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Effects of Magnetized Water on Growth Performance, Photosynthetic Pigments Accumulation and Yield Attributes of Vigna unguiculata (l.) Walp

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Abstract

This study aimed at examining the biological effects of magnetically treated water on growth performance, biochemical attributes and yield of *Vigna unguiculata* (cowpea) under screenhouse conditions in 2019 season. The treatments were divided into two regimes. The first regimes were supplied daily with magnetized water and the second regime was watered daily with tap water. The regimes were laid down in Completely Randomized Design (CRD) with six replicates. The following growth and yield parameters were taken shoot height, number of leaves, leaf area, number of flowers, number of fruits, seed weight and number of seeds in pods. Crop growth rate, relative growth rate, net assimilation rate, leaf area ratio, tissue water contents and root to shoot ratio were also determined from leaf area and dry matter. Some biochemical attributes such as photosynthetic pigments accumulation were also determined using standard methods. The result obtained from this study indicated that magnetized water improved shoot heights, number of leaves, length of internodes, leaf area of *Vigna unguiculata*. The growth indices of *Vigna unguiculata* such as crop growth rate, net assimilation rate, leaf area ratio, tissue water content and root to shoot ratio; biochemical parameters such as photosynthetic pigments; and yield parameters such as number of fruits, seed weight and number of seeds in pods were significantly different and higher in *Vigna unguiculata* treated with magnetized water from plant treated with tap water. It may therefore be concluded that magnetized water can be used to improve growth, biochemical attributes and yield of *Vigna unguiculata*.

Keywords: Cowpea; Growth; Magnetized water; Photosynthetic pigments; Tap water; Yield

Introduction

Water scarcity is considered as a major limitation for increased agricultural production and food security for world population in this century. As good quality water is scarce, water of marginal quality has to be considered for use in agriculture [1]. Nowadays, the use of permanent magnets to improve water quality is of significant interest due to low cost compared to chemical and physical treatments [2]. Water solution passes through magnetic field acquire finer and more homogeneous structures, which increases the fluidity, dissolving capability for various constituents like minerals and vitamins and consequently improves the biological activity of solutions, affecting positively the performance of crops [3]. Using magnetically treated water offers improvements in industry and agriculture such as scale reduction and increased crop yields [4].

Physical science showed that water changes weight under the influence of magnetic fields. More Hydroxyl (OH^-) ions are created to form alkaline molecules, and reduce acidity. Increasing both the electric conductivity and the dielectric constant of water was documented [2]. Normal water has a pH level of about 7, whereas magnetized water can reach pH of 9.2 following the exposure to 7000 gauss strength magnet for more than 48 hours [2]. Exposing water to strong magnetic fields affected the mineral content of water and its effects depended on the strength of the magnetic field and exposure time [4].

Researchers found that when a permanent magnet is kept in contact with water for a period of 48 hours water gets magnetically charged and acquires magnetic properties [5]. Such magnetically treated water and consuming plants treated with this water has positive effect even on the human body when taken internally and regularly for a considerable period of time [6]. Surface tension in magnetized water is reduced by 10-12% whilst its velocity is increased in compared with regular water. Therefore it's penetration into cell wall would be facilitated which can accelerate ordinary diffusion of water that is vital for growth of different [7, 8].

Vigna unguiculata (cowpea) is known to be economically important due to its soil improvement abilities by increasing soil nitrogen levels [9,10]. *Vigna unguiculata* also suppresses weed growth and prevents soil erosion through excellent ground cover. Furthermore, it is a source of cash for rural communities provided through the trade of seed [9]. Many subsistence farmers and rural communities living in less developed countries rely largely on the vegetable crop as a good source of nutritious food. Farmers also obtain fodder and forage for their animals [10]. It has been reported that all the parts of the cowpea plant (i.e. roots, leaves and seeds) are used medicinally [11].

Based on the previous background, it is a must to look for cheap, healthy and ecologically safe approaches to improve the properties of soil and water quality, which in turn enhances plant growth and productivity. One of these approaches that improve higher productivity and quality water for plant growth and productivity is using water passed through a magnetic material. However, only some closely related studies have reported some beneficial effects of magnetized water for crop improvement. Hence, there is dearth of information, with valid scientific experiments, on the effects of magnetized water on growth, biochemical attributes and yield of *Vigna unguiculata*.

