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Effect of Potassium Silicate, Vermicompost and Urea on Seven Growth Parameters in *Abelmoschus esculentus*

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Abstract The aim of this study was to evaluate the effect of urea, potassium silicate, vermicompost and a combination of all three on seven growth parameters in the common lady's finger plant- *Abelmoschus esculentus.* Uniform sized and healthy 8 days old saplings of *A. esculentus,* raised from seeds were planted in pots containing about 2 kg of red soil each. These pots were grouped into 4 experimental groups namely E1, E2, E3, E4 and a control E0 comprising of six plants per group. On day 10, 1% urea (E1), 1% potassium silicate (E2), 1% vermicompost (E3), 1% a combination of all three (urea, potassium silicate and vermicompost as E4) were added to the respective pots in each group E1, E2, E3 and E4. In the control E0 only red soil was used. The 5 groups of plants were watered and maintained till day 50. The various growth parameters namely, number of leaves, leaf length, leaf width, shoot height, shoot circumference, number of flower buds and number of fruits in each of the 5 groups were assessed on day 50. The results were statistically analysed by one-way ANOVA. Potassium silicate was found to be most effective and produced maximum impact on all the seven parameters studied, followed by vermicompost, a combination of all three fertilizers and urea. The plants used in the experimental groups for this study were resistant and did not show any mealy bug infestation, while the infestation was observed in the control group. The study recommends potassium silicate and vermicompost as amendments that facilitate better plant growth comparatively.

Keywords Vermicompost, Potassium Silicate, Urea, *A. esculentus*

1. Introduction

Fertilizers are used to develop the fertility of soil so that it can support maximum cultivation which constitutes the most, used by farmers to pledge plant nutrient into their soil, so that enough nutrients are convenient to provide the crop. Soil fertility is slowly reducing due to the utilization of synthetic fertilizers. In order to control this, organic wastes and bio-fertilizers are applied to cope with the nutrient inadequacy of crops. Several efforts are being implemented to combat the unfavorable penalty of chemical farming.

Indiscriminate use of chemical fertilizers has led to a degradation in the quality of agricultural lands and hence safe and alternate form of plant augments has become inevitable need of the day. Many researchers have insisted on the need for fertilizers which would enhance plant growth and at the same time induce resistance to infestations [1,2].

Silicon is the second richest element in the earth's crust, and it is rich in most soils. The soluble silica concentration in soil ranges from 30 mg to 40 mg. Research works on the usefulness and effectiveness of silicon in plant growth and disease prevention have been well documented [3,4,5]. Guntzer et al., [6] have shown that application of silicon protects plants against a broad range of pathogens. The

ability of silicon to reduce the severity of fungal diseases in many plants has also been well documented [2,7].

Organic waste can be degraded and stabilized biologically, through vermicomposting process that uses earthworms and microorganisms to form vermicompost. Earthworms fragment the organic waste substrates, stimulate microbial activity greatly and increase rates of mineralization [8].

Urea, a synthetic organic fertilizer manufactured from inorganic materials, has been proved efficient in the development of stems and leaves in plants, increasing disease resistance and hardiness, strengthens the cell walls, and has the ability to cause grass to stand up and reduce lodging. It is also capable of affecting water intake by plant cells [9]. Hence a comparative analysis of the effect of potassium silicate, vermicompost and urea on seven growth parameters in *A. esculentus* (lady's finger) was attempted in this study.

2. Material and Methods

Abelmoschus esculentus, the common lady's finger- a flowering plant in the mallow family was used in this study. The plant is valued for its edible green seed pods. Red soil was used for the study. Seeds of *A.esculentus* were purchased from Vanoli Ulzhavar Sevai Sangam, Tiruchirappalli. The seeds were soaked in water overnight and then sown in pots, watered and grown to raise about 100 saplings. Healthy, uniform sized saplings were chosen, and then transferred to earthenware pots (40×30 cm) on day 8, which contained about 2 kg of red soil. On day 10, five experimental groups were designed, each having 6 pots with red soil and 1 sapling planted in it. Four plant augments were chosen for this study namely, 1% urea (E1), 1% potassium silicate- K_2SiO_3 (E2), 1% vermicompost–VC (E3) and a combination of all three –E4 (urea+ potassium silicate + vermicompost) in 1:1:1 ratio, while group E0 served as the control with red soil only. These plants were watered daily in the morning and placed in the green house at Holy Cross College for 40 days until day 50.

