treatments (50 mG, 100 mG, 150 mG, 250 mG and control). The control was kept in place zero magnetic field while each replicate had four seeds. The experiment was conducted in the laboratory at room temperature 35°C. After imbibition and exposure the seeds were planted in pots and transferred to the screen house for growth observations.
Observations made in this study evidently showed that after germination, the growth of seedlings of

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seeds exposed to magnetic treatment of 100 mG the 3rd day after planting had the highest sprout with emergence percentage of 58.33 compared to other treated seeds and control.

Keywords: Cowpea; seed germination; imbibition; Akungba-Akoko.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is an annual legume of Fabaceae family. It is widely cultivated in Nigeria mainly for its edible seed [1]. Cowpea had been cultivated as food crop more than 4000 years where it is spread to India, the Caribbean's, Asia, Australia and United States of America [2]. Cowpea is of economic and nutritional importance. Its high protein content makes it extremely valuable in Tropical Africa, and as a replacement for meat and fish [1]. Cowpea is the main source of plant protein in the Western and Central region of Africa. Its grains and leaves have a high protein content of about 24.8%, fat, 1.9%; fibre, 6.3%; Carbohydrate, 63.6% and Water, 8-9% [3]. There was also a report that at the early stages of cowpea growth, its leaves could be useful for human consumption [4].

Cowpea is a valuable component of farming systems in many areas because of its ability to restore soil fertility for succeeding cereal crops [5].

Cowpea is susceptible to frost, grows well only in warm season with 25-35°C optimum temperature, and also tolerant to moderate shade but subjected to mildew in heavy shade. Plant growth habit can be erect, semi-erect, prostrate (trailing) or climbing depending mostly on genotype, although photoperiod and growing conditions can also affect plant stature [5]. Cowpea is an annual herb reaching height up to 80 cm with a strong root and many spreading lateral roots in the surface soil [2,6,7]. Cultivated cowpea seeds weigh between 8 and 32 mg and ranges from round to kidney shaped [5].

Emergence is epigeal, where the cotyledons emerge from the ground during germination which makes cowpea more susceptible to seedling injury, since the plant does not regenerate buds below the cotyledonary node [5]. Cowpea germinates within 5 days. Leaves are alternate and trifoliate. The first pair of leaves is simple and opposite. Leaves exhibit considerable variation in size and shape and they are usually dark green. The leaf petiole is 5-25 cm long. The stems are striate, smooth or slightly hairy and sometimes tinged with purple.

Sequel to the importance of cowpea in Nigeria and the world at large, its continual cultivation and production becomes germane. The objective of this research was to determine the effect of low frequency (50 Hz) magnetic field on the growth of cowpea as well as the magnetic field threshold that would enhance prompt germination of cowpea seeds.

2. MATERIALS AND METHODS

2.1 The Study Site

The experiment was conducted in the laboratory and screen house of the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria during the late planting season of August to November.

2.2 Materials Used

The cowpea, *Vigna unguiculata* seeds and the pots used were purchased from "Oja Oba" Market in Akure, Ondo State, Nigeria. The pots were perforated and filled with rich loamy soil. Other materials which included, OHASU Adventurer Sensitive weighing balance, Petri dishes, Stool, Spatula, Tissue paper, Distilled water, Beakers, a Magnetic field coil, Rheostat, Electro boy clock, 60 watt bulb, Variance a.c generator and EMF-Tester with probe (model EMF 828 made in Taiwan) were obtained from the Department of Physics and Electronics of Adekunle Ajasin University, Akungba - Akoko, Ondo State, Nigeria.

2.3 Determination and Selection of Viable Seeds

Viable seeds were selected through floatation method and were also physically observed for insect exit holes.

2.4 Seed Preparation

60 viable seeds were selected under ambient laboratory condition. The viable seeds were soaked in distilled water for 3minutes in a beaker to allow imbibition. With the use of a spatula, the seeds were removed and placed in Petri dishes

lined with a lean sheet of absorbent tissue paper. Each Petri dish contained four seeds. There were four treatments corresponding to magnetic strengths of 50 mG, 100 mG, 150 mG and 250 mG with three replicates each. There was a control experiment which comprised of petri dishes containing seeds which were not subjected to the magnetic field strength.

