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Physiological Compatibility of Ferrites for Seed Treatment and its Effects on Germination

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Abstract

The present work deals with the approach to find out applications of ferrite materials in the field of agriculture. The compatibility of ferrite materials for their use in seed treatment and its effect was tested. Ferrite materials (spinal, Y type, Z type, M type, and W type) were applied on four types of non-germinated angiosperm seeds (Vigna radiate, Vigna aconitifolia, Abelmoschus esculentus and T. foenum-graceum). By applying various ferrites to non-germinated seeds, they were studied for their germination, growth and productivity. The idea was to develop a coating of ferrites on different species of seeds, which initiates the iron contain inside the seeds by applying magnetic fields, resulting in better germination and growth of the treated seeds.

Keywords: Ferrites, agriculture, seed germination.

Introduction

The application of special capsules for green-sprouting of seeds before their sowing is known. Typically, for this purpose, the biologically active porous materials, where seeds are placed together with a nutrient medium, are used. When a hexagonal ferrite particle, which is a miniature magnet (its size is less than 10 μm) is placed together with a seed, it substantially stimulates the process of green-sprouting. Hexagonal ferrite particles orient themselves along the Earth's magnetic lines, and this provides independence of the greens sprouting speed upon the seed's initial spatial orientation. The required magnitudes of the magnetic field intensity and coercive force are 0.5 T and 5 T, respectively (1). Ferro fluids have been found to have a novel ability of affecting chlorophyll ratio in some plants, indicating the high sensitivity of LHC II system to ferrofluids (2, 3). Magnetic fluids (MF) are stable collioidal suspensions composed of monodomain ferrite based (MFe_2O_4) magnetic nanoparticles dispersed in organic or inorganic liquid carriers [4]. Conventional MF are organic based colloidal suspensions stabilized by steric repulsions after coating the magnetic nano particles with surfactant agents. Ionic magnetic fluids are (IMF) are water based colloidal suspensions stabilized by coulombic repulsions after adding an electric surface charge density at the magnetic nanoparticles. The biocompatibility of many ferrofluids is under investigation [5]. However, there are many possibilities of applications of biocompatible MF in biology and medical diagnosis and therapy as for instance separation and purification of cells [6], MRI contrast agents [7] and magneto-thermo-cytolysis [8, 9].

The influence of ferrofluids in Opium poppy and Zea mays (maize) plant varieties have been reported in recent years. When petroleum ferrofluid was applied to already germinated Opium seeds (VFG) and to non-germinated seeds (VFnG) the results were different. When the already germinated Opium seeds were treated with 10 micro liters per liter concentration of ferrofluid and exposed to North Pole of bar magnet, they developed plants with slightly increased chlorophyll a and b contain as compared pure water nonmagnetic control. The ferrofluid treated freshly germinated seed without magnetic field exposure showed better result. The values of chlorophyll a and b were increased remarkably as compared to control for ferro fluid concentration corresponding to 50 and 70 micro liters per liter. The results are even better when the ferrofluid treatment is given to non-germinated seeds, without external magnetic field exposure. A Remarkable increase in chlorophyll a and b contain in the plants whose seeds treated with 50 and 70 micro liter per liter was observed. The effect does not follow an even trend which shows that the chlorophyll contain can be stimulated as well as inhabited by changing the treatment concentration and applying external magnetic fields to treated variants. Thus, the chlorophyll ratio can be changed by using appropriate ferrofluid treatment to Opium seeds [2]. The ferrofluid treatment to Zea mays seeds also influenced the chlorophyll contain and thus the chlorophyll ratio in the young plants developed. Similar to the

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case in Opium seeds it did not follow a simple increase or decrease trend however the chlorophyll ratio varied with treatment concentration. When 200 micro liters per liter concentrated ferrofluid was given treatment of two freshly germinated seeds of Zea mays both the chlorophyll contain were increased remarkably [3]. The results shows that ferrofluid treatment can be a good way of increasing chlorophyll contain in plants.

The present experiment dealt with developing a coating of ferrites on different species of seeds, which is supposed to initiate the iron contain inside the seeds by applying magnetic fields. This resulted in better germination and growth of the treated seeds. The ferrite coating on the seeds is only a physical contact between seeds and ferrites, not supposed to involve any chemical changes if only water is applied to seeds.