The various growth parameters in each plant in the five groups were evaluated on day 50. The number of leaves, leaf length (cm), leaf width (cm), shoot height (cm), shoot circumference (cm), number of flower buds and fruits in each of the 6 plants in E0 (control), E1 (urea), E2 (K_2SiO_3), E3 (VC), E4 (a combination of all three) were counted by direct observation, and represented as mean ± SD for each.

Statistical analysis: The results of the above parameters were further analysed using statistical tool SPSS 17.0 version. One Way Analysis of Variations was used and data exhibiting significant variation was further subjected to Duncan's Post Hoc Multiple Comparison test to test the homogeneity in the growth parameters as an outcome of the application of the chosen plant augments.

3. Result & Discussion

Urea, vermicompost, potassium silicate and a combination of all three were chosen to study the impact of the same on 7 growth parameters in *A.esculentus*. Many authors have shown that fertilizers like urea [9], vermicompost [10] produce marked effect on the growth parameters in plants. Plate 1 represents a photographic image of the *A.esculentus* treated with the four applications and control on day 10 & 50. The control had an infestation with mealy bugs. The results of the study clearly indicated a marked difference on the efficacy of the tested fertilizers on the growth of lady's finger plant.

The number of leaves in *A. esculentus* saplings on day 10 prior to application of fertilizers was found to be 4.00 ±0.00 in all the four groups and as well as in the control (Table 1). The plants were applied with the four combinations of fertilizers on day 10 and were maintained for 40 days. The analysis of the count of the leaves in the different experimental groups namely, potassium silicate, urea, vermicompost, a combination of all three on day 50 were 22.67±0.58, 12.67±0.58, 16.33±0.58, 13.33±0.58 respectively. Whereas the number of leaves in the control group was 9.67±0.58 (Table 2).

The results of one-way analysis of variance depicted in Table 3 revealed a significant variation ($p < 0.05$) in the number of leaves on exposure to the various fertilizers. These results were further subjected to Duncan's Post Hoc Multiple Comparison test for homogeneity which segregated the five groups into 4 subsets. Urea and a combination of all three fertilizers were similar in their impact on leaf number and hence placed together as a subset. Plants applied with vermicompost and that of K_2SiO_3 were placed as a unique subset exhibiting maximal activity. The protective role of K_2SiO_3 observed in this study was also reported on the leaves of bitter gourd [11,12].

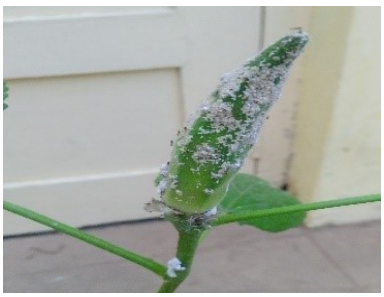
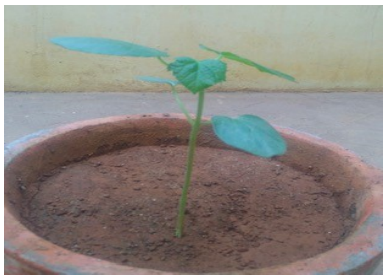
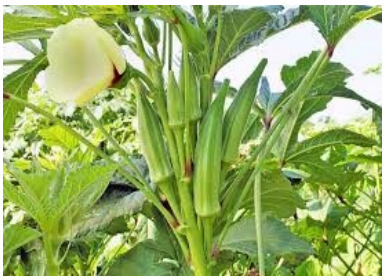
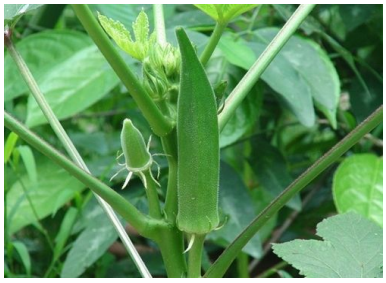
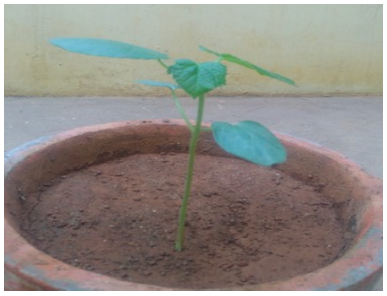
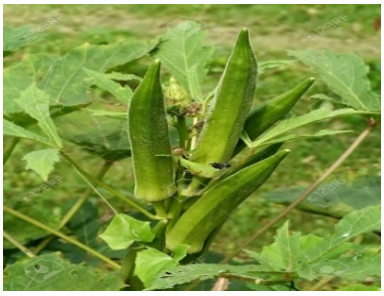
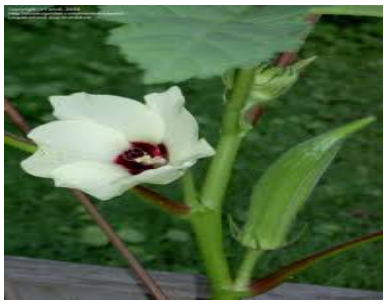
10^{th} Day	50^{th} Day
Control 	**Control** 
K_2SiO_2 	**K_2SiO_2** 
Urea 	**Urea** 
Vermicompost 	**Vermicompost** 
K_2SiO_2+ Urea+ VC 	**K_2SiO_2+ Urea+ VC** 

