Studies on the Effect of Growth Regulators on Pollen Germination and Tube Growth in 'Shoe Flower'

(Hibiscus Rosa-sinensis L.)

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Introduction

With the advancement of the understanding of various vital phenomena of plant life the importance of plant growth regulators came to be emphasised more and more. The close of the first quarter of the twentieth century ushered in an era of extensive research on growth regulators from various stand points—biophysical, biochemical and biological. But their application to the broader fields of economic importance started on a large scale only after the discovery that they could be synthesised in the laboratory.

Growth regulators find varied applications in plant sciences and agriculture. Among the more important of these, are early rooting of cuttings, prevention of preharvest drop of fruits, increase in fruit set and production of seedless fruits. Prolongation of dormancy in nursery stock, delaying blossoming in fruit trees, improvement in regulation of flowering in pine-apple are some other effects Besides these, growth regulators are being used for thinning of fruit, hastening of fruit maturity, reducing water loss in vegetables and destruction of weeds and undesirable woody plants. Recent studies by many investigators have shown that they may affect pollen germination and pollen tube growth also.

'Shoe-flower' (*Hibiscus Rosa-sinensis* Linn. and *H Schizopetalus* Hook) is a common horticultural plant belonging to the natural order Malvaceae. Most of the varieties are non-seed-setting. Though a few produce seeds, the plants are usually propagated vegetatively The non-seed-setting nature of many varieties may be due to the failure of either pollen germination on the stigma or pollen tube growth in the style,

The present investigation aims at studying the effect of growth regulators like gibberellic acid, 3-indoleacetic acid and 2, 4-Dichlorophenoxy acetic acid on pollen tube growth 'in-vitro'.

1. Post-Graduate student. Part II of the Thesis submitted to the University of Kerala for the award of the M. Sc. (Agri) Degree, 1963. Published by kind permission of the University of Kerala, Trivandrum.

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Review of Literature

Zeigler and Brancheidt (1927) observed an increase in the percentage of pollen germination and pollen tube growth when stigma of a variety of grape was added to the sucrose solution in which pollen of the same variety was cultured. Golubinski (1950) was successful in enhancing the percentage of germination of pollen grains and growth of pollen tubes in apple, pear, cherry and blackcurrant by adding stigmas, petals or whole flowers to the sucrose solution. Pollen germination in this case was found to be stimulated by aromatic substances secreted by floral organs.

/• *General effects ofgrowth substances*

Smith (1939) recorded the effect of 3-IAA on pollen germination and reported that it increased the percentage of germination and rate of tube elongation. Cooper (1939) obtained high pollen germination in *Carica papaya* with lactoflavin and ascorbic acid. Thiamin chloride, nicotinic acd, IAA and hydrochlorides of several amino acids were also foundto influence pollen germination. Loo Tsung Le and Hwang Tsung Chen (1944) observed stimulation of pollen germination and pollen tube elongation by manganese sulphate, indole 3-acetic acid and colchicine. Raghavan and Baruah (1965) studied the germination of pollen grains of arecanut and growth of pollen tubes under the influence of certain auxins, vitamins and trace elements. Arecanut pollen grains were cultured in sucrose medium to which various doses of four auxins, three vitamins and seven trace elements had been added. It was found that pollen germination and tube growth were stimulated to a considerable extent by boric acid, ascorbic acid and auric chloride. These results indicate that growth substances promote pollen germination and pollen tube growth.

Singh (I960) investigated the effects of IAA, ABA, IPA, NAA, 2, 4 D, 2, 4, 5-T, borax, boric acid, GA and colchicine on pollen germination and pollen tube growth of mango. Of these 20 ppm boric acid and borax gave the best results. It was followed by 10 ppm boric acid, IBA and 20 ppm NAA. The remaining ones failed to increase pollen germination and tube elongation. 2, 4, 5-T, 2, 4-D, IPA, IAA, colchicine and GA were toxic and gave lower pollen germination than the control. Bose (1960) found that 3-IAA, kinetin and boric acid at concentrations ranging from 0.05 to 250 mg/l (ppm) did not promote pollen germination in *Pisum sativum*.