Design of the Experiment

The aim of the experiment was to study the compatibility of ferrites for their use in seed treatment and to study its effect on germination, growth and productivity of seeds. This study was carried out in two weeks duration from 13 Feb. 2014 to 26 Feb. 2014. The experiment was carried out at biotechnology lab of dept. of Botany Institute of Science, Nagpur. Temperature during this duration ranged from 10 to 14 minimum and from 24 to 32 maximum on Celsius scale. Availability of free air and sunlight was ensured to all the experimental variants. Four kinds of seeds were used to study the ferrite coating effect on them. 5 types of ferrite materials were applied on these 4 types of seeds. The 5 ferrite samples were applied individually on batches of 20-20 seeds of each type, and 20-20 seeds of each type were taken uncoated and marked as control. This resulted into 1 control and 5 variants of all 4 seed types and a 6 x 4 matrix arrangement. Germination, Average Root & Shoot length, and average gross weight were the parameters studied. (10)

Materials and Methods

The ferrite coating effect was tasted on Vigna radiate, Vigna aconitifolia, Abelmoschus esculentus and T. foenum-graceum. The mineral contain of these angiosperms and some magnetic properties of ferrites used are given in table 1 and 2.

Table 1: Mineral contain of the seed species used.

Seed Type		Mineral Content in mg per 100g				Ref.
	Iron	Calcium	Magnesium	Zinc	Copper	
Vigna radiate	9.7	84	55.6	-	-	11
Vigna aconitifolia	7.5	244.1	214.04	1.41	0.76	12
Abelmoschusesculentus	0.9	58.27	51.12	1.31	-	13
T. Foenum-graecum	8.9	550	26.91	6.45	0.73	14

Table 2: Selected magnetic properties of ferrites used for treatment.

Sample No.	Ferrite material		Magnetic Properties			Ref.
		Ms (Am^2kg^{-1})	Hc	HA (k Am^{-1})	Tc (^oC)	
1	Y Hexaferrite	34	Low	2228	340	15,16
2	Spinal Ferrite		V. low			17
3	Z Hexaferrite	50	V. Low	1035	410	16
4	M Hexaferrite	72	High	1353	450	16
5	W Hexaferrite	50	Low	1687	490	16

Good quality certified seeds of above mentioned 4 types of plants are collected. Seeds are allowed to soak in water for two hours, in presence of free air. Meanwhile 100 mg compounds of each type are weighed for every seed type using a digital weighing machine i.e. 5 set of 100 mg compound is weighed using all 5 compounds. 20-20 seeds of each type are selected and dried on blotting paper, and then gross weight of every set of twenty seeds is recorded. The association of ferrite powder with seeds is performed using honey. A set of twenty seeds of one type is taken into plastic container and a drop of honey was added to it. The seeds were shaken to have a layer of honey on them. Then slowly ferrite compound was added to it with shaking, so that a uniform layer of ferrite powder is formed on seeds. This way all the five types of ferrite samples were applied on all the 4 seed types. Sets of 20-20 seeds of each seed type were kept uncoated and called as control. All these seeds were then kept in their respective containers on blotting paper. These set of seeds were arranged in a 6X4 matrix. The nomenclature was as. The seed type A with ferrite sample no. 2 coating was called A2. Similarly, C4 was the C seed type coated with sample no. 4. All the four control were AC, BC, CC and DC. Equal watering was done on all experimental variants and controls.

Fig 1: Step 1

Fig 2: Step 2, Step 3 and Step 4

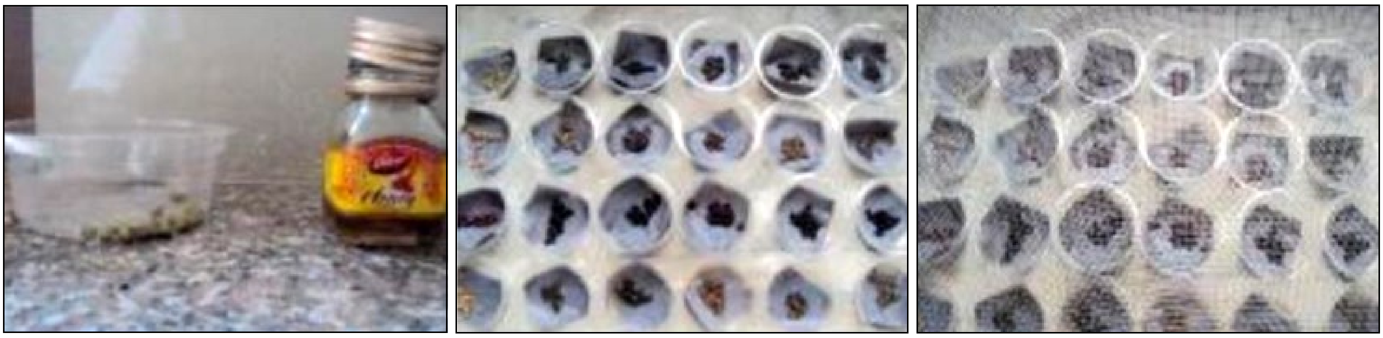

Fig 3: Step 5, Step 6 and Step 7

Result and Discussion

Keeping in mind, that there may be natural fluctuations in growth parameters of seeds. Only those observations which have a difference of at least 10% with respect to the control were selected to be reported as significant observations. The tabulated experimental data was analyzed by graphical means.