Materials and Methods

Preparation of magnetized water

Bar Magnets (of 4 cm long, 10 in number (3000 gauss)) collected

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from the Department of Physics and Engineering Physics, Obafemi Awolowo, University, Ile-Ife, Nigeria were deep in a 5 litres of tap water following [5] and was observed for 48 hours. The magnet were left in the 5 litres of tap water of water throughout the course of the experiment in order to retain the magnetic property of the water. The pH values of the tap water were measured using pH meter (PH M84 radiometer, Copenhagen, Germany) both before and after exposure to permanent magnets. The different electrical conductivities of the tap water was determined before and after exposure to permanent magnets by using portable EC meter (HI 98303 EC, New Dehli, India). Surface tension was determined before and after exposure to permanent magnets by maximum bubble pressure.

Raising of seedlings

The seedlings were raised under a screenhouse of Botany Department, Obafemi Awolowo University, Ile-Ife, Nigeria, to minimize extraneous factors. 32 pots (of 9 cm in diameter and 7.5 cm in height, conical in shape), 16 for each regimes were used. Each of these pots was filled with 10 kg of collected loamy soil. Ten holes of about 3 mm were bored at the bottom of the pots. This is to allow for proper drainage and prevent water logging during the course of the experiment. The seeds of *Vigna unguiculata* were then sown at a depth of 3 cm below the soil [12]. These seeds were sown at the rate of three seeds per pot to ensured survival and reduce rate of competition of the seedlings. The pots were then supplied with 500 mL of tap water of the pots capacity until the seedlings become fully established. After two weeks of sowing when the seedlings become fully established, the sample pots were divided into two regimes. The first regimes were supplied daily with magnetized water and the second regime was watered daily with tap water. The regimes were laid down in Completely Randomized Design (CRD) with 6 replicates.

Measurement of growth parameters

Sampling was carried out two weeks after sowing when seedlings become fully established and was further continued every week. The following growth attributes were determined: shoot height (from above the soil level to the tip of the youngest leaves in the shoot apex.), length of the first two internodes which were determined with the aid of metric rule calibrated in centimeters and number of leaves which were counted manually from the first week of sampling to the end of the experiment.

Measurement of growth indices

The following growth indices were determined during the vegetative stage of growth according to [12] using the data collected from leaf area and dry matter: Crop Growth Rate (CGR); Relative Growth Rate (RGR); Net Assimilation Rate (NAR); Leaf Area Ratio (LAR), Tissue Water Contents (TWC); Root to Shoot Ratio (RSR); Shoot to Root Ratio (SRR).

$CGR = (W_2-W_1)/ (t_2-t_1)$; 34

$NAR = (W_2-W_1) (\ln A_2- \ln A_1)/ (A_2-A_1) (t_2-t_1)$;

$LAR = (A_2-A_1) (\ln W_2-\ln W_1)/ (W_2-W_1) (\ln A_2-\ln A_1)$;

TWC = Fresh weight-dry weight/fresh weight ×100

RSR= Total root dry weight (g)/Total shoot dry weight

W_1 and W_2 is weight at t_1 and t_2, while A_1 and A_2 is the respective leaf area.

Leaf area was calculated from leaf length and width following [12]. The leaf length was measured from the leaf petiole to the tip of the leaf blade. The widest area of the leaf blade was measured as the leaf width. These were done with the aid of metre rule calibrated in centimeters as follows:

LA= L * W * CF (0.75). Where CF is the Correction Factor

Measurement of biochemical parameters

Determination of chlorophylls and carotenoids: 8 g of leaves of plant from each treatment were harvested; the leaves were ground immediately with mortar and pestle. A pinch of sodium bicarbonate was added to prevent the degradation of chlorophyll. 16 ml of 80% acetone was added. The blended materials were then filter through a Whatman's No 1 filter paper [13]. The absorbance of the samples was determined on a digital spectrophotometer at wavelengths of 470 nm, 646 nm and 663 nm. Concentrations of Chlorophyll a and Chlorophyll b and the carotenoid in the leaf extract was determined using Beer-Lambert equation as follows:

