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Morphological and Anatomical Variations of *Vicia faba* L. Seedlings in Response to Static Magnetic Force

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الملخص:

القوي المغناطيسية الساكنة تعتبر من القوي المؤثرة على كل الكائنات الحية علي سطح الكرة الأرضية. لذا فقد اختير تأثير القوي المغناطيسية الساكنة المتولدة من مغناطيس حديدي مقاس 4x 2.5x 1.0سم بقوة 30 هرتز، على بذور نبات الفول من خلال نظامين. النظام الأول تعريضهم للمجال المغناطيسي قبل النقع، لخمس دورات مغناطيسية لمدة 30 دقيقة لكل دورة تفصلهم فترة زمنية بمقدار 30 دقيقة ثم نقعهم في مياه الصنبور لمدة 6 ساعات قبل البدء في الأنبات.

النظام الثاني تم نقع البذور في مياه الصنبور أولا لمدة 6 ساعات قبل تعريضهم للمجال المغناطيسي، ثم تعريضهم لخمس دورات مغناطيسية لمدة 30 دقيقة لكل دورة تفصلهم فترة زمنية بمقدار 30 دقيقة. كما عملت عينات ضابطة بدون تعريض لأي مجال مغناطيسي للحالتين (بدون نقع وبالنقع في المياه لمدة 6 ساعات قبل الأنبات). واستمرت التجربة لمدة 26 يوم حتى انتهاء الإنبات وضمور البادرات. وقد قسنا نسب الإنبات وأحوال المجموع الخضري والمجموع الجذرى ودراسة الأنسجة الداخلية ونسب الخشب الي اللحاء. ووجدنا أن نسب الأنبات زادت في النظام الأول عن عن العينة الضابطة بينما تأخرت في النظام الثاني في أول أسبوعين ثم تحسنت لتصل الي العينة الضابطة فيما بعد. وكانت أكثر الأشياء تأثرا هي المجموع الجذرى ولون ومساحة الأوراق، وأنحناءات والتواءات الأوراق بالأضافة الي مساحة منطقة القشرة، نوع الحزم الوعائية وأيضا نسبة نسيج الخشب الي اللحاء.

من هذه الدراسة نستنتج أن القوى المغناطيسية الساكنة لها تأثير فعال على كل من الصفات الشكلية والداخلية للنبات ولذا فالاعتماد على هذه الصفات في تصنيف النباتات، في ظل الظروف البيئية الراهنة، أصبح غير دقيق.

الكلمات المفتاحية:

إنبات البذور، تشريح البذور، الشكل العام للبذور، مجال المغنطيسية الساكنة، *Vicia faba*.

Abstract

Static magnetic force (SMF) is the most important factors affecting all living creatures. This force investigated for its effect on human physiology, animal behavior and migration and plant germination and horticulture. *Vicia faba* seeds subjected to static magnetic forces arising from iron magnetic (4.0X2.5X1.0 cm, Y30H) in two regimes. The first one (A) post soaked seeds exposed to five magnetic cycles for 30 minutes and 30 minutes in between the two cycles. Then these seeds (A) soaked in tap water for six hours before starting the germination. The second portion (B), first soaked in tap water (Presoaked) for six hours, then exposed to the five cycles beside the Blank seeds. Germination %, seedlings morphology and anatomical structure recorded throughout the experiment which last for about 26 days. The germination % increased in the first regime (A) than the control, while the second regime (B) delayed the germination till the first two weeks and then respond to be as the blank ones. The most effective seedlings portions are the root system, the leaf color and area, leaf ptyxis , number of cortex layers, chlorophyll density beside the type of vascular bundles as well as xylem/phloem ratio.

SMF has great effect on seed germination, seedling morphology andanatomicalstructure of the stem.

Keywords: seed germination**;** seedling anatomy; seedling morphology; static magnetic field- *vicia faba*.

1. INTRODUCTION

Living creature has affected and developed by the environmental magnetic forces since their first day on the Earth. They adapted and experienced with the Earth`s magnetic force (Geomagnetic Force GMF) as a natural component of the surrounding environment. This force has its effect on all the physiological process, external appearance and internal structures of living creatures and gradually it affects their evolution.

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process. Now a day, the progress in modern technologies with different electromagnetic forces, high voltage communication towers, household appliances, medical instruments, transportation vehicles, and communication equipment expose plants (more than any other creatures) to a greater amount of the MF[1]. These changes have been noticed and studied by many scientists since the beginning of this century[2,3,4,5,6,7,8,9,10]. Broad[11] announced that earth's magnetic force has been decreased through the last two hundred years by about 15% as a result of high temperature and environmental disorders. Thus, our planet faced great challenge as natural magnetic field has a great effect on all living creatures as it controls their growth and existence as well as animal migration and has an important role in our life. Occhipintiet al[12] mentioned that the Magnetic force (MF) strength, now a day, ranges from less than 30 μT in the south Atlantic to almost 70 µT around the magnetic poles in northern Canada, South Australia and part of Siberia.

The study of SMF on the external features of plants was few and most research works in this concern related to plant physiology, growth and metabolism. Taia and Kootbi[13] Found that the different magnetic forces greatly affected the number of leaves and lateral branches, overall plant formation and shape, maturity of the flowers, pollen grains, as well as seeds and micropyles shapes. They found the most affected portion of the plants is the root system. The use of MF in agronomy and enhancing seed germination became popular, especially in the exposure to the MF before sowing which known as "magneto-priming" [14,15,16,17]. In the present time, everything is exposed to magnetic fields with different forces and exposure times. This made it worth noticing how much this force will affect the living creatures. The unit of the magnetic field, in the SI system (International System), is Tesla (T) while in the CGS system (centimeter–gram–second system) it is the Gauss (G) with 1 G = 10^{-4} T. The strength of the magnetic field decreases with the distance from the source. The geomagnetic field of the Earth is dipolar (the magnetic poles are not coincident with the geographic poles) and varies at the surface from 26 µT near the equator to about 60 µT near the poles. Actually, Magnetic field affects all sort of life, because every part of matter generates a magnetic field. Generally, the Earth's magnetic field is so small; it never exceeds 50 micro Tesla i.e. 0.5G[18]. Thus this work has been carried out on a very common economic plant in Egypt, *Viciafaba*L., to investigate the effect of high MF arising from magnetic iron at different lengths, to ensure different strengths, on both seed germination and seedling morphology and anatomy. *Viciafaba*L., broad beans, is one of the most economic legume crops. It belongs to family Fabaceae, which characterize by producing legumes containing seeds and both are edible.This plant considered an ideal species for experiments

2. AIM OF THE WORK

The work aimed to investigate how much the SMFs resulted from a magnetic iron affect the germination percentage, seedling morphological and anatomical characters and internal structure.