2.5 Determination of Influence of Magnetic Field on Seedling Growth

The low frequency Magnetic Field designed for the experiment was made from a solenoid coil of diameter 5cm and length 30 cm. The number of turns of the coil was 850 and the current passing the coil was pre-set in order to produce a maximum field of 1000 mG. A horizontal bench, whose top surface was 2cm below the centre of the coil was made to lie along the solenoid axis from one end as shown in Plate 1.

The replicated petri dishes containing the seeds were placed on the bench in a direction perpendicular to the central axis of the solenoid coil from where the field was observed to be fairly uniform. The selected field strength points which were determined with an EMF Tester gauss meter were 50 mG, 100 mG, 150 mG and 250 mG.

This set up was monitored with an Electro boy clock for 30 minutes to expose the seeds to the different magnetic fields after which the seeds were planted in the soil-filled pots in the screen house of the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba – Akoko, Ondo State, Nigeria.

2.6 Potted Experiment

The cowpea seeds which were planted and monitored in the screen house of the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba – Akoko, Ondo State, Nigeria were irrigated once per day ensuring that the pots were not waterlogged.

2.7 Data Collection and Statistical Analysis

Data were collected from seedling emergence plant to maturity on growth parameters of cowpea. Data which included rate of seedling emergence, plant height, number of leaves, stem girth and number of pods was subjected to Analysis of Variance (ANOVA) to determine significant differences among the mean parameters of treated seeds as well as the control. Treatment means were separated using Tukey's Honestly Significant Test at 5% level of significance.

Plate 1. Laboratory set up of seed exposure to magnetic field

3. RESULTS AND DISCUSSION

In conformity to the report on short time exposure of seeds to magnetic field [8], the seeds of *Vigna unguiculata* were exposed to different levels of magnetic field strengths for 30 minutes and were subsequently transferred to the screen house for seed growth and development monitoring. Observations were then made on the growth parameters of *V. unguiculata*. The results obtained on plant morphology varied with respect to the magnetic fields used.

3.1 Effect of 50Hz Magnetic Field on the Rate of Seedling Emergence

Table 1 shows the rate of seedling emergence of the seeds placed at the different magnetic regimes. It shows that the seeds did not germinate within 2 days after planting. It was observed that the fastest seedling emergence was in the magnetic field treatment of 100 mG which was on the 3rd day after planting. This attribute that is required in plant growth corroborates the view of [9] that a magnetic field is an inevitable environmental factor for plants. Consequently, all the treatment levels including the control had 100% emergence the 4th day after planting. This is also suggestive that the pre-planting procedures of seed viability test and exposure of seeds to different magnetic fields were appropriate.

Literatures have shown that the role of magnetic field in seed germination cannot be under emphasized. The increased rate of germination observed in the treated seeds could be attributed to the expedited hydrolysis of water which a pre-requisite process in seed germination. Magnetic field had been reported to weaken the Van der Waals bonding between water molecules and that Van der Waals forces between the water molecules provide a boost for holding the molecules together [10]. The Van der Waals forces however, are weaker hydrogen bond. The weakening of Van der Waals forces was regarded as the reason for the enhancement of water evaporation in a magnetic field but not outside a magnetic. This assertion was further corroborated that the weakening Van Der Waals forces in water can be regarded as another aspect contributing to increase water evaporation with the increment of the magnetic field [11].

The procedure of H^+ production is at the same time required for food production in plants and subsequent growth. This assertion had earlier been explained that hydrogen bonds in water can be classified into two types: intra cluster and inter cluster hydrogen bonds such that the magnetic field could break the intra cluster hydrogen bond and strengthen the inter cluster hydrogen bonds. The result is the weakening of intra cluster and the formation of smaller cluster with stronger inter-cluster hydrogen bonds. Regardless of how hydrogen bonds in water are affected by a magnetic field, their changes definitely influence evaporation of water [12]. In similar applications, it has been reported that the changes which occur in the structure of liquid water under the effect of an external magnetic field are also important in water treatment, biological processes and biotechnology. Since 1980, the effect of applying a magnetic field to liquid water has been intensively studied [13] and the use of a magnetic field to generate large water cluster of considerable interest in a number of applications had also been documented [13].