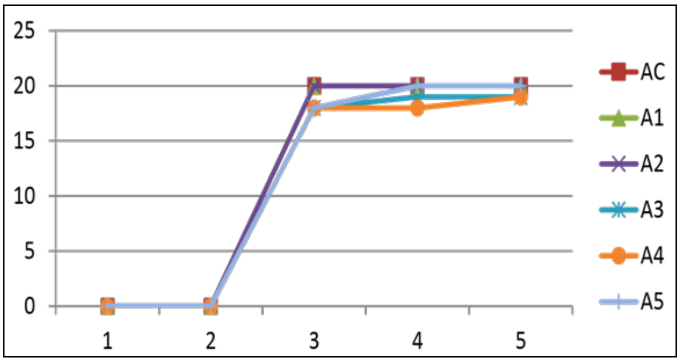

Fig 4: Number of seeds germinated Vs experimental days in Vigna radiate species.

Fig. 4 depicts the line graph of no. of seeds germinated were plotted against experimental days. This graph shows that the rate of germination of control and variants A1 and A2 were same. Slightly slow germination rate was observed in case of variant A5. In all the variants except A3 and A4, the all the 20 seeds germinated and germination was 100%. While in variants A3 and A4 maximum 19 seeds germinated and germination was 95%. The lowest germination percentage as well as germination rate was observed in A4.

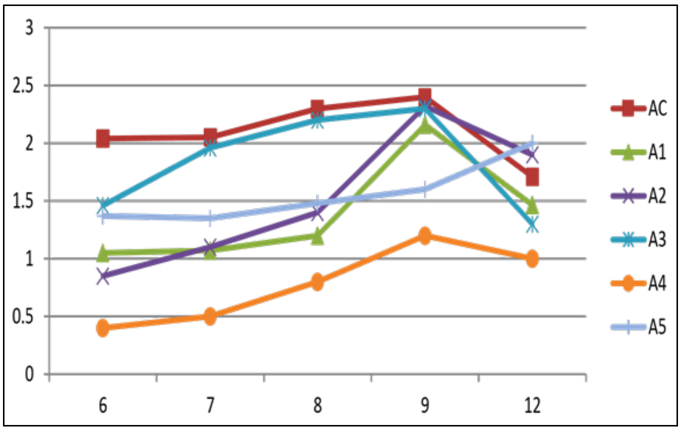

Fig 5: Average root length in cm Vs experimental days in Vigna radiate species.

Fig. 5 depicts the line graph of root length of plants were plotted against successive experimental days. On 6, 7, 8 day the average root length in the experimental variants followed the order: AC > A3 > A5 > A1~ A2 >A4. The highest root length was observed in control and lowest in A4. On ninth day highest root length was observed in case of AC and the A1, A2, A3 and A5 were close to AC. On 12 th day the growth of all experimental variants restricted. However, A4 variant has the lowest root length throughout the experiment. The growth of roots in variant A4 is restricted by 50% with respect to the control AC. This was a significant effect.

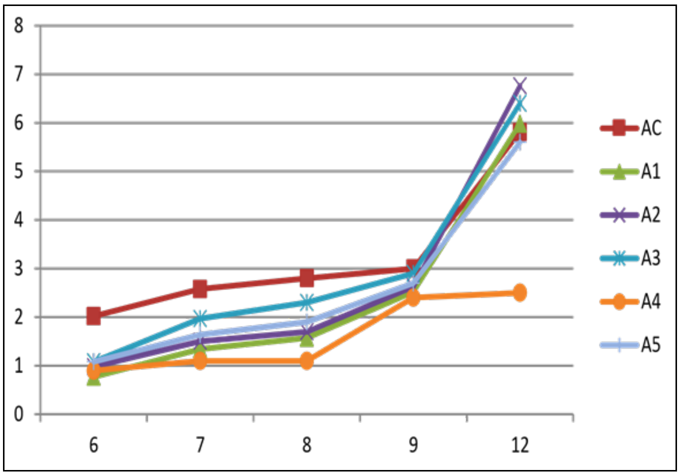

Fig 6: Average shoot length in cm Vs experimental days in Vigna radiate species.

Fig. 6 depicts the line graph of shoot length of plants were plotted against experimental days. On 6th to 9th day the control AC leaded the average shoot length followed by equivalent values for A1, A2, A3, and A5. On 12th day AC and A5 were found to be having nearly same shoot length. And A1, A2, A3 had slightly increased shoot length than control. The average shoot length in A2 was found to be 16% more than AC. This was a significant observation. The growth of A4 variant was restricted most. It has lowest shoot length in all days. The shoot length in variant A4 was lowered by 57%. This was a significant observation.