3. MATERIALS AND METHODS

Neodymium block magnets (4.0X2.5X1.0 cm, Y30H) were used to create a magnetic field. The magnets were fixed on both sides of the pots at different lengths from the seeds. Magnetic field strength was measured using Gauss/MilliTeslameter at each distance. Magnetic field ranging between 23 ± 0.5 G and 25 ± 0.5 G were adjusted at each distance from the seeds.

3.1. Seeds preparation

540 dry *V. faba* seeds have been used in this investigation. Seeds of *V.faba* (broad beans) were purchased from food shop. The seeds were washed with an anti-bacterial soap, rinsed with tap water, and then washed three times with normal tap water. After washing the seeds, they were divided into two portions, each with 240 seeds and extra 60 seeds were used as control without any treatment. The experiment began in the 23rd of June 2021, soaked in water for six hours, and planted in the pots after the beginning of germination in the 26th of June, and last till the 21st of July 2021. Twenty seeds were placed in each Petri dish and 12 Petri dishes were used for each treatment beside three Petri dishes control. The first portion (A) has been exposed to five SMF (23-25 G) cycles arising from an iron magnet (Post soaked), each cycle for 30 minutes and 30 minutes in between the two cycles. Then these seeds (A) soaked in tap water for six hours before starting the germination. The second portion (B), 240 seeds, first soaked in tap water (Presoaked) for six hours, then exposed to five cycles of SMF for 30 minutes in each cycle and 30 minutes in between each two cycles. The Blank (60 seeds) soaked in water for six hours and started the germination process (Fig. 1).

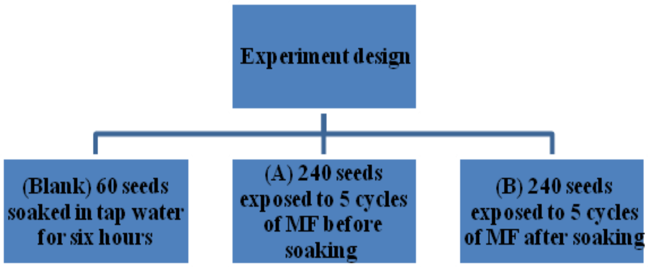

Figure 1. Design of the experiment

3.2. Germination

The germination experiment lasts for 25 days till the complete destruction of the plants. The seeds were put in Petri dishes lining with wet filter papers for three days to observe the germinated seeds and first emergence of the radical (Photo. 1). After that the seeds planted in the pots and exposed to the different MFs. Each portion was divided into four sets, each with 60 seeds, and planted in 12 rectangular pots

(29 X 11.5 X 6.0cm) filled till 4.5 cm with Patmos + mixed clay soil 1 : 1, each with 20 seeds in two rows (Fig. 2)

Figure 2. showing the germination, experiment design and seedling emerging

3.3. Measurements

The following measurements have been recorded during the experiment period, and the emerging seedlings were measured and examined carefully to recognize any differences in the morphological characters. The measurements were by using ruler in cm, and the number of nodes and length of internodes were according to ten seedlings in each treatment.

1- Percentage of germination, from the first emergence of radicles in each treatment and the control for the first three days.

2- Radicle shape and length in each stage.

3- Secondary root status.

4- Recording the first emerging of the shoot system.

5- Ptyxis of the leaf first emerging.

6- The length of the seedlings from the end of the terminal bud to the end of the growing point in the root in cm.

7- Ratio between radicle and plumule lengths (R: P).

8- Color of the first foliage leaves.

9- Total number of leaves after 25 days.

10- Leaf area for five middle leaves from each pot.

11-Xylem/Ploem ratio in five T.S. sections

3.4-Anatomical investigation

Seedlings at the last stage have been subjected to anatomical investigation. Hand transverse sections in the fourth internodes of the stems have been done to examine the internal tissues of the seedlings. Outline of the T.S., cortex width, number of chlorenchyma layers, patches of fibers, number of vascular bundles, and relation between xylem and phloem have been noticed. Photographs and examinations of the sections by OPTICA (B-150D) light microscope fitted with USB digital-Video Camera and Computer Software.

4. RESULTS

4.1 Germination rate

Different intensities of static MFs (23.7- 24.3G) were tested on seed germination and seedling growth of *Viciafaba* seeds. In the first regime (A) in which the seeds were exposed to 5 cycles of MF exposure before soaking in water accelerate the percentage ratios. After three days the germination ratio increased, especially in those exposed to 23.7G (A4), while those exposed to 23.9G (A3) the germination rates were higher than control during the experiment and reach 100% after 10 days. Higher MFS (A1, A2, 24.3 and 24.0G) the germination ratios delayed at the beginning but afterwards start to germinate as the control ones (Table 1 and Fig.1).

The second regime (B) the germination ratio was less than control except after a week it starts to increase gradually especially to those exposed to 23.7 and 23.9G, with the best result at those exposed to 23.7G (B4) (Table 1 and Fig.3).