2. *Effect of Gibberellic acid*

Lawrence Rappaport and Singh (1961) reported gibberellin enhances pollen germination and tube elongation in a number of species and inhibits them in many others. Chandler (1957) working with the pollen of 27 plants, representing 16 different families, using different concentrations of GA showed that GA may stimulate, not affect or inhibit, pollen germination, as well as tube elongation, but there was a marked stimulation in pollen germination and tube growth in the pollen of 10 plants only. Inhibition of tube growth was recorded in 10 plants, while there was no effect on the rest of the plants.

Weaver and McCune (1960) in their studies with GA on *Vitis vinifera*foundthat pollen germinability was markedly decreased by KGA-3 solutions at 1-25 ppm.

Kato (1955) obtained in the pollen of *Lilium longifolium* increased growth of the pollen tube, five times more than that of the control, by the addition of 50 mg/l (ppm) of GA to the culture medium. But concentrations 100-200 mg/1 (ppm) inhibited tube growth.

Bose (1959) studied the effect of GA on the growth of pollen tubes of *Pisum sativum*. He found that GA did not affect pollen germination. Tube length was increased seven times that of the control at 0.05 mg/1 (ppm). But at higher concentrations GA had less effects. Higher concentrations also caused broadening of tube tips and bursting of the grains. Singh and Randhawa (1961) found that GA at concentrations 15 to 60 ppm decreased pollen germination in two varieties of 'mandarin orange'. But there was a marked increase in tube length at 60 ppm. Madhava Rao and Abdul Khader (1962) observed in the pollen of sapota that both germination and tube growth were promoted by the addition of GA upto 100 ppm. The increase in the percentage of germination and length of pollen tube at 100 ppm GA was nearly four and three times respectively over the control. Concentrations higher than 100 ppm seemed to have an inhibitory effect.

3. Differential action

Addicot (1943) studied the effect of 33 pure growth substances on the germination of pollen and the growth of pollen tubes on tropaeolum and milla. Of these, only 16 substances were found to be effective. Further it was observed that among these 16 substances some increased pollen germination, whereas others promoted tube elongation. His results reveal that germination and tube growth are at least in part physiologically independent of each other. Thompson and Batjer (1950) studied the effect of boron, NAA, 2,4-D and B-napthoxy-acetic acid on the pollen of many deciduous fruit trees. Boron in low concentrations, viz., 2.5 to 40 ppm stimulated pollen germination and tube growth but higher concentrations had the reverse effect. 10 ppm NAA, 2, 4-D, B-naphthoxy-acetic acid and 3-IAA had some effects only. Thus different substances differed in their specific effects.

Konar's (1958) results also give evidence to this fact. In his studies on the effect of IAA and kinetin on the pollen of *Pinus roxburghii*, IAA showed both increased percentage of germination and higher rate of tube elongation, whereas kinetin promoted tube elongation only.

4. Mode of action

Dikshit (1956) in his studies on the effect of hormones on loquet pollen found that NAA at 5 ppm induced rapid germination in 68 minutes, but later its effect was sluggish. But maximum germination was obtained with 10 and 15 ppm of IAA where the increase was gradual.

J. *Concentrations*

Different concentrations of one and the same substance affected pollen germination and tube growth differently. Thompson and Batjer (1950) found that boron in low concentrations (2.5-40 ppm) stimulated pollen germination and tube growth significantly, but high concentrations had the reverse effect. 10 ppm NAA, 2, 4-D, B-naphthoxy-acetic acid and 3-IAA also had some effects on pollen germination. In loquent pollen Dikshit (1956) found that, though NAA (5 ppm) and IAA (10 and 15 ppm) increased the percentage of germination, increase in the concentration of either

of the growth regulators, lowered the percentage of germination and rate of tube elongation. Resnik (1958) studied the effect of 2, 4-D, thiamin, boric acid and IBA on pollen germination and tube growth in 'people orange'. Among the different concentrations used, better germination and tube growth were obtained in 150 ppm thiamin, 10-100 ppm boric acid and 50-150 ppm IBA. Bose (1959) found that 3-IAA, kinetin and boric acid at concentrations ranging from 0.05 to 250 mg/l (ppm) did not promote pollen germination in *Pisum sativum.* Singh (1960) studied the effect of IAA, IBA, IPA, NAA, 2, 4-D, 2, 4,5-T, boric acid and borax on the pollen of mango. Of these 20 ppm boric acid and borax gave the best results. It was followed by 10 ppm boric acid, IBA and 20 ppm NAA. The remaining ones failed to increase pollen germination and tube elongation.