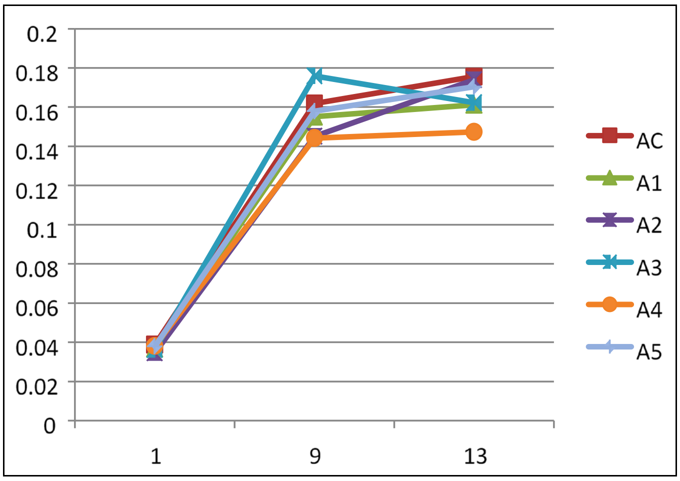

Fig 7: Average gross weight in grams Vs experimental days in Vigna radiate species.

Fig. 7 depicts the line graphs of average gross weight per seed were plotted against experimental days. On first day it was insured that all the experimental variants have seeds with equal average gross weight. On 9th and 12th day all the variants except A4 had equivalent biomass production. The average gross weight per seed in variant A4 was lagging by 11% and 16% on 9th and 13th day respectively. This was a significant observation.

Graph B1: Number of seeds germinated Vs experimental days in Vigna aconitifolia species.

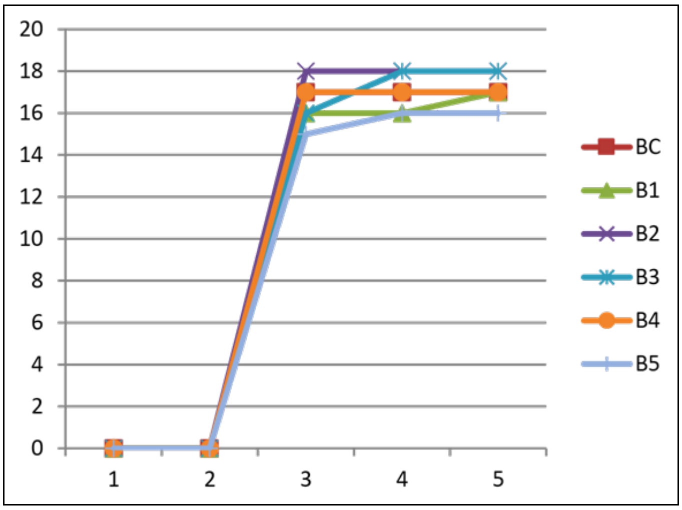

Fig 8: Number of seeds germinated Vs experimental days in Vigna aconitifolia species.

Fig. 8 depicts the line graph of no of seeds germinated were plotted against experimental days. This graph shows that the rate of germination was highest in variant B2 followed by B3, BC, B4 and B1 in order. The lowest germination rate and germination % was observed in B5.

The germination % in control BC was 85% while that in B5 was 80%. It means a minimum of 80% seeds was germinated in all experimental variants including control.

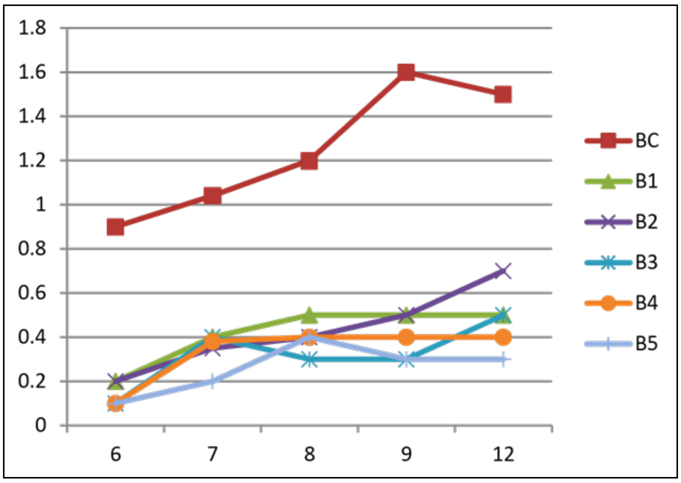

Fig 9: Average root length in cm Vs experimental days in Vigna aconitifolia species.

Fig. 9 depicts the line graph of root length of plants were plotted against successive experimental days. In this seed sample the results were a considerable restriction in root lengths of plants in experimental variants as compared to the control. Throughout the experiment BC has the highest root length followed by B1, B2 and B3 variants with 68% reduction in root length. Trend was further followed by B4 having 75% less root length than control. The lowest root length was observed in B5 variant with reduction in root length by 80% as compared to the control BC. All the observation of negative effect of ferrite treatment for all samples on vigna aconitifolia was significant observations.