Table 1. Germination percentage in each treatment before planting in pots (A), B,C,D,E seedling emerging after planting in pots and under MF. Start of experiment: 23/6/2021, Planting: 27/6/2021,Use of magnet: 28/6/2021 Table 1: Germination percentage in each treatment before planting in pots (A), B,C,D,E seedling emerging after planting in pots and under MF. Start of experiment: 23/6/2021, planting: 27/6/2021, use of magnet: 28/6/2021

Date→ Treat.↓	26\6 (A)	29\6 (B)	1\7 (C)	3\7 (D)	5\7 (E)
Control	**98.3%**	**65%**	**80%**	**90%**	**90%**
A1 (20 cm) 24.3 G	**91.4%**	**50%**	**80%**	**90%**	**90%**
A2 (30 cm) 24.0 G		**55%**	**90%**	**90%**	**90%**
A3 (40 cm) 23.9 G		**75%**	**90%**	**95%**	**100%**
A4 (50 cm) 23.7 G		**95%**	**95%**	**95%**	**95%**
B1 (20 cm) 24.3 G	**92.4%**	**10%**	**70%**	**80%**	**80%**
B2 (30 cm) 24.0 G		**10%**	**70%**	**75%**	**85%**
B3 (40 cm) 23.9 G		**50%**	**75%**	**85%**	**90%**
B4 (50 cm) 23.7 G		**45%**	**80%**	**85%**	**95%**

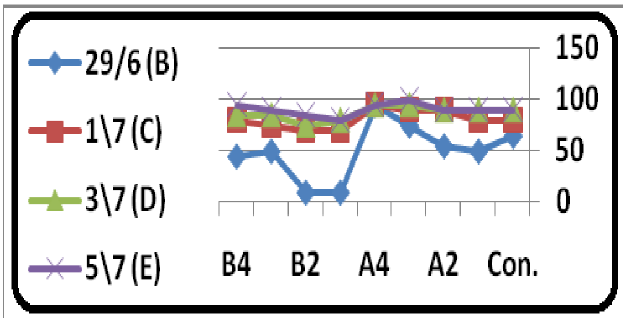

Figure 3. Differentiation in germination percentage in the two regimes (A & B) within the different forces

4.2 Seedling morphology

Results of the seedling morphology are summarized in Table 2 and illustrated in Plates 1 and 2 and (Figs. 4 and 5). The measurements last for three weeks, from 7/7 to 21/7, till the complete burning of them. In the first week (7/7), the shoot length increased considerably in all the first regime treatments (A). In the second regime treatments (B) the shoot length retarded at 23.9 G and 24.0 G (B3&B2), while in the other two MFs the shoot lengths were nearly as the control. The lengths of the root system decreased in all the treatments within the first regime (A), while the second regime (B) in the higher MFs (B1) increased and become as the normal in B4 (23.7 G.) (Fig. 4 and Plate 1). The ratio between shoot and root lengths are more indicative to the seedling state, from the table this ratio increased in all the (A) regime and B4 only, while B1,B2 and B3 it decreased considerably than control.

The shape and state of the 1^{ry}. root and 2^{ry} roots are considerably affected by the exposure to the MFs. The control was straight 1^{ry} root and sparse 2^{ry} while the first regime (A) the 1^{ry} roots wereshort and either undulated, straight or curved with dense and either long or short 2^{ry} roots in A2 &A3 while they were short and sparse in A1&A4. In the second regime (B) the first three treatments the 1^{ry}roots were long and curved while B4 it was short and straight. The 2^{ry} roots were long, moderate or short and either dense or sparse (Plate 1)

The numbers of nodes and leaves were mostly alike or inconsiderably varied but the length of internodes varied between the two regimes and between the MFs as shown in Table 2 and Fig. 5. The leaves were dark green in all the treatments and control and no ptyxis recognized within them. The leaf area varied between the treatment with significant increase in the A regime and both regimes increased than control (Table 2).

Table 2. Characters investigated in the two magnetic force regimes
Abbreviations: CSp=Curved sparse, LC=Long curved, LD=Long dense, LM=Long moderate, LS=Long straight, LSp=Long sparse, LU=long undulate, S.D.=Standard Deviation, ShC=Short curved, ShM=Short moderate, ShS=Short straight, ShSp=Short sparse, ShU=Short undulate,

Tr.→ Ch.↓		Cont.	A1	A2	A3	A4	B1	B2	B3	B4
Shoot L.	**7 July**	**12.8-26 19.4±**	**22.2-31 26.6±**	**17.2-35 26.1±**	**16.2-33 24.6±**	**26.9-31 29±**	**11.1-28.5 19.8±**	**7.8-18.5 13.2±**	**10.1-18 14±**	**16-22.3 19.2±**
S.D.		**9.33**	**6.22**	**12.59**	**11.88**	**2.90**	**12.30**	**7.57**	**5.59**	**4.45**
Root L.		**3-9 6±**	**2.3-3.5 2.9±**	**2.3-3.9 3.1±**	**3.8-5.7 4.8±**	**4-4.2 4.1±**	**9.2-10 9.6±**	**1.8-8.1 5±**	**1.5-10.9 6.2±**	**2-5.5 2.5±**
S.D.		**4.24**	**0.85**	**1.13**	**1.34**	**0.14**	**0.57**	**4.45**	**6.65**	**2.47**
Shoot/Root		**3.2**	**9.2**	**8.4**	**5.1**	**7.1**	**2.1**	**2.6**	**2.2**	**7.7**
1ry root status		**LS**	**ShU**	**ShS**	**ShS**	**ShC**	**LC**	**LC**	**LC**	**ShS**
2ry roots		**LSp**	**ShSp**	**LD**	**ShD**	**ShSp**	**LD**	**ShM**	**LSp**	**ShSp**
No. of nodes		**4-6 5±**	**5-6 5.5±**	**5-6 5.5±**	**5-6 5.5±**	**5-6 5.5±**	**4-6 5±**	**3-5 4±**	**4-6 5±**	**5-6 5.5±**
S.D.		**1.41**	**0.71**	**0.71**	**0.71**	**0.71**	**1.41**	**1.41**	**1.41**	**0.71**
Internodes L.		**2-7.5 4.2±**	**1.2-8.5 5.2±**	**1.5-9 4.4±**	**1.7-9 4.6±**	**3-8.6 5.6±**	**1.5-9 3.7±**	**1.7-6.5 3.4±**	**1.2-6 2.9±**	**1.2-7.2 3.6±**
S.D.		**2.14**	**2.61**	**2.54**	**3.01**	**1.79**	**2.77**	**1.81**	**1.79**	**1.97**
No. of leaves		**2-4 3.1**	**3-4 3.6**	**3-4 3.5**	**3-4 3.1**	**3-4 3.1**	**2-4 3**	**1-3 2**	**2-4 3**	**3-4 3**
Leaf colors		**D.G.**	**D.G.**	**D.G.**	**D.G.**	**D.G.**	**D.G.**	**D.G.**	**D.G.**	**D.G.**
Leaflet area (cm^2)		**2.56**	**10.78**	**4.10**	**4.75**	**5.40**	**3.96**	**2.71**	**3.37**	**4.78**
Ptyxis of leaves		**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**
Shoot L.	**14 July**	**14.2-15.5 14.8±**	**31.3-39 35.2±**	**23.6-26 24.8±**	**23-23.5 23.2±**	**29.5-31.9 30.7±**	**24.4-26 25.2±**	**7.7-18.5 13.1±**	**15.5-17.5 16.5±**	**13-35.5 24.2±**