6. *Effect of growth regulators on related varieties and species*

Growth substances may show more or less similar effect on the pollen of different varieties of the same species and also of closely related species. Resnik (1956) in his studies on the effect of growth substances on the pollen of citrus species obtained 10–15 % more germination with the pollen of Meyer lemon' on addition of 2, 4-D, thiamin, boric acid and IBA to the basic medium. In a later study Resnik (1958) got similar results with many other varieties and species of citrus. Singh and Randhawa (1961) found that in two varieties of 'mandarin orange' 16-60 ppm of GA decreased germination.

Materials and Methods

Four varieties of shoe flower were selected for this study. They were

1. Rose (V_1)
2. Australian single (V_2)
3. Sunset (V_3)
4. Schizopetalus (V_4)

The effect of three growth regulators at four levels was studied. The growth regulators selected for the trial were:

1. Gibberellic acid (GA)—(supplied by BDH)

2. 3-indole-acetic acid (IAA)—(L. Light & Co., Ltd., Colonbrook, England)

3. 2, 4-Dichlorophenoxy acetic acid 2, 4-D)—(supplied by BDH)

The concentrations taken for the study were the following :

Concentrations	GA (T_1)	3-IAA (T_2)	2, 4-D (T_3)
C_1	25 ppm	15 ppm	50 ppm
C_2	50 ppm	30 ppm	100 ppm
C_3	75 ppm	45 ppm	150 ppm
Co	Control		

The experiment was conducted adopting a randomised block design with 40 treatments and five replications.

4 Varieties —V_1, V_2, V_3 and V_4.
3 Growth regulators — T_1, T_2, and T_3
4 Concentrations —C_0, d, C_2, and C_3
Treatment combinations: 40.

$V_1 T_1 C_0$	$V_2 T_1 C_0$	$V_3 T_1 C_0$	$V_4 T_1 C_0$
$V_1 T_1 C_1$	$V_2 T_1 C_1$	$V_3 T_1 d$	$V_4 T_1 C_1$
$V_1 T_1 C_2$	$V_2 T_1 C_2$	$V_3 T_1 C_2$	$V_4 T_1 C_2$
$V_1 T_1 C_3$	$V_2 T_1 C_3$	$V_3 T_1 C_3$	$V_4 T_1 C_3$
$V_1 T_2 C_1$	$V_2 T_2 d$	$V_3 T_2 d$	$V_4 T_2 C_1$

$V_1 T_2 C_2$	$V_2 T_2 C_2$	$V_3 T_2 C_2$	$V_4 T_2 C_2$
$V_1 T_2 C_3$	$V_2 T_2 C_3$	$V_3 T_2 C_3$	$V_4 T_2 C_3$
$V_1 T_3 C_1$	$V_2 T_3 C_1$	$V_3 T_3 C_1$	$V_4 T_3 C_1$
$V_1 T_3 C_2$	$V_2 T_3 C_2$	$V_3 T_3 C_2$	$V_4 T_3 C_2$
$V_1 T_3 C_3$	$V_2 T_3 C_3$	$V_3 T_3 C_3$	$V_4 T_3 C_3$

Different concentrations of the growth regulators were made by dissolving the required quantity of the chemical in 2 ml of 95% alcohol and then diluting to get the desired concentrations. The different concentrations of growth regulators were added to the standardised basic medium.

The media containing different concentrations of growth regulators were taken in separate clean and sterile petridishes The area of each petridish was divided into four equal chambers by marking with a glass marking pencil on the underside of the petridish. The pollen grains of the four different varieties were carefully dusted separately into each of these chambers.