Plate 1. Photographic image of the different experimental groups of *A. esculentus* on day 10 and 50

The length of the leaf [cm] of *A. esculentus* plant treated with different fertilizers was found to be maximum for the group treated with potassium silicate with 13.83±0.06. On the contrary minimal leaf length was reported in the group treated with urea with 9.53±0.12. The leaf length in group treated with a combination of all three fertilizers and vermicompost was found to be 11.47±0.12 and 11.43±0.06 respectively. It is interesting to note that leaf length in the control group was very less with 6.83±0.06 (Table 2). One-way analysis of variance (Table 3) showed significant variance ($p<0.05$) in the length of the leaf. Duncan's Post Hoc Multiple Comparison test for homogeneity showed that plants applied with vermicompost and a combination of all three fertilizers, had similarity in their effect on leaf length hence were placed under one subset. Whereas group treated with K_2SiO_3 were expressed as unique subsets with maximum efficacy for K_2SiO_3 and minimal for urea. Increased plant growth in Si applied strawberry were well documented [13] and suggested, enhanced tissue elasticity and symplastic water volume associated with cell expansion and plant growth. Many researchers insist on the need for Si amendments in temperate as well as tropical crop production systems for increased productivity and sustainable production [14].

The leaf width (cm) in *A. esculentus* plants that were supplemented with the chosen fertilizers was found to be minimum with 9.37±0.06 for the group treated with urea. The maximum leaf width [cm] were expressed in the group treated with potassium silicate fertilizer 13.80±0.10 and the plants treated with a combination of all three fertilizers and vermicompost were found to be 11.10±0.17 and 11.17±0.06 respectively. While that of control was 6.63±0.06 (Table 2). These results were statistically analysed by one-way analysis of variance (Table 3) and the impact of the chosen fertilizers on leaf width was found to be significant. Further, Duncan's Post Hoc Multiple Comparison test for homogeneity revealed, K_2SiO_3 to be unique and formed a separate subset with maximum efficiency. Whereas, vermicompost and a combination of all three fertilizers were similar in their effects, while urea was found to exhibit minimal impact and thus formed a separate subset. The impact of potassium silicate in strawberry was credited to an increase in chlorophyll content and hence plant growth [15], while increase in the quantity of mobile phosphate was associated with leaf growth [16].

Table 1. Table on the seven growth parameter in *A.esculentus* on day 10, prior to the application of the tested fertilizers

Growth Parameters	Control	K_2SiO_3	Urea	Vermicompost	Combination of all three
No of leaf [no]	4.00 ±0.00	4.00 ±0.00	4.00 ±0.00	4.00 ±0.00	4.00 ±0.00
Leaf length [cm]	5.07 ±0.06	5.07 ±0.06	5.07 ±0.06	5.07 ±0.06	5.07 ±0.06
Leaf width [cm]	5.17 ±0.12	5.17 ±0.12	5.17 ±0.12	5.17 ±0.12	5.17 ±0.12
Shoot height [cm]	17.13 ±0.15	17.13 ±0.15	17.13 ±0.15	17.13 ±0.15	17.13 ±0.15
Shoot circumference [cm]	0.47 ±0.06	0.47 ±0.06	0.47 ±0.06	0.47 ±0.06	0.47 ±0.06
No of flower buds	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00
No of fruits	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00	0.00 ±0.00