S.D.		**0.92**	**5.44**	**1.70**	**0.35**	**1.70**	**1.13**	**7.64**	**1.41**	**15.91**
Root L.		**4.2-9.7 7±**	**10.4**	**4.5-7.5 6±**	**2.3-8.4 5.4±**	**6-10.5 8.2±**	**2-6.3 4.2±**	**1.2-5.1 3.2±**	**2-10.5 6.2±**	**1.2-6.5 3.8±**
S.D.		**3.89**	**0**	**2.12**	**4.31**	**3.18**	**3.04**	**2.76**	**6.01**	**3.75**
Shoot/Root		**2.1**	**2.3**	**4.1**	**4.3**	**3.7**	**6**	**4.1**	**2.7**	**6.4**
1ry root status		**LS**	**ShS**	**ShS**	**ShS**	**LS**	**ShS**	**LS**	**LS**	**ShS**
2ry roots		**LM**	**LSp**	**ShM**	**ShSp**	**ShSp**	**LD**	**ShSp**	**LD**	**ShSp**
No. of nodes		**5-6 5.5±**	**7-8 7.5±**	**6-7 6.5±**	**6**	**6-7 6.5±**	**6-7 6.5±**	**5**	**5-7 6.5±**	**5-7 6±**
S.D.		**0.71**	**0.71**	**0.71**	**0**	**0.71**	**0.71**	**0**	**1.41**	**1.41**
Internodes L.		**0.5-4.8 2.5±**	**0.5-12 5.1±**	**1.5-7.2 4±**	**0.9-7.3 4.1±**	**0.3-9.3 4.9±**	**0.5-7.5 4.1±**	**0.5-8 2.8±**	**0.9-5.4 3±**	**0.9-8.4 4.2±**
S.D.		**1.51**	**3.30**	**1.87**	**2.30**	**2.71**	**2.25**	**2.47**	**1.55**	**2.41**
No. of leaves		**3-4 3.5**	**4-5 4.5**	**4-5 4.5**	**4**	**4-5 4.5**	**4-5 4.5**	**3**	**2-3 2.5**	**3-5 4**
Leaf colors		**D.G.**	**L.G.**	**L.G.**	**L.G.**	**L.G.**	**L.G.**	**L.G.**	**L.G.**	**L.G.**
Leaflet area (cm^2)		**6.02**	**6.77**	**4.30**	**4.22**	**5.68**	**4.88**	**2.05**	**4.86**	**4.68**
Ptyxis of leaves		**No**	**No**	**Pr**	**Pr**	**Pr**	**No**	**Pr.**	**No**	**Pr.**
Shoot L.	**21 July**	**12.5-17.3 14.9±**	**23.5-31.2 27.4±**	**20.5-25.2 22.8±**	**22-24.8 23.4±**	**32-42.1 37±**	**21.5-31 26.2±**	**12.2-18.5 15.3±**	**14.5-20.8 17.6±**	**11.5-34.6 23±**
S.D.		**3.39**	**5.44**	**3.32**	**1.98**	**7.14**	**6.72**	**4.45**	**4.45**	**16.33**
Root L.		**5.5-9.8 7.6±**	**4-5.5 4.8±**	**2.3-6.1 4.2±**	**2-6.9 4.4±**	**6.3-7 6.6±**	**8.5**	**2-3.3 2.6±**	**1.5-10.1 5.8±**	**2-10.4 6.4±**
S.D.		**3.04**	**1.06**	**2.69**	**3.46**	**0.49**	**0**	**0.92**	**6.08**	**5.94**
Shoot/Root		**1.9**	**5.7**	**5.4**	**5.3**	**5.6**	**3.1**	**5.9**	**3**	**3.6**
1ry root status		**ShS**	**ShS**	**ShS**	**ShS**	**ShS**	**LS**	**LS**	**ShS**	**LU**
2ry roots		**LD**	**LD**	**ShSp**	**LD**	**ShSp**	**ShSp**	**ShSp**	**LD**	**LSp**
No. of nodes		**5-7 6±**	**6-8 7±**	**6-7 6.5±**	**5-7 6±**	**6-7 6.5±**	**5-7 6±**	**5-6 5.5±**	**5-7 6±**	**5-8 6.5±**

S.D.		**1.41**	**1.41**	**0.71**	**1.41**	**0.71**	**1.41**	**0.71**	**1.41**	**2.12**
Internodes L.		**0.5-3.7 2.5±**	**0.6-7 4±**	**0.4-7.4 3.7±**	**0.5-7 4±**	**3-10 6±**	**0.6-9.5 4.6±**	**0.5-6 3±**	**0.6-6.2 2.9±**	**0.5-6.5 3.8±**
S.D.		**1.40**	**3.15**	**2.35**	**1.78**	**2.74**	**2.16**	**2.38**	**1.59**	**1.97**
No. of leaves		**3-5 4±**	**3-4 3.5±**	**4-5 4.5±**	**3-5 4±**	**4-5 4.5±**	**3-5 4±**	**3-4 3.5±**	**3-5 4±**	**3-6 4.5±**
Leaf colors		**LG**	**LG**	**LG**	**LG**	**LG**	**LG**	**LG**	**LG**	**LG**
Leaflet area (cm^2)		**7.43**	**8.16**	**4.66**	**3.45**	**5.31**	**5.28**	**2.73**	**4.27**	**7.29**
Ptyxis of leaves		**No**	**No**	**Pr**	**Pr**	**Pr**	**Pr**	**Pr**	**Pr**	**Pr**

In the second week (14/7) the shoot length increased considerably in all the treatments and regime than the control while the root system decreased in all the treatments in both regimes, except in A1 & A4 they elongated than the control (Fig. 4 and Plate 2). The ratio between shoot and root lengths increased in all the treatments and both regimes than the control (Table 2). The 1^{ry} root was short and straight in the control and A4, B2 and B3 and short and straight in the rest of the treatments (Plate 2).