Observations were made as to pollen germination and tube growth after 1, 2, 4, 6, 8 and 24 hours from dusting. At each observation counts of the germinated and non-germinated grains were made. Observations were confined to normal full grains. For comparison of treatment effects, the observation at 24 hours after dusting was utilised, The percentage of germination at this stage was calculated, and the data were tabulated and analysed adopting the analysis of variance method. The tube lengths of ten grains at random were measured with a standardised ocular micrometer. Care was taken to see that the tube length of the same pollen grains was measured in each observation. This was achieved by further dividing each of the four chambers into smaller areas.

The observations at different stages of growth revealed that tube elongation was not appreciable between 8 and 24 hours. So the tube length measurements at 24 hours were utilised for comparison of treatment effects. The measurements were recorded in microns and the mean length of pollen tube in each treatment was calculated. The data were tabulated and subjected to analysis adopting the analysis of variance technique.

Results

The results obtained during the present investigation are furnished below.

A. Pollen germination

In all the treatments it was observed that the pollen grains started germination within 30 minutes of dusting. The rate of germination was highest during the first hour. After that only a few grains germinated. No more germination was observed after the fourth hour, so that the observations made after 4, 6, 8 and 24 hours to the percentage of germination were more or less the same. It is found that the various treatments are significantly different.

1. *Comparison of varietal means*

The four varieties were significantly different from one another in their percentage of germination. The mean percentage of germination was highest in rose followed by schizopetalus, sunset and australian single, (Plate-1).

2. *Comparison of growth regulators*

(a) Between GA, 3-IAA and 2,4-D.

There was no difference between GA and 3-IAA in their effects on pollen germina-

tion. But 2,4-D produced a significantly lower percentage of germination than the former two.

(b) GA, 3-IAA and 2,4-D against control.

It is seen that GA and 2, 4 I) produced a significantly lower percentage of germination than the control. So these substances can be said to inhibit pollen germination, But 3-IAA did not exhibit such an inhibitory effect.

3. Comparison of the effects of growth regulators in individual varieties

i) Variety Rose

The effects of GA and 3-IAA on pollen germination were not significantly different. But 2, 4-D produced a significantly lower germination than GA and IAA.

The effects of GA and 3-IAA are not significantly different from that of the control. But 2, 4 I) produced a significantly lower pollen germination than the control and so can be said to inhibit germination in the variety ' rose '.

ii) Australian single

The difference between the effects of GA and 3-IAA is not significant. But 2, 4-D was found to produce a significantly lower pollen germination than the control.

GA and 3-IAA did not produce a different effect from the control but 2, 4-D reduced the percentage of germination significantly.

Hi) Variety Sunset.

The effects of GA, 3-IAA and 2, 4-D are significantly different in this variety. The percentage of germination of pollen grains was maximum in 3-IAA followed by GA and 2, 4-D.

GA and 3-IAA did not produce any effect on germination of this variety. The mean percentage of germination was significantly lower in 2, 4-D than that of the control.

iv) Variety Schizopetalus

3-IAA and GA did not differ in their effects on pollen germination. But 2, 4-D produced a significantly lower percentage of germination than the other two growth regulators in this variety.

GA and 2, 4-D effectively reduced the percentage of pollen germination, whereas 3-IAA did not produce any such effect.

4. Comparison of the different concentrations of each growth regulator

The effects of various concentrations of GA, 3-IAA and 2, 4-D on pollen germination are found to differ significantly.

i) Concentrations of GA.

It is seen that GA at concentrations of 25 and 50 ppm did not produce any significant effect on pollen germination. But at 75 ppm. it gave a significantly lower percentage of germination, thereby suggesting that GA at higher concentrations reduce pollen germination.

ii) Concentrations of 3-IAA.

3-IAA at concentration of 15 ppm increased pollen germination and 45 ppm decreased it significantly. But at 30 ppm it had no effect.

iii) Concentrations of 2, 4-D,

2, 4-D was found to reduce pollen germinability in concentrations of 100 and 150 ppm. But at 50 ppm it did not produce any difference from the control. Thus 2, 4-D was found to reduce germination progressively at concentrations beyond 50 ppm.