3.2 Effect of 50 Hz Magnetic Field on the Plant Height (cm) of *Vigna unguiculata*

Table 2 shows the effect of 50 Hz magnetic field on the plant height.

On the plant heights, it was observed that all the seeds exposed to the different magnetic fields excel compared to the control except the 50 mG that was not significantly different at 1 WAP. Significant differences were not observed among the treatment means from 3 WAP to 5 WAP. Consequently, magnetic treatment of 250 mG was observed to have the highest mean value compared to other treatment levels.

Table 1. Rate of seedling emergence under the varied magnetic field treatment

Days	Seedling emergence (%)				
	Control	50 mG	100 mG	150 mG	250 mG
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00
3	16.68	41.67	58.33	50.00	41.67
4	100	100	100	100	100
5	100	100	100	100	100
6	100	100	100	100	100
7	100	100	100	100	100

Table 2. Effect of 50 Hz magnetic field on the plant height (cm) of *Vigna unguiculata*

Week(s) after planting	Magnetic field treatment (mG)				
	Control	50 mG	100 mG	150 Mg	250 mG
1	7.54 ± 0.15^a	7.76 ± 0.77^a	8.47 ± 0.5^b	8.38 ± 0.43^b	8.16 ± 0.45^b
2	11.80 ± 0.23^a	12.17 ± 0.88^{ab}	12.60 ± 0.64^{ab}	13.04 ± 1.12^{ab}	13.13 ± 0.50^b
3	13.80 ± 0.65^a	13.92 ± 0.90^a	14.18 ± 0.45^a	14.31 ± 1.08^a	14.34 ± 0.47^a
4	15.25 ± 0.53^a	15.38 ± 1.23^a	15.54 ± 0.59^a	15.62 ± 0.94^a	15.64 ± 0.45^a
5	17.22 ± 0.80^a	17.28 ± 1.37^a	17.51 ± 0.42^a	17.59 ± 1.03^a	18.01 ± 0.79^a
6	18.60 ± 0.59^a	19.11 ± 1.29^a	19.05 ± 0.22^a	19.43 ± 1.08^b	20.57 ± 0.92^b
7	19.12 ± 0.69^a	19.76 ± 1.16^{ab}	19.18 ± 0.37^a	19.59 ± 1.12^{ab}	21.17 ± 0.86^b

Values are mean±standard error. Mean with similar alphabetical superscript on the row are not significantly difference at P = .05

3.3 Effect of 50Hz Magnetic Field on the Number of Leaves

Table 3 shows the effect of 50 Hz magnetic field on the number of leaves of *V. unguiculata*. The results obtained from the experiment showed that there was no significant difference among the number of leaves of *V. unguiculata* obtained from seeds subjected to magnetic field treatments of 50 mG, 100 mG, 150 mG and 250 mG from 1 WAP to 3 WAP and 6 WAP. Although at some instances, significant differences were observed among treatment levels.

3.4 Effect of 50Hz Magnetic Field on Stem Girth

The result from this experiment showed that there was no significant difference in the stem girth of *V. unguiculata* among the treatment levels at 2 WAP, 3 WAP and 5 WAP. Although, at some instances, significance differences were observed. This is suggestive that since early seedling emergence positively influences the development of plant morphological features, this translated to the correlation observed in the growth parameters at these treatment regimes. Table 4 shows the effect of 50 Hz Magnetic Field on the Stem girth of *V. unguiculata.*

The stem girth of the plant was also influenced like other morphological parts. Observations showed that the largest girth was in the 50 mG but which was not significantly different from 100 mG and control.

3.5 Effect of 50 Hz Magnetic Field on the Number of Pods

Fig. 1 shows the result of the effect of 50 Hz magnetic field on the number of pods obtained from *V. unguiculata*. It was observed that the number of pods at the treatment level of 50 mG was the highest which was not significantly different from other treatment levels.

Early seed germination is an attribute of a good plant. Seed germination depends on both internal and external conditions. The most important external factors include temperature, water, oxygen and sometimes light or darkness. Various plants require different variables for successful seed germination. Often this depends on the individual seed variety and is closely linked to the ecological conditions of a plant's natural habitat. For some seeds, their future germination response is affected by environmental conditions during seed formation; most often these responses are types of seed dormancy [14].