The numbers of nodes and length of internodes increased in the treated seedlings, both regimes than the control. The number of leaves was mostly alike or inconsiderably varied between the control and treated seedlings (Table 2 and Fig. 5). The leaves were dark green in the control and light green in all the treatments and ptyxis i.e. rolling of the small leaves, recognized within A2,A3,A4, B2 and B4. The leaf area decreased in all the treatment than the control, except in A1 it slightly increased(Table 2).

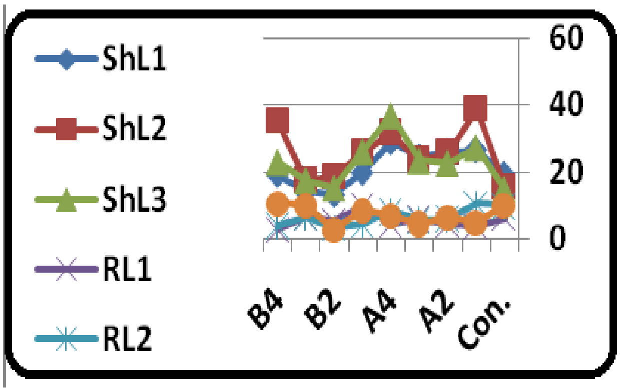

Figure 4. Differentiation in shoot and root lengths in the two regimes (A & B) within the different forces and through the three weeks. ShL1&RL1=shoot length & root lengths in the 1stweek, ShL2&RL2=shoot &root lengths in the 2ndweek, ShL3&RL3=shoot&root lengths in the 3rdweek.

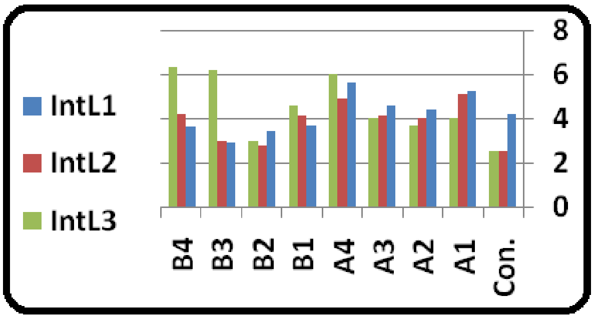

Figure 5. Differentiation in Internode lengths in the two regimes (A & B) within the different forces and through the three weeks. Int1=Internode lengths in the 1stweek, Int2=Internode lengths in the 2ndweek, Int3=Internode lengths in the 3rdweek

In the third week (21/7) the shoot length increased considerably in all the treatments and regime than the control while the root system decreased in all the treatments in both regimes (Plate 2). The ratio between shoot and root lengths increased in all the treatments and both regimes than the control (Table 2). The 1^{ry} root was short and straight in the control and all the treatments of the first regime. The second regime (B) 1^{ry} root was long and straight or undulate, except in B3 it was short and straight (Plate 2). Worth noticing that the 1^{ry} root in A2 and B2 becomes dark in color, while in B4 it was very thin. The 2^{ry} roots varied between the control and the treatments within both regimes (Table2).

The number of nodes and leaves did not vary greatly between the control and the treated seedling, while the length of internode increased in all the treatments than the control (Fig.3). All the treated leaves were light green and ptyxis appeared in all the emergent ones, while in the control, no ptyxis noticed.

4.3 Anatomical structure of the seedling stem

Representatives of the seedling at the end of the third week have been subjected to internal examinations. Hand Transverse sections done in the stem of the seedlings. The results summarized in table 3 and photographed in Plate 3.

Outline of the T.S., cortex width, number of chlorenchyma layers, number and type of vascular bundles, and relation between xylem and phloem have been noticed. Photographs and examinations of the sections by OPTICA (B-150D) light microscope fitted with USB digital-Video Camera and Computer Software. The seedlings stem outlines are rectangular in all the treatments and control, but in the treated ones the outline becomes undulated or wavy. The chlorenchyma layers are either one or two layers and reach three layers with condensed chloroplasts in A3 only. The width of the cortex varied from 6 layers in A3 to 10 layers in B4 with the widest cortex in the control 11 layers (Fig. 6). The number and relation between the xylem and phloem are from the important characters in the plant. Variations in the number of vascular bundles shown in Figure 7, where they are increased than the control in all the treatments, with the maximum increase in A4, B3 & B4. Bicolateral vascular bundles noticed in A1 and A2 while in the rest of the treated stems it is collateral V.B. Root nodules noticed in B1, B2 & B3 seedlings by the second and third weeks (Table 3).