Chlorophyll a (μg/ml) = 12.21A663 – 2.81A646

Chlorophyll b (μg/ml) = 20.13A646 – 5.03A663

Carotenoids (μg/ml) = (1000A470 – 3.27 [Chl a] – 104[Chl b])/227

Total chlorophyll (μM) = 7.93A663 + 19.53 A646

In the carotenoid equation, '[chl a]' and '[chl b]' refer to the calculated concentration of chl a and chl b from the previous equations. The subscripts 470, 646 and 663 represent the absorbance at wavelength 470, 646 and 663 nm.

Measurement of yield parameters: After harvest, the following yield parameters were recorded: number of flowers, number of fruits and number of seeds per pods which were counted manually. 50 seed weights from each regime were determined with the aid of a weighing balance.

Statistical analysis: Statistical analysis was performed using Statistical Analytical Software (SAS) version 9.2. One way ANOVA was done using Fisher's L.S.D to separate the means and test the significance difference between magnetized water and the control (tap water) at 5 percent probability level, Degree of freedom=5 on the determined parameters. Simultaneous 95% confidence limits were determined using Dunnett's t-test.

Results

Chemical analysis of tap water and magnetized water

The result showed that the electrical conductivity of the tap water (1440 μS/cm) before magnetization is higher than it after magnetization (1431 μS/cm) (Table 1). The pH value of the tap water before magnetization is 7.94 which is neutral tending towards alkaline. The pH value of the tap water after magnetization is 8.05 indicating a weak alkaline solution. Concentration of Ca^{2+} (135 ppm) and Mg^{2+} (86 ppm) ion in the tap water before magnetization is higher than it concentration in the tap water after magnetization (Ca^{2+}=129; Mg^{2+}=80). The hardness of the tap water reduced by 4.76% after magnetization. There was significant difference in the electrical conductivity, pH, Concentration of Ca^{2+} and Mg^{2+} ion, and hardness among the treatments at $p \leq 0.05$.

Table 1: Chemical analysis of tap water and magnetized water.

Water properties	Tap water	Magnetized water
EC (µS/cm)	1440[a]	1431[b]
pH	7.94[b]	8.05[a]
Ca (ppm)	135[a]	129[b]
Mg (ppm)	86[a]	80[b]
Hardness ($CaCO_3$) (ppm)	462[a]	440[b]

Means with the same letter along the same row are not significantly different at p ≤ 0.05

Effects of magnetized water on the growth parameters of *Vigna unguiculata*

The shoot height of *Vigna unguiculata* was positively influenced by the exogenous application of magnetized water is shown (Figure 1). The shoot height of *Vigna unguiculata* of the control and with those treated with magnetized water increased from the beginning to the end of the experimental period. From the second week of the experimental period to the end of the experimental period, the shoot height (24.83-49.38 cm) of *Vigna unguiculata* treated with magnetized water was higher than the control (21.23 cm-37.17 cm). At the beginning of the experimental period to the third week of growth period, there was no significant difference at $p<0.05$ in the shoot height of the control plant to those treated with magnetized water. From the fourth week of the experimental period to the end of the experimental period, the shoot height of *Vigna unguiculata* treated with magnetized water was significantly different from the control plants.

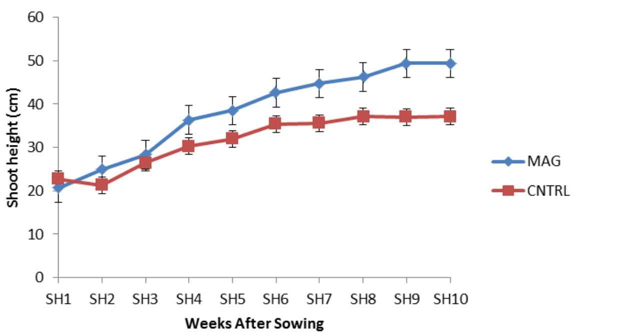

Figure 1: Effects of magnetized water on the shoot height of *Vigna unguiculata.*