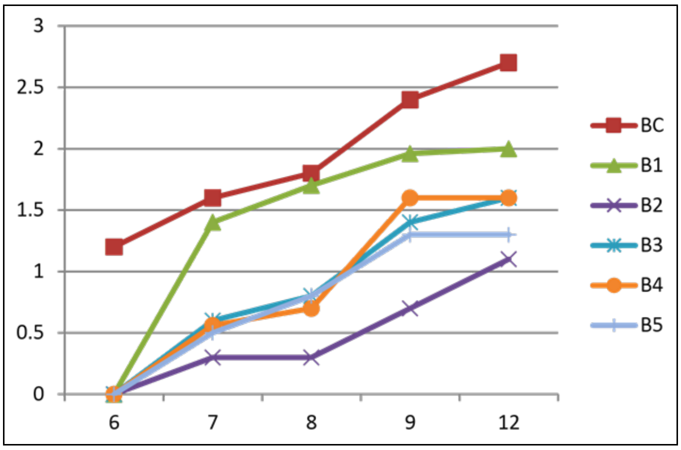

Fig 10: Average shoot length in cm Vs experimental days in Vigna aconitifolia species.

Fig. 10 depicts the line graph of shoot length of plants were plotted against experimental days. On 6th day only control BC has developed shoot system. Plants in other 5 ferrite treated sample variants could not develop shoot system on 6th day. On 7th day onwards other variants started developing shoot system. But the rate of shoot system development was very slow as compared to control BC. On 12th day control was having highest average shoot length followed by B1 with a reduction of 26%. The trend was followed by B3, B4, B5 with reduction of 40%, 40% and 51.85% respectively. The lowest value of average shoot length was found in case of B2 variant with a reduction in shoot length by 59.25% with respect to control BC. All the observation of negative effect of ferrite treatment for all samples on Vigna aconitifolia was significant observations.

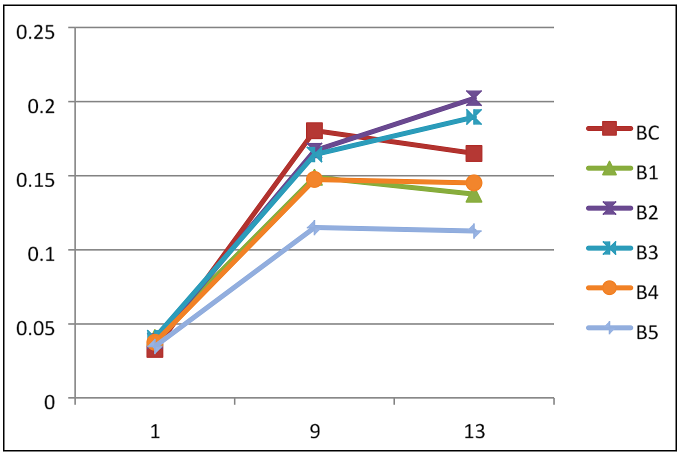

Fig 11: Average gross weight in grams Vs experimental days in Vigna aconitifolia species.

Fig. 11 depicts the line graphs of average gross weight per seed were plotted against experimental days. On first day it was insured that all the experimental variants have seeds with equal average gross weight. On 9th day control BC has highest average gross weight followed by B2 and B3 with a slight decrease. The trend was followed by B1 and B2 with gross weight less than control by 17%. The lowest value of average gross weight on 9th day was B5 60% less than control. On 12th day however, the growth of BC was stopped and B2 and B3 gained more average gross weight than control by 22% and 15%. Remaining variants have same value of gross weight as on 9th day.

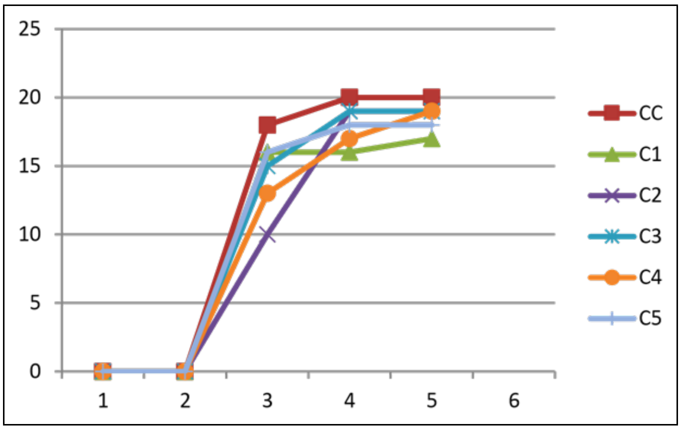

Fig 12: Number of seeds germinated Vs experimental days in Ablemoschus esculentus species.