Table 3. Anatomical characters of the seedlings stem under the different treatments
Abbreviations used:Ab=Abscent, Bicol=Bicollateral, Col=Collateral, F=Few, M=moderate, P=Present, SR=Straight rectangular, UR=Undulate rectangular,VS=Very small, VW=Very wide, W=Wide, WR=Wavy rectangular

Char.→ Treat.↓	Stem Outline	No. of Chlor.	Cortex layers	No. of V.B.	V.B. Type	Xy/Ph	Central Cavity	C.C. H.D.	Root nodules
Control	**SR**	**1**	**11**	**14- 17 (15)**	**Col**	**4**	**VS**	**Ab**	**Ab**
A1	**WR**	**1**	**8**	**18- 19 (18)**	**Bicol**	**2**	**VW**	**F**	**Ab**
A2	**UR**	**1**	**7**	**17**	**Bicol**	**3**	**W**	**M**	**Ab**
A3	**UR**	**3**	**6**	**16- 18 (17)**	**Col**	**3**	**M**	**F**	**Ab**
A4	**UR**	**2**	**7**	**18-20 (19)**	**Col**	**2**	**W**	**F**	**Ab**
B1	**UR**	**2**	**8**	**16-17 (16)**	**Col**	**1**	**W**	**F**	P
B2	**UR**	**1**	**8**	**16- 18 (17)**	**Col**	**1.5**	**W**	**M**	P
B3	**UR**	**2**	**7**	**20**	**Col**	**1**	**VW**	**Ab**	P
B4	**UR**	**2**	**10**	**19**	**Col**	**1.5**	**W**	**F**	**Ab**

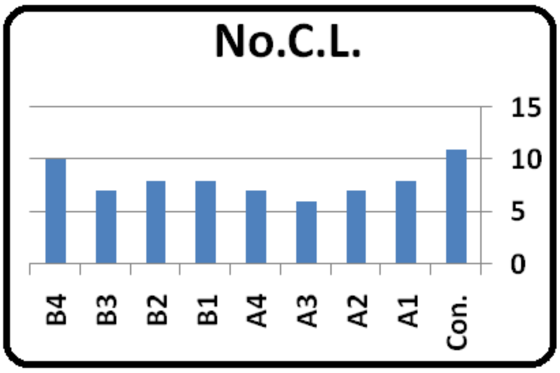

Figure 6. Differentiation in cortex layers in the two regimes (A & B) within the different forces.

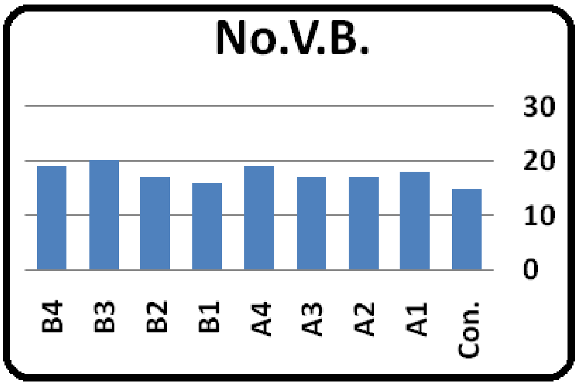

Figure 7. Differentiation in vascular bundles numbers in the two regimes (A & B) within the different forces.

5. DISCUSSION

There are three theories for how living creatures receipt magnetic waves, the first is generating magnetic minerals that allow them to sense

Earth`s magnetic field. The second is electromagnetic induction, while the third is biochemical reaction that generates radical pairs-quantum molecules with unpaired electron. These theories are postulated to explain the effect of MF on living creatures. Magnetic fields became from the most effective forces to all living creatures. These fields, with different forces created by either magnetic materials (SMF) or by the movement of charged particles (EMF). Simply the existence of life on Earth ultimately owes to the sun, which has a very large magnetic field that affects all the living organisms in many unseen ways. These forces and their effects investigated mainly on their effect on human physiology, animal migrations and behavior beside plant growth and agriculture [19,20,21,22,23 and 24].

Studies on the effect of SMF on seed germination have been done by many authors and all of them found that exposure of seeds to MFs promote seed germination. From these studies are those done by [25] who found that, even 4 and 7 mT promoted seeds germination and seedling growth of Wheat. Liu et al.,[26] found that soaked seeds of Wheat in water overnight and treated with 30 mT SMF promotes seed germination. Bukhari et al.,[27] examined the effect of static magnetic field on sunflower seeds at varying intensity (millitesla) for different exposure times and found that magnetic treatment at 50 mT/45 min greatly promote seed germination. All the studies on the effect of magnetic force on plants were concerning their physiological effects. Few observations concerning the external features of the plants have been done.

The presoaked regime (B) retarded the germination in the bigger SMFs (B1, B2,B3) and in B4 it became as the control. The second regime (A) promotes seed germination after three days in A3 and A4 (23.9 and 23.7G). While A1 and A2 it was as the control. (Table 1 and Fig.1). These founding support the previous works of [14, 26, 27,28]. Seedling morphology in the two regimes with the different forces has affected by the STM as shown in the results. The most affected portions are those related to the root system, leaf color, ptyxis and size. These foundations mentioned before by [13] on *Ocimumbasilicum* seedlings. Ptyxis is from the important taxonomic feature which is neglected by most of the researches. This character indicates that the plant grow under heat stress. This character shown by the rolling of the young leaves near the buds. The first noticed the effect of the leaves to the SMF mentioned by [29]who noticed that the electromagnetic Radio-Frequency caused perturbations of plant leaflet rhythms. Thus they concluded that the electromagnetic fields affect plant leaf characters. Taia et al.,[30] found that SMF has great effect on both seed germination and seedling morphology of *Ocimumbasilicum.* Meanwhile Taia et al.,[13] found that SMF altered the leaf characters of *Ocimumbasilicum* and its shoot and root morphological characters. While Shine *et al.*[14] found that treatment with MF improved germination-related parameters like water uptake, speed of germination, seedling length, fresh weight, dry weight, and vigor indices of soybean seeds under laboratory conditions.

The study of the effect of STM on the internal structure of the plants is undiscovered till now. The previous notification was on shoot meristem done by (26). Thus this investigation considered from the first observations on that issue. The SMF has affected both the cortical layers and chloroplast intensity beside the type and number of vascular bundles and

changes and we cannot consider them as constant taxonomic characters and relay on them in constructing identification keys.

xylem/phloem. This can be explained through the effect of this force on the water uptake as mentioned by[14].

Plate 1: Morphology of Seedlings. 1-9 at 7 July; 10-15 at 14 July.

Plate 2: Morphology of Seedlings. 1-3 at 14 July; 4-12 at 21 July.