From the third week of the experimental period to the fifth week of the experimental period, the number of leaves of *Vigna unguiculata* of the control (10.17-14.83 cm) was higher than the number of leaves of the *Vigna unguiculata* plants treated with magnetized water (9.33-14 cm) (Figure 2). From the sixth week of the experimental period to the end of the experimental period the number of leaves of *Vigna unguiculata* treated with magnetized water (16.83-18.83 cm) was higher than the control plants (12.83-14.50 cm). From the beginning of the experimental period to the fifth week of growth period, there was no significant difference at $p<0.05$ in the number of leaves of the control plant to those treated with magnetized water. Meanwhile, from the sixth week of the experimental period to the end of the experimental period, the number of leaves of *Vigna unguiculata* treated with magnetized water was significantly difference from the control plants.

The leaf area of *Vigna unguiculata* was positively influenced by the

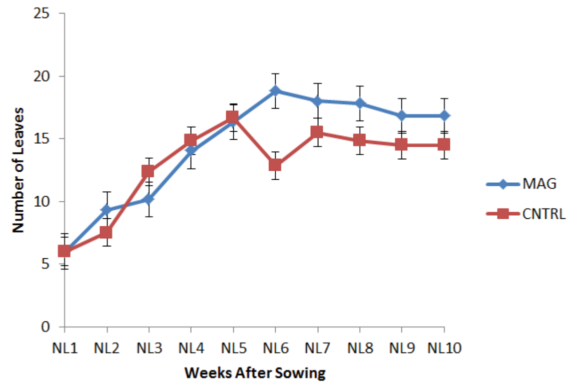

Figure 2: Effects of magnetized water on the number of leaves of *Vigna unguiculata.*

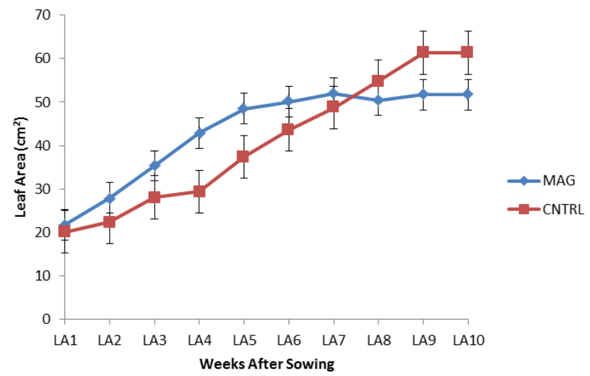

Figure 3: Effects of magnetized water on the leaf area of *Vigna unguiculata*.

application of magnetized water (Figure 3). The leaf area of cowpea of the control and with those treated with magnetized water increased nominally from the beginning to the end of the experimental period. The leaf area of cowpea treated with magnetized water was the highest in larger part of the experiment. From the beginning of the experimental period, the leaf area of *Vigna unguiculata* treated with magnetized water (21.76-50.06 cm) was higher than those of the control plant (20.12-43.61 cm) up to the seventh week of the experimental period. From this week, the leaf area of the control plant 51.98-61.31 cm) out-numbered the leaf area of *Vigna unguiculata* treated with magnetized water (48.69-51.68 cm. At the beginning of the experimental period to the sixth week of growth period, there was significant difference in the leaf area of the control plant to those treated with magnetized water and from the eighth week to the end of the experimental period.

From the beginning of the experimental period to the end of the experimental period, the length of internode of *Vigna unguiculata* treated with magnetized water (1.23-4.83 cm) was higher than those of the control (1.03-3.83 cm). There was significant difference in the length of internode of *Vigna unguiculata* treated with magnetized water and the control from the beginning of the experimental period up to the fifth week and from the eighth week towards the end of the experimental at $p<0.05$.