B. Pollen Tube Elongation

Observations made after 1, 2 4, 6, 8 and 24 hours indicate that the rate of tube elongation was highest in all treatments during the first hour. Afterwards up to 8 hours there was an increase in tube length in all the varieties, but the rate of elongation during this period varied with variety and treatment. During the period from 8 to 24 hours there was no appreciable difference in the length of pollen tube. So the pollen tube length at 24 hour stage was taken as a standard for comparison of different treatments. The analysis of variance of the data reveals that the various treatments are significantly different in their effects.

i) Comparison of varietal means

The varietal means are significantly different. Highest lube length was met with in sunset followed by schizopetalus, rose and australian single.

ii) Comparison of growth regulators

The three growth regulators differed significantly in their effects on pollen tube elongation. The greatest tube length was produced by IAA and GA.

GA, 3-IAA and 2, 4-D produced significantly greater tube length than that of the control. So these substances can be said to promote pollen tube elongation.

Hi) Comparison of the effects of growth regulators in individual varieties

GA, 3-IAA and 2, 4-D differed significantly in their effects on the tube length in the variety rose. The greatest tube length was attained in 2, 4-D followed by 3-IAA and GA.

GA, 3-IAA and 2, 4-D produced significantly greater tube length than the control. These substances increased tube length significantly.

The effects of these substances on pollen tube elongation were significantly different in austrailan single. Maximum lengih was obtained in 2, 4-D followed by 3-IAA and GA.

All the three substances differed significantly in their effects on tube elongation in the variety sunset. 3-IAA produced the greatest tube length followed by 2, 4-D and GA. These substances produced greater tube length than the control

The growth regulators were found to be significantly different in their effects on tube elongation in schizopetalus. Maximum length was obtained in 3-IAA followed by ?, 4-D and GA and their effects were greater than the control.

4. Comparison of the effects of different concentrations of each growth regulator

It is evident that different concentrations of GA, 3-IAA and 2, 4-D differ significantly in their effects on pollen tube growth.

GA in all concentrations was found to increase tube length significantly. Maximum length was met with in 50 ppm followed by 25 ppm and 75 ppm.

The different concentrations of 3-IAA were found to differ significantly in their effects on pollen tube elongation. The highest length was met with in 15 ppm followed by 30 ppm and 45 ppm. Though higher concentrations may promote tube elongation, a progressive reduction in tube length is met with when the concentration is increased.

2, 4-D was also found to promote tube elongation at concentrations 50 and 100 ppm. Maximum was obtained in 100 ppm followed by 50 ppm. 150 ppm had ao effect on tube elongation. Thus

there is a progressive reduction in the effect from 100 ppm onwards.

Photographs showing pollen tube elongation due to the effect of 50 ppm GA, ppm 3-IAA and 100 ppm 2, 4-D in each variety are presented in Plates II-IV.

Discussion

A. Pollen germination

The rate of pollen germination is found to be the highest during the first hour in all the treatments. Since no pollen germinated after the fourth hour, it may be concluded that viable grains require only four hours or less for germination.

The results obtained in the present investigation indicate that GA and 2, 4-D inhibit pollen germination whereas 3-IAA does not produce any such effect. Thus only certain of the growth regulators are found to affect pollen germination. This result is comparable with the results obtained by Addicot (1943) and Thompson and Batjer (1950).

The four varieties differ significantly in the percentage of pollen germination. Highest percentage is obtained in **'rose'** followed by **'schizopetalus', 'sunset'** and australian single. This indicates that the four varieties show a differential response to the effect of growth regulators. The intervarietal difference in germinability observed is not due to a differential response of varieties to growth regulators, but may possibly be due to a difference in the viability of grains of these varieties. This does not indicate the possibility of a differential response of varieties to growth regulators. This is in agreement with the results of Resnik (1956, 1958) in citrus pollen.

When the varieties are taken individually it is seen that in none of the four varieties pollen germination is affected significantly by 3-IAA, but in all the varieties germination is inhibited by 2, 4-D. GA has no effect in rose, sunset and australian single, but inhibits germination in schizopetalus Thus 3-IAA and 2, 4-D are found to have similar effects on the four varieties, but GA produces dissimilar effects. These results are in agreement with the results of Singh (1960) in mango, Chandler (1956) and Rappaport and Singh (1961)

The different concentrations of growth regulators are found to differ in their effects. 3-IAA at 15 ppm is found to enhance germination, but 30 ppm has no effect and 45 ppm decreases germination. This is in agreement with the resu of Dikshit (1956).