Fig. 12 depicts the line graph of no of seeds germinated were plotted against experimental days. This graph shows that the rate of germination was highest in variant CC control, followed by slightly slower germination rate in other ferrite treated variants. The germination % was highest in control 100% followed by C2, C3 and C4 with 95% germination. Lower germination % was observed in C5 and C1 respectively 90 and 85%. Minimum germination of ferrite treated sample was 85% which clearly suggests that ferrite treatment has no significant effect on germination of seeds.

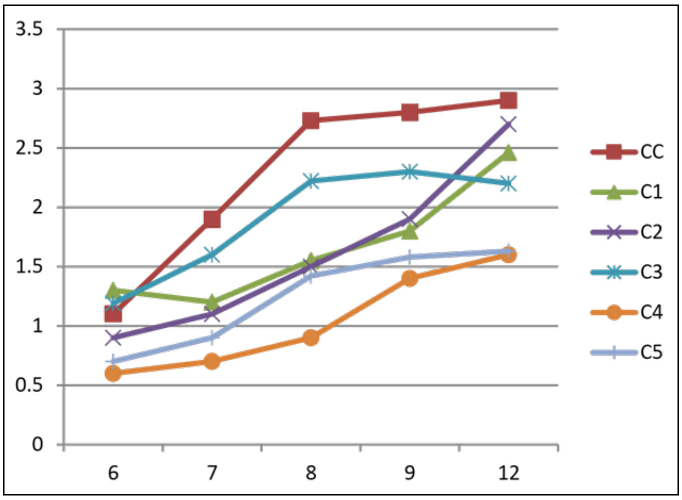

Fig 13: Average root length in cm Vs experimental days in Ablemoschus esculentus species.

Fig. 13 depicts the line graph of root length of plants were plotted against successive experimental days. The result was slight restriction in root growth of ferrite coated seeds in okra seed type. The highest root length was observed in control CC. The average root length decreased in following order: CC ~ C2(6% less than CC) > C1 (15% less than CC) > C3 (24% less than CC) > C5 (43.79% less than CC) > C4 (44.82% less than CC). Decrease in average root length in experimental variants C1, C3, C5 and C4 are significant observations.

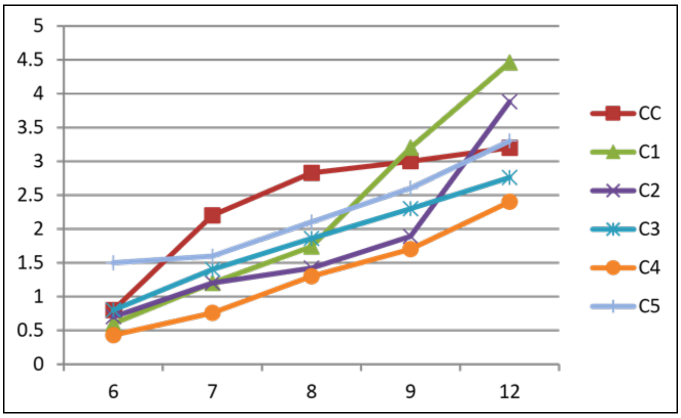

Fig 14: Average shoot length in cm Vs experimental days in Ablemoschus esculentus species.

Fig. 14 depicts the line graph of shoot length of plants were plotted against experimental days. The growth rate patterns followed by all experimental variants are not same. On 6th day highest and lowest shoot length was observed in C5 and C4 respectively. All the other variants including control were in between and in equivalent range. This difference was not significant. On 7th and 8th day highest shoot length was in control followed by other variants. From 9th day onwards the growth pattern changed significantly. On 12th day C1 and C2 had significantly high shoot length than control (39% and 21% increase than CC). C5 had shoot length equivalent to control followed by C3 and C4 with 13% and 25% less shoot length than CC. 12th day observations were significant observations.

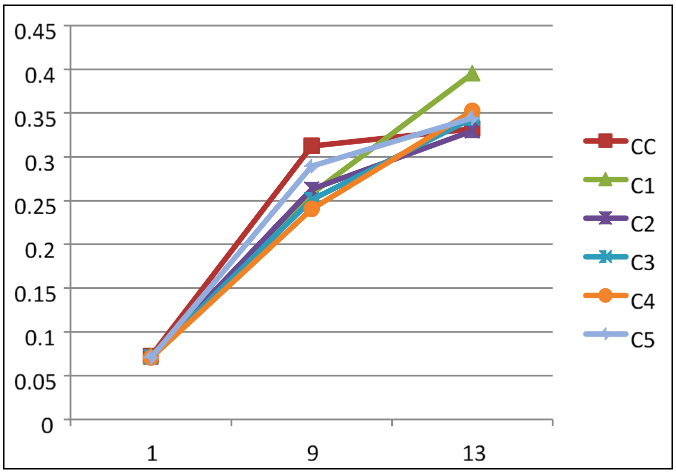

Fig 15: Average gross weight in grams Vs experimental days in Ablemoschus esculentus species.