Effects of magnetized water on the plant growth indices of *Vigna unguiculata*

Leaf area ratio (26.80), net assimilation rate (3.54), tissue water contents (86.86) and crop growth rate (17.31) of *Vigna unguiculata* treated with magnetized water were higher than the Leaf area ratio (4.37), net assimilation rate (1.69), tissue water contents (79.37) and crop growth rate (9.81) of control plants, while relative growth rate (34.73) and root to shoot ratio (0.20) of the control plant were more than the relative growth rate (29.37) and root to shoot ratio (0.15) of *Vigna unguiculata* plants treated with magnetized water (Table 2). The net assimilation rate, leaf area ratio, relative growth rate, crop growth rate, root to shoot ratio and shoot to ratio of *Vigna unguiculata* plants treated with magnetized water were significantly different from the control plants at $p<0.05$.

Effects of magnetized water on the photosynthetic pigments accumulation of *Vigna unguiculata*

Table 3 showed the effect of magnetized water on the photosynthetic pigment accumulation of *Vigna unguiculata*. Chlorophyll a (15.69 µg/ml), Chlorophyll b (21.13 µg/ml) and total Chlorophyll (41.27 µg/ml) of *Vigna unguiculata* treated with magnetized water were higher than Chlorophyll a (9.12 µg/ml), Chlorophyll b (14.09 µg/ml) and total Chlorophyll (26.02 µg/ml) of those treated with tap water, while the carotenoid accumulation (2055.73 µg/ml) of those treated with tap water was higher than the *Vigna unguiculata* plant treated with magnetized water (1479 µg/ml). Chlorophyll a, Chlorophyll b, total Chlorophyll and carotenoid accumulation of *Vigna unguiculata* treated with magnetized water were significantly different from those treated with tap water at $p \leq 0.05$ (Figure 4).

Table 2: Effects of magnetized water on the plant growth indices of *Vigna unguiculata*.

Plant Growth indices	Magnetized water	Tap water	Simultaneous 95% confidence limits
Net Assimilation Rate	3.54 ± 0.02^a	1.69 ± 0.05^b	1.85
Leaf Area Ratio	26.80 ± 0.4^a	4.37 ± 0.04^b	22.43
Relative Growth Rate	29.37 ± 0.04^b	$34.73 \pm 2.0.02^a$	5.36
Tissue Water Content	86.86 ± 0.03^a	79.37 ± 0.04^b	7.49
Crop Growth Rate	17.31 ± 0.01^a	9.81 ± 0.01^b	7.50
Root/Shoot Ratio	0.15 ± 0.03^b	0.20 ± 0.1^a	0.05
Shoot/Root Ratio	6.65 ± 0.03^a	5.00 ± 0.5^b	1.65

Means with the same letter along the same row are not significantly different at $p \leq 0.05$. ± S.E is standard error of the means

Table 3: Effects of magnetized water on the photosynthetic pigments accumulation of *Vigna unguiculata*.

Photosynthetic pigments	Magnetized water	Tap water	Simultaneous 95% confidence limits
Chlorophyll a	15.69 ± 0.05^a	9.12 ± 0.01^b	6.47
Chlorophll b	21.13 ± 0.02^a	14.09 ± 0.05^b	7.04
Total Chlorophyll	41.27 ± 0.04^a	26.02 ± 0.01^b	15.25
Carotenoid	1479.50 ± 0.25^b	2055.73 ± 0.02^a	57.62

Means with the same letter along the same row are not significantly different at $p \leq 0.05$. ± S.E is standard error of the means

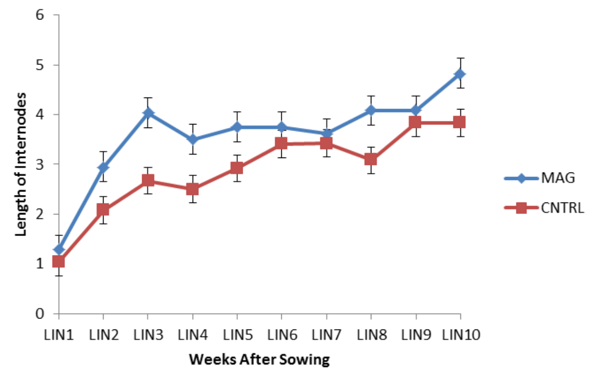

Figure 4: Effects of magnetized water on the length of internodes of *Vigna unguiculata.*