Table 3. Effect of 50 Hz magnetic field on the number of leaves of *Vigna unguiculata*

Week(s) after planting	Magnetic field treatment (mG)				
	Control	**50 mG**	**100 mG**	**150 mG**	**250 mG**
1	2.00±0.00[a]	2.00±0.00[a]	2.00±0.00[a]	2.00±0.00[a]	2.00±0.00[a]
2	5.50±0.25[a]	5.75±0.75[a]	5.00±0.00[a]	5.75±0.43[a]	5.25±0.25[a]
3	10.08±0.55[a]	9.42±0.83[a]	10.00±0.58[a]	9.75±0.66[a]	9.58±0.46[a]
4	16.25±1.42[b]	14.67±1.80[ab]	13.25±1.23[a]	13.75±1.63[a]	13.58±0.17[a]
5	31.25±4.67[b]	24.67±4.04[ab]	26.08±4.10[b]	24.58±3.89[ab]	20.19±0.58[a]
6	34.75±5.59[a]	33.75±2.90[a]	35.58±6.44[a]	32.42±4.96[a]	31.67±1.40[a]

Values are mean±standard error. Mean with similar alphabetical superscript on the row are not significantly difference at P = .05.

Table 4. Effect of 50 Hz magnetic field on the stem girth (mm) of *Vigna unguiculata*

Week(s) after planting	Magnetic field treatment (mG)				
	Control	**50mG**	**100mG**	**150mG**	**250mG**
2	2.62±0.20[a]	2.84±0.15[a]	2.87±0.24[a]	2.72±0.20[a]	2.62±0.07[a]
3	3.14±0.18[a]	3.16±0.22[a]	3.16±0.15[a]	2.99±0.30[a]	2.89±0.12[a]
4	3.81±0.38[a]	3.95±0.30[a]	3.92±0.20[a]	3.67±0.41[a]	3.61±0.10[a]
5	4.92±0.40[a]	5.14±0.43[a]	4.94±0.35[a]	4.77±0.49[a]	4.71±0.23[a]
6	5.82±0.40[ab]	6.40±0.40[b]	6.23±0.26[ab]	5.66±0.24[a]	5.65±0.26[a]

Values are mean±standard error. Mean with similar alphabetical superscript on the row are not significantly at P = .05.

The moisture required for seed germination is necessary to bring about the vital activity of the dominant embryo to dissolve various salts and to hydrolyze many organic substances stored in the cotyledon or in the endosperm, to facilitate necessary chemical changes and to help the embryo come out easily by softening the seed coat. In their resting state, seeds are characteristically low in moisture and relatively inactive metabolically and that most seeds have critical moisture content for germination to occur [14]. For example this value in corn is 30%, wheat 40% and Soybean 50%. Once that critical seed moisture content is attained in the seed, sufficient water is present to initiate seed germination and if moisture content decreases below the critical moisture content, seed will essentially decay in the soil. Consequently, the significance of oxygen as the main source of the seedling's energy had been documented [15].

Seed germination is a complex process involving many individual reactions and phases, each of which is affected by temperature. The effect on germination can be expressed in terms of cardinal temperature: that is minimum, optimum and maximum temperature at which germination may actually be proceeding but at such a slow rate that determination of germination is often made before actual germination is completed. In the same vein, the response to temperature had been confirmed to depend on a number of factors, including the species, variety, growing region, quality of seed, and duration of time from harvest. Similarly, most seeds are not affected by light or darkness, but many seeds, including species found in forest settings, will not germinate until an opening in the canopy allows sufficient light for growth of the seedling.

These factors moderately affect seed germination under the influence of nature and nurture.

The adopted use of magnetic field in stimulating seed germination is a biological stimulation which should play an important role in optimizing crops in terms of the maximization of yield, promotion of plant growth and protection against disease. This assertion corroborates the views that the absence of toxic residue in electromagnetic stimulation method gave an edge over the use of traditional chemical processes [16] and that the exposure of seeds to magnetic field for a short time was found to help in accelerated sprouting and growth of seedling [8]. These assertions gave an insight to this research finding on the use of cowpea, *Vigna unguiculata*.