Fig. 15 depicts the line graphs of average gross weight per seed were plotted against experimental days. On first day it was insured that all the experimental variants have seeds with equal average gross weight. On 9th day control CC had maximum average gross weight which was followed by C5 and equivalent gross weights in C1, C2, C3 and C4. On 13th day maximum average gross weight was observed in C1 with a gain of 19%, which was a significant observation and was followed by equivalent gross weights in all remaining variants including control.

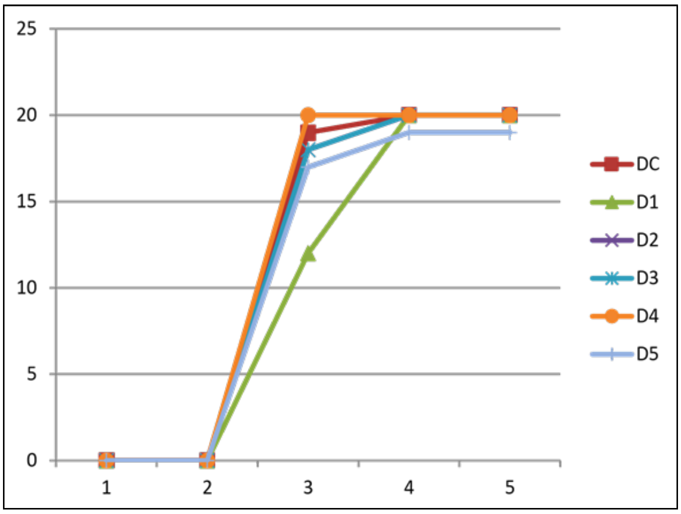

Fig 16: Number of seeds germinated Vs experimental days in T. foenum-graecum species.

Fig. 16 depicts the line graph of no. of seeds germinated were plotted against experimental days. The graph shows that the rates of germination of fenugreek seed variants were same. All the variants attained their maximum germination i. e. 100% germination on 4th experimental day. In D5 variant the germination was 95%. This showed that there is no significant effect of ferrite coating on germination of fenugreek seeds.

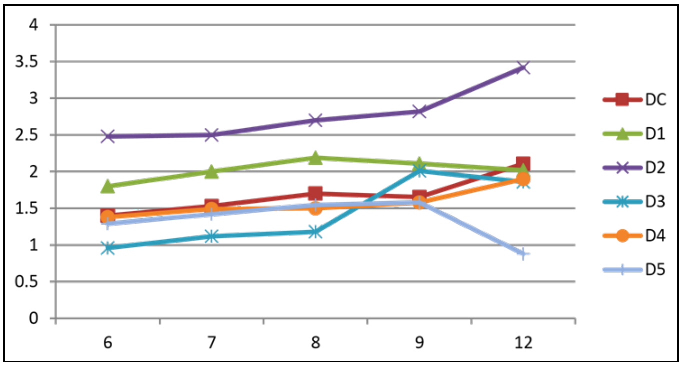

Fig 17: Average root length in cm Vs experimental days in T foenum-graecum species.

Fig. 17 depicts the line graph of root length of plants were plotted against successive experimental days. The root length in fenugreek variant followed same trend for 6th, 7th and 8th day but deviated slightly from 9th day onwards. On 6th to 8th day, the highest root length was observed in D2 followed by D1 and the control was followed by D3, D4 and D5. On 12th day D2 variant were observed to be having 62% more root length than control CC, which was a significant observation. D1, D3, D4 and control were having equivalent root lengths. However lowest value of average root length was observed in D5 experimental variant with 58.25% less value than control leading to a significant observation.

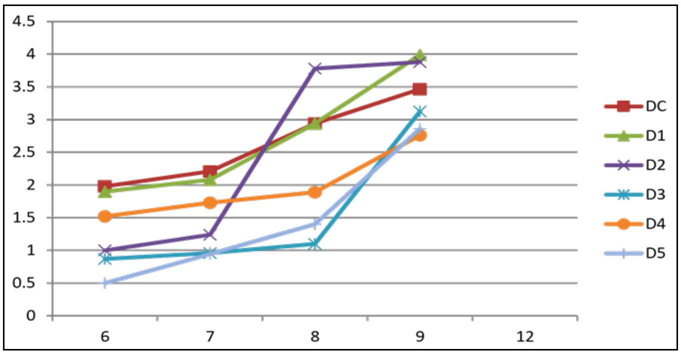

Fig 18: Average shoot length in cm Vs experimental days in T. foenum-graecum species.