Table 2. The impact of the chosen soil fertilizers on the seven growth parameters in *A.esculentus* on day 50 [day 30 for flower buds alone]

Growth Parameters	Control	K_2SiO_3	Urea	Vermicompost	Combination of all three
No of leaf [no]	9.67±0.58	22.67±0.58	12.67±0.58	16.33±0.58	13.33±0.58
Leaf length [cm]	6.83±0.06	13.83±0.06	9.53±0.12	11.43±0.06	11.47±0.12
Leaf width [cm]	6.63±0.06	13.80±0.10	9.37±0.06	11.17±0.06	11.10±0.17
Shoot height [cm]	40.03±0.21	85.00±0.10	61.37±0.15	72.17±0.25	67.60±0.26
Shoot circumference [cm]	1.10±0.10	3.77±0.06	2.03±0.06	2.63±0.21	2.87±0.15
No of flower buds [no] [day 30]	3.33±0.58	12.00±1.00	4.67±0.58	7.33±1.15	7.67±0.58
No of fruits [no]	2.67±0.58	5.33±0.58	2.00±0.00	2.67±0.58	2.67±0.58

Table 3. One way analysis of variance carried out to study the impact of the chosen fertilizers on the seven growth parameters of *A.esculentus*

Parameters		Sum of Squares	Df	Mean Square	F	Sig.
No. of Leaves [no]	Between Groups	291.600	4	72.900	218.700	.000
	Within Groups	3.333	10	.333		
	Total	294.933	14			
Leaf length [cm]	Between Groups	81.671	4	20.418	2784.227	.000
	Within Groups	.073	10	.007		
	Total	14				
Leaf width [cm]	Between Groups	83.677	4	20.919	2091.933	.000
	Within Groups	.100	10	.010		
	Total	83.777	14			
Shoot height [cm]	Between Groups	3283.153	4	820.788	19542.579	.000
	Within Groups	.420	10	.042		
	Total	3283.573	14			
Shoot circumference [cm]	Between Groups	11.797	4	2.949	176.960	.000
	Within Groups	.167	10	.017		
	Total	11.964	14			
No of flower buds [no]	Between Groups	133.333	4	33.333	50.000	.000
	Within Groups	6.667	10	.667		
	Total	140.000	14			
No of fruits [no]	Between Groups	18.400	4	4.600	13.800	.000
	Within Groups	3.333	10	.333		
	Total	21.733	14			

The shoot height of the *A. esculentus* treated with the different fertilizers namely potassium silicate, urea, vermicompost and a combination of all the three showed a mean height of shoot (cm) of 85.00±0.10, 61.37±0.15, 72.17±0.25 and 67.60±0.26 respectively (Table 2). ($p<0.05$) Significant variation (Table 3) was revealed in the results of one-way analysis of variance. Duncan's Post Hoc Multiple Comparison test for homogeneity grouped the treatments into four subsets of unique activity with no similarity in effect.

Impact of potassium silicate, urea, vermicompost and a combination of all the three on the circumference of shoot (cm) in lady's finger plant revealed 3.77±0.06, 2.03±0.06, 2.63±0.21 and 2.87±0.15 respectively (Table 2). The result of one-way analysis of variance showed significant variation ($p<0.05$) among the 4 tested applications (Table 3). Duncan's Post Hoc Multiple Comparison test for homogeneity depicted 3 subsets. Vermicompost and a combination of all three fertilizers were placed in one subset of similar activity. Potassium silicate represented a maximum impact and was placed in a separate subset. Whereas urea was found to have minimal effect and placed as a separate subset. Many researches have showed that high uptake of silica, improved drought resistance, increased resistance to fungi and other pathogens so as to improve plant growth rate and yield [17,18,19]. Researchers have also reported side effects to be attributed with high uptake of silica. Silica amendments could contribute to the neutralization of soil toxicities probably due to high levels of soluble Mn_2^+, Fe_2^+ and AI_3^+ [20]. Many have insisted on the role of phytohormones on growth in plants as well [21,22].