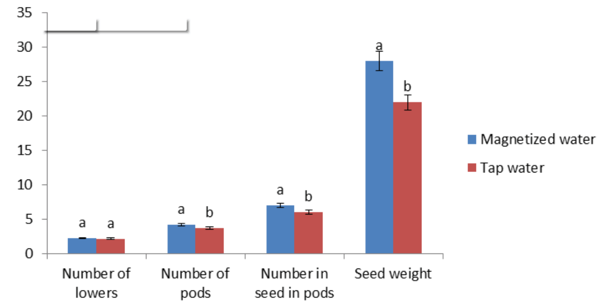

Figure 5: Effects of magnetized water on the yield of *Vigna unguiculata.*

Effects of Magnetized Water on the Yield of *Vigna unguiculata*

The yield of *Vigna unguiculata* as positively influenced by the application of magnetized water is shown (Figure 5). Number of flowers (2.26), number of pods (4.2), number of seeds in pods per plants (7) and seed weight (28 g) of *Vigna unguiculata* treated with magnetized water were higher than number of flowers (2.16), number of pods (3.75) and number of seeds in pods per plants (6) seed weight (22 g) of those treated with tap water. There was no significant difference in the number of flowers of *Vigna unguiculata* treated with magnetized water and those treated with tap water. There was significant difference in the number of pods per plant, number of seeds per pods and seed weight of *Vigna unguiculata* in the treatments.

The higher shoot height, number of leaves and length of internodes of the test crop compared to those plants treated with magnetized water compared to those treated with tap water may be attributed to the hydrogen bond and softness of the magnetized water which is highly affected by magnetic fields permitting increased in minerals solubility than tap water thereby enhancing and stimulating the overall growth parameters than those treated with tap water. The influenced may be also be due to the higher crop growth rate, net assimilation rate of nutrients and higher tissue water contents in those plants treated with magnetized water than the control plants. This correlates with the findings of [14] in cowpea; [15] in lentil.

The enhancement in leaf area and leaf area ratio in the study plants treated with magnetized water may be due to increase in the accumulation the elements available for development of leaf and leaf expansion. This is because the elements are diamagnetic which are repelled by a magnetic field [16]. This may also be attributed to increase chlorophyll content which favours higher photosynthetic activities resulting in higher interception of light and the greater amount of assimilates accrued to the plants available for vegetative growth. This is in line with the work of [17] in tomato who revealed an increase in leaf expansion and influx of water as a result of magnetized water treatments.

The higher net assimilation rate, tissue water and crop growth rate observed in the treated study plants with magnetized water than the control plants may be ascribed to the lower surface tension and electrical conductivity of the magnetized water which permits the dissolution of mineral elements and lowering the concentration gradients thereby creating a magnetic force promoting the uptake and absorption of surrounding elements. The accumulated essential element promotes the plant biomass. This result is in agreement with those obtained by [18] who found significance increase in the rate of water absorption accompanied with an increase in total mass of lettuce with the increase of magnetic force. The higher root to shoot ratio observed in the plants treated with magnetized water was related to increasing of root growth which improved water and ions uptake into the stem.

Higher number of fruits and seeds in pods per plants observed in the treated plants to those treated with tap water may be attributed to the high impact of magnetized water on flower production. Higher yields were also obtained for celery and white peas by the application of magnetized water to that containing a mixture of salt [19, 20].

The ability of treated water (magnetized water) plants to have high content of photosynthetic pigments considered a benefit point for this plant. The enhancement of Chlorophyll a, b and total chlorophyll in cowpea treated with magnetized water than the control is in line with the study of [21] who attributed the increase of photosynthetic pigments to the decrease of the amount of manganese in magnetized water compared to normal water [21]. This is also in line with the study of [22] who stated that irrigation with magnetized water increased photosynthetic pigment content, such as chlorophyll a, chlorophyll b and carotenoids and total chlorophyll content.

Conclusion

The results of the current study showed that magnetized water had positive significant effect on the morphological attributes, growth indices, biochemical attributes and yield of *Vigna unguiculata* than those treated with tap water. Therefore magnetized water can be can be used to improve growth, biochemical attributes and yield of *Vigna unguiculata* in house gardens and greenhouse condition. Further studies can be carried on the use of magnetized to improve growth and yield of other crops on the field.

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