Fig. 18 depicts the line graph of shoot length of plants were plotted against experimental days. The growth rate patterns followed by all experimental variants were not same. On 12th day the maximum shoot length was observed in D1 (15% greater than DC), followed by D2 (12% greater than DC). The control was followed by D3 (10% less than DC), D5 (17% less than DC) and D4 (20% less than DC).

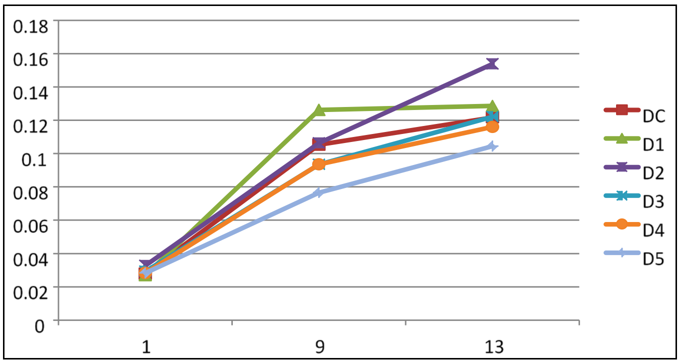

Fig 19: Average gross weight in gram Vs experimental days in T. foenum-graecum species.

Fig. 19 depicts the line graphs of average gross weight per seed were plotted against experimental days. On first day it was insured that all the experimental variants have seeds with equal average gross weight. On 12th day of experiment maximum gross weight was observed in D2 (26% more than DC), followed by D1. The gross weight in control was followed by D3 and D4. The lowest average gross weight was observed in case of D5 (14% less than DC).

Fig 20: The growth of plants on 13th day in Vigna radiate variants Placed in order from left to right: AC, A1, A2, A3, A4, A5.

Fig 21: The growth of plants on 13th day in Vigna aconitifolia variants placed in order from left to right: BC, B1, B2, B3, B4, B5.

Fig 22: The growth of plants on 13th day in Abelmoschus esculentus variants placed in order from left to right: CC, C1, C2, C3, C4, C5.

Fig 23: The growth of plants on 13th day in fenugreek variants placed in order from left to right: DC, D1, D2, D3, D4, D5.

Conclusion

Effect of Y Hexaferrite: Rate of germination and maximum germination % was not affected by Y hexaferrite. Root length was not affected in case of Vigna radiate, and fenugreek but leaded to reduction in root length in case of vigna aconitifolia and okra by 68% and 15% respectively. Shoot length was not affected in case of vigna radiate, increased in case of fenugreek and okra by 15% and 39% respectively, decreased in case of vigna aconitifolia by 26%. Biomass production was not affected in case of vigna radiate and fenugreek. Increased by 19% in case of okra and decreased by 17% in case of vigna aconitifolia.

Effect of Spinal Ferrite: Rate of germination and maximum germination % was not affected by Spinal ferrite. Root length was not affected in case of vigna radiate and okra. Increased by 62% and decreased by 68% in case of fenugreek and vigna aconitifolia respectively. Shoot length was not considerably affected in case of vigna radiate but reduced in case of vigna aconitifolia by 59.25%, increased in case okra and fenugreek by 21% and 12% respectively. Biomass production was not considerably affected in case of vigna radiate and okra but increased in case of vigna aconitifolia and fenugreek by 22% and 26% respectively.

Effect of Z Hexaferrite: Rate of germination and germination % was not considerably affected in all cases. Root length was not considerably affected in case of vigna radiate and fenugreek but reduced by 68% and 24% in case of vigna aconitifolia and okra. Shoot length was not considerably affected in case of vigna radiate, but reduced in case of vigna aconitifolia, okra and fenugreek by 40%, 13% and 10% respectively. Biomass produced was not considerably affected in case of vigna radiate, okra and fenugreek but increased by 15% in case of vigna aconitifolia.

Effect of M Hexaferrite: Rate of germination and germination % was not considerably affected in all cases. Root length was not considerably affected in case of fenugreek. It decreased in case of vigna radiate, vigna aconitifolia and okra by 50%, 75% and 44.82% respectively. Shoot length was decreased in vigna radiate, vigna aconitifolia, okra and fenugreek by 57%, 40%, 25% and 20% respectively. Biomass production was not much affected in case of okra and fenugreek, reduced in vigna radiate and vigna aconitifolia by 11% and 12% respectively.

Effect of W Hexaferrite: Rate of germination and germination % was not considerably affected in all cases. Root length was not considerably affected in case of vigna radiate, but reduced in vigna aconitifolia, okra and fenugreek by 80%, 43.79% and 58.25% respectively. Shoot length was not considerably affected in vigna radiate and okra. It reduced by 52% and 17% in case of vigna aconitifolia and fenugreek. Biomass production was not considerably affected in case of vigna radiate and okra. It reduced by 60% and 40% in case of vigna aconitifolia and fenugreek respectively.

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