It is seen that 2, 4-D at 50 ppm has no effect, whereas concentrations of 100 and 150 ppm reduce germination. The results obtained by Resnik (1958) and Singh (1960) are in agreement with the result obtained in this investigation.

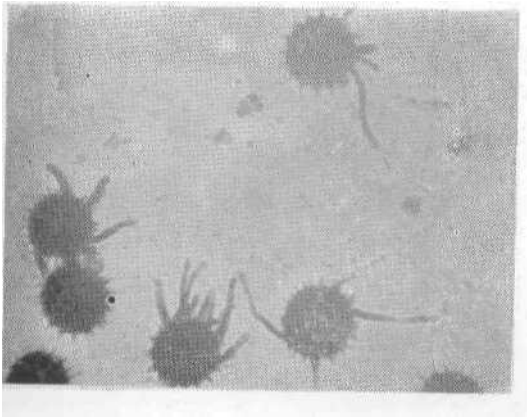
GA at 25 and 50 ppm does not produce any significant effect on germination whereas 75 ppm reduces pollen germination. Reports of Weaver and Mc Cune (1950), Singh and Randhawa (1961) and Madhava Rao and Abdul Khader (1962) reveal that the effect of GA in general, and of different concentrations in particular, is mostly dependent on the crop on which it is tried.

B. Pollen tube elongation

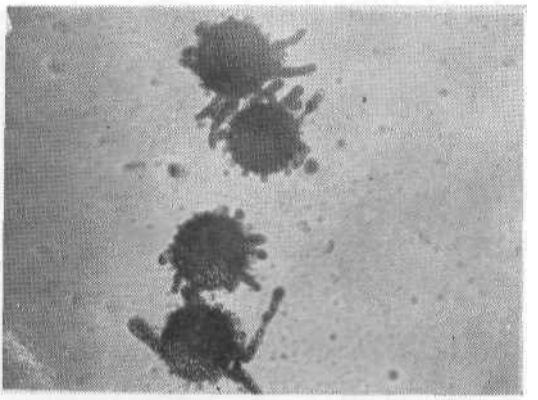
The rate of tube elongation is found to be highest during the first hour in all treatments. Upto eight hours there is a gradual

Plate I. Comparative study of pollen tube elongation of the four varieties of shoe flower in basic medium

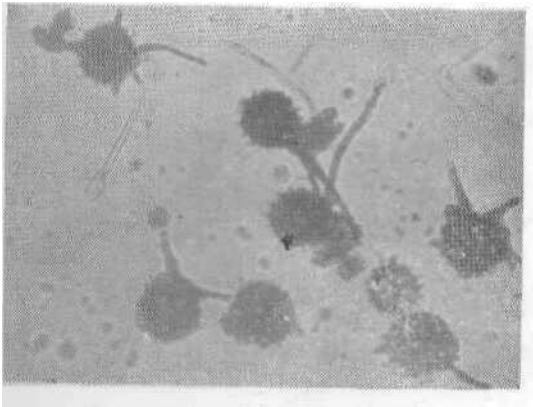
Variety ' rose '



Variety ' australian single '



Variety ' sunset '



Variety ' schizopetalus '

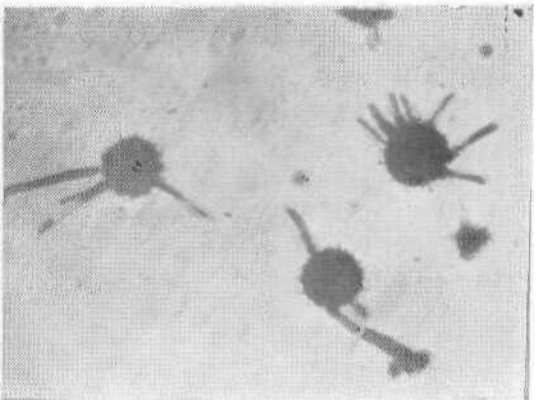