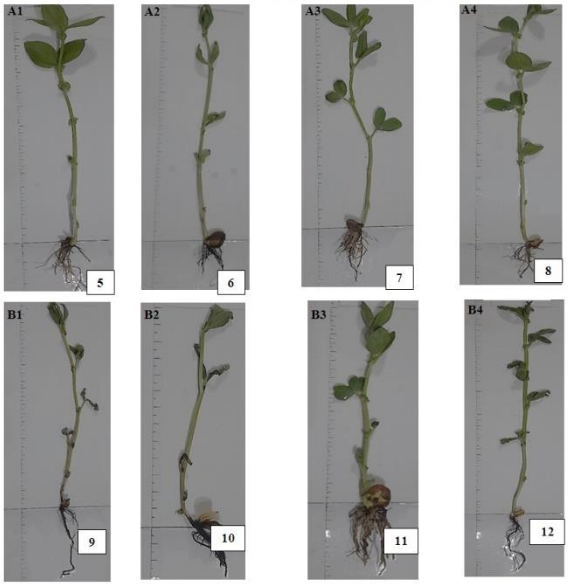

Plate 2: Morphology of Seedlings. 1-3 at 14 July; 4-12 at 21 July.

Plate 3

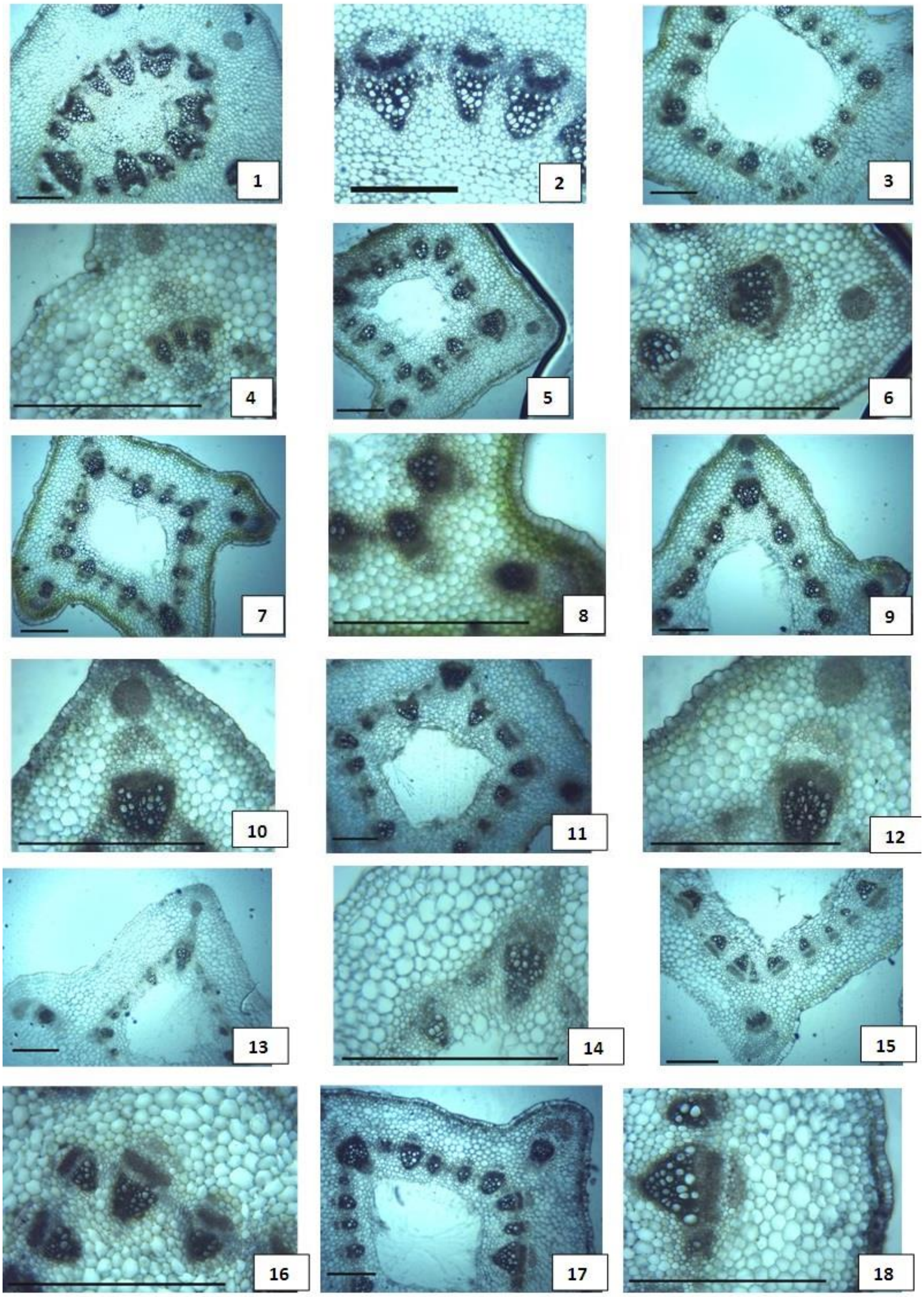

Plate 3. T.S. in *Vicia* Stem (Scale bar = 0.2 mm): 1, 2. Control; 3, 4. A1; 5, 6. A2; 7, 8. A3; 9, 10. A4; 11, 12. B1; 13, 14. B2; 15, 16. B3; 17, 18. B4.