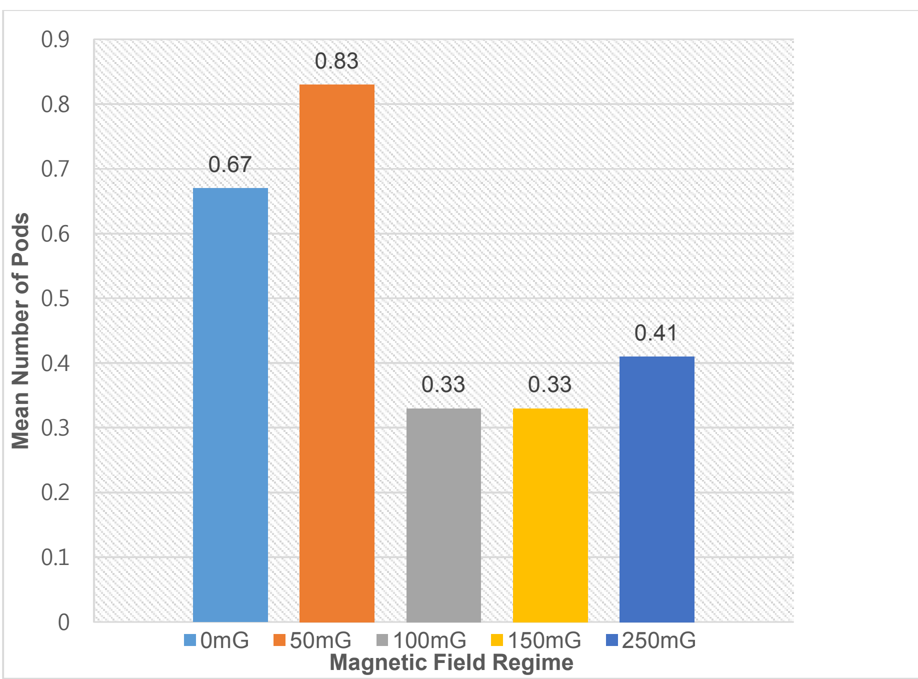

Fig. 1. Mean number of pods of *V. unguiculata* at the different magnetic field regimes

The findings in this research work corroborates the report on the exposure of *Zea mays* seedlings to low static magnetic of 50 mG [17]. The research reviewed the stimulatory influence on plant in their early ontogenetic stages, significant enhancement of the fresh tissue mass, assimilatory pigment level as well as the chlorophyll ratio, average nucleic acid level, increase of the average plant length while for an enhanced magnetic field induction ranging between 100 to 250 mG, an inhibitory effect for all measured parameters was obtained. This is a similar observation in this research where most vigour was experienced in the 50 mG compared to other magnetic field regimes. It could also be stated that there was a retardation in the parameters obtained in other magnetic regimes as observed in the number of pods in Fig. 1 where the control had a higher number of pods compared to other treatment regimes.

The results obtained in this research with the imbibition period and low frequency magnetic field used corroborate the view that 30 minutes exposure of wheat seeds during their imbibition to an extremely low frequency magnetic field (ELF-MF) cause a still increase in the numbers of sprouted seeds and increased seedling length [18], and also that magnetic field treatment can change and mostly enhance seed germination [19]. They found that suitable magnetic field pre-treatment could speed up seedling development and increase biomass. On an experiment on water absorption by lettuce seed previously treated in stationary magnetic field of 1-10, an increase in water up-take rate due to the applied magnetic field was reported and this may be the explanation for the increase in germination seed of treated lettuce seeds [20].

Similarly, other researches had been published on the adopted use of magnetic field in influencing seed germination in various plants whereby the magnetic field strength, the period and effect of exposure were considered.

4. CONCLUSION

The use of magnetic field in seed germination is no more a conjecture. This research has also proven that the exposure of cowpea seeds to 50 mG to 250 mG for 30 minutes could effectively increase germination rate and consequently influence the growth parameters and yield but it is most desirable at the 50 mG.

It is recommended that the use of magnetic field be extended to scarified seeds. This approach will enhance seed improvement, germination and crop yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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