The mean number of flower buds on day 30 in *A. esculentus* plants, supplemented with the chosen fertilizers

namely potassium silicate, urea, vermicompost and a combination of all the three was found to be 12.00±1.00, 4.67±0.58, 7.33±1.15, 7.67±0.58 respectively. Whereas the number of flower buds of controlled plants was 3.33±0.58 (Table 2). The results (Table 3) of one-way analysis of variance of flower buds were found to be significant ($p<0.05$). Duncan's Post Hoc Multiple Comparison test for homogeneity revealed 3 subsets. Urea with least impact formed first subset. Vermicompost and a combination of all three fertilizers had a similar effect and hence were placed in one subset. Whereas third subset represented potassium silicate, it exhibited maximum efficiency and hence formed a subset. Vermicompost is reported to induce sustainability in improvement of horticulture, agriculture production, soil nutrient improvement and enhance plant growth [23]. Urea affects water intake by plants cells and plants with inadequate potassium may wilt in the presence of ample moisture. Hence the positive effects of urea could be related to that of the development of stems and leaves, increase disease resistance and hardiness [24].

The mean number of fruits produced by the different groups of *A. esculentus* supplemented with potassium silicate, urea, vermicompost and a combination of all the three were found to be 5.33±0.58, 2.00±0.00, 2.67±0.58 and 2.67±0.58 and the mean of controlled group plant was 2.67±0.58 (Table 2). Table 3 depicts results of the one-way analysis of variance test and it is evident that the number of fruits produced by different groups of fertilizers is significant ($p<0.05$). Duncan's Post Hoc Multiple Comparison test for homogeneity revealed 2 subsets of similar effect. Groups treated with urea, vermicompost and a combination of all three fertilizers were placed in the one subset, while that of potassium silicate formed a 2nd subset of maximal activity. Useful effects of silicon on plant growth and disease prevention and its help in growth of the plants have also been reported [3,4,5]. Researchers have reported that vermicompost can increase soil organic carbon, nitrates, phosphates, exchangeable calcium and some other nutrients for plants. Urea is considered to be less corrosive than other nitrogen fertilizers and hence suitable as a carrier for several herbicides [9].

It is interesting to note a similarity in the resistance to diseases and hence enhanced plant growth as reported earlier [25]. They have reported plant growth and reduced damage caused by wilt disease in cucumber plants applied with SiO_2 for a 3 years period. Few authors have demonstrated the impact of silicate on the development and growth of hydroponic cucumbers and prevention of powdery mildew [*Sphaerotheca fuliginea*] [26]. Similarly, in this study it was interesting to observe that plants on which fertilizers were applied were resistant to an infestation when compared to the control which was severely affected. Application of silicates has shown to reduce the severity of fungal diseases in many plants [2, 7]. Therefore, potassium silicate, urea, vermicompost and a combination of all three fertilizers could also be attributed to resistance.

4. Conclusions

The effect of potassium silicate, vermicompost, urea and a combination of all three, on seven growth parameters in the common lady's finger plant- *Abelmoschus esculentus* was assessed in this study. 8 days old saplings of *A. esculentus,* raised from seeds were planted in pots, grouped in 4 experimental groups namely E1, E2, E3, E4 and a control E0 comprising of six plants per group. On day 10, 1% urea (E1), 1% potassium silicate (E2), 1% vermicompost (E3), 1% a combination of all three (urea, potassium silicate and vermicompost as E4) were added to the respective pots in each experimental group E1, E2, E3 and E4. In the control E0 only red soil was used. The 5 groups of plants were watered and maintained till day 50. The growth parameters (number of leaves, leaf length, leaf width, shoot height, shoot circumference, number of flower buds and number of fruits) in each plant in all the groups were assessed on day 50. The results were statistically analysed by one-way ANOVA. Potassium silicate was found to be most effective and produced maximum impact on all the seven parameters (number of leaves- 22.67±0.58, leaf length- 13.83 ±0.06, leaf width- 13.80±0.10, shoot height- 85.00±0.10, shoot circumference- 3.77±0.06, number of flower buds- 12.00±1.00 and number of fruits- 5.33±0.58). This was followed by vermicompost, a combination of all three fertilizers and urea. The study hence recommends potassium silicate and vermicompost as amendments that facilitate better plant growth comparatively.

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Conflict of Interest

The authors declare no conflicts of interest.

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