6. CONCLUSIONS

This study concluded that SMF with different forces affects plant germination, growth, external morphology and anatomy of *Viciafaba*. The great effect was that of the post soaked seeds, after exposing to MF before soaking, then start germination under the different forces. The presoaked seeds; affected as well; by the SMFs but at lesser extent. These mean that both external and internal characters are subjected to environmental

7. REFERENCES

1. Nia M,Noori M, Ghanati F. Effect of static magnetic field on certain physiological and biochemical features of Cicerarietinum in vegetative growth phase. PajouheshSazandegi, 2008; 21, 62–68.
2. Rogers LE, Warren JL, Hinds NR,Gano KA, Fitzner RE, Piepel GF. Environmental studies of a 1100kV prototype transmission line. Annual Report for the 1980 Study Period. Battelle Pacific Northwest Laboratories, Portland, Oregon, 1981.
3. U.S. Navy. An evaluation of the U.S. Navy's extremely low frequency submarine communications ecological monitoring programme Washington DC: National Academy Press, 1997.
4. Reilly P. Applied Bioelectricity. New York: Springer-Verlag; 1998.
5. Foster KR. Thermal and nonthermal mechanisms of interaction of radiofrequency energy with biological systems. IEEE Trans Plasma Science. 2000; 28: 17-23.
6. Koops FBJ. Electric and magnetic fields in consequence of undersea power cables. In: Proceedings of International Seminar on Effects of Electromagnetic Fields on the Living Environment, 4-5 October 1999, Ismaning Germany. Oberschleissheim: ICNIRP: 189-210.
7. Kalmijn ADJ. Detection and biological significance of electric and magnetic fields in microorganisms and fish. In: Proceedings of International Seminar on Effects of Electromagnetic Fields on the Living Environment, 4-5 October 1999, IsmaningGermany. Oberschleissheim: ICNIR: 97-112.
8. Soja G. Effects of EMF on plants. . In: Proceedings of International Seminar on Effects of Electromagnetic Fields on the Living Environment, 4-5 October 1999, Ismaning Germany, 2000; Oberschleissheim: ICNIR: 79-93.
9. Foster KP, Repacholi MH. Environmental Impacts of Electromagnetic Fields From Major Electrical Technologies. In: Radiation and Environmental Health, Worth Health Organization CH-1211, Geneva, Switzerland, 2001.
10. Repachoili MH. An Overview of WHO's EMF Project and the Health Effects of EMF Exposure. Proceedings of the International Conference on Non-Ionizing Radiation at UNITEN (ICNIR 2003) Electromagnetic Fields and Our Health 20 th–22 nd October 2003.
11. Broad WJ. Earth's magnetic field reversing, shocking info. Live Science, Space news, Astra online. Free Space, Thread views: 2013.
12. Occhipinti A, De Santis A,Maffei, ME. Magnetoreception: an unavoidable step for plant evolution? Trends Plant Sci. 2014; 19, 1–4 10.1016/j.tplants.2013.10.007.
13. Taia WK, Kootbi AM. Effect of Magnetism on Some Morphological Characters in Sweet Basil Ocimumbasilicum L. (Lamiaceae). The 2nd International Conference of the Egyptian Society for Environmental Sciences 2007; Catrina 2 (2): 163-174.
14. Shine M, Guruprasad K, Anand A. Enhancement of germination, growth, and photosynthesis in soybean by pre-treatment of seeds with magnetic field. Bioelectromagnetics, 2011; 32, 474–484.
15. Bhardwaj J, Anand A, Nagarajan S. Biochemical and biophysical changes associated with magnetopriming in germinating cucumber seeds. Plant Physiol. Biochem., 2012; 57, 67–73.
16. Kataria S, Baghel L, Guruprasad K. Acceleration of germination and early growth characteristics of soybean and maize after pre-treatment of seeds with static magnetic field. Int. J. Trop. Agric., 2015; 33: 985–992.
17. Anand A, Kumari A, Thakur M, Koul A. Hydrogen peroxide signaling integrates with phytohormones during the germination of magnetoprimed tomato seeds. Sci. Rep. 2019, 9, 1–11.
18. Belyavskaya NA. Biological effects due to weak magnetic fields on plants. Advanced Space Research, 2004; 34(7): 1566-1574.
19. Naleem A, Salinas E, Bowtell JL, Mileva KN, Alford NM, Dimitriou S. Communications: Effect of static magnetic fields on human skeletal muscle performance. Human Physiology C15-C43 PC2-PC31A, King's College London J Physiol, 2005; 565P, PC15.
20. Palmer SJ, Rycroft MJ,Cermack, M. Solar and geomagnetic activity, extremely low frequency magnetic and electric fields and human health at the Earth’s surface. SurvGeophys, 2005; 27: 557-595.
21. Johnsen S,Lohmann KJ. Magnetoreception in animals. Physics Today, 2008; 61: 29–35.
22. Wiltschko R, Wiltschko W. Magnetoreception. *BioEssays*, 2006; 28: 57–168.
23. McCraty R. In Bio electromagnetic and Subtle Energy Medicine, Second Edition (ed Paul J. Rosch). Marcel Dekker, 2015; 541-562.
24. McCraty R, Al Abdulgader A. Consciousness, The Human Heart and The Global Energetic Field Environment. CardiolVasc Res., 2021; 5(1): 1-19.
25. Cakmak T, Dumlupinar R, Erdal S. Acceleration of germination and early growth of wheat and bean seedlings grown under various magnetic field and osmotic conditions. Bioelectromagnetics, 2010; 31:120–129.
26. Liu L, Li C, Song S, Teo ZW, Shen L, Wang Y, Jackson D, Yu H. FTIP-Dependent STM Trafficking Regulates Shoot Meristem Development in Arabidopsis. Cell Reports, 2018; 23, 1879–1890
27. BukhariSA, Tanveer TM, Mustafa G, Ud-Den NZ. Magnetic Field Stimulation Effect on Germination and Antioxidant Activities of Presown Hybrid Seeds of Sunflower and Its Seedlings. Journal of Food Quality, 2021. Article ID 5594183 | https://doi.org/10.1155/2021/5594183
28. Radhakrishnan R., Magnetic field regulates plant functions, growth and enhances tolerance against environmental stresses. PhysiolMolBiol Plants, 2019; 25(5):1107–1111.
29. EllingsrudS, Johnson A. Perturbations of Plant Leaflet Rhythms Caused by Electromagnetic Radio-Frequency Radiation. Bioelectromagnetics, 1993, 14(3): 257-271.
30. Johnsen S, LohmanKJ.Magnetoreception in animals Physics Today. 2008, 61, 3, 29. https://doi.org/10.1063/1.2897947
31. Taia WK, El-Zahrani HS, Kootbi AM.The Effect of Static Magnetic Forces on Seed Germination and Seedling Morphological Characters of Sweet Basil Ocimumbasillicum L. (Lamiaceae). Bio-Science Research Bulletin, 2005; 21(2): 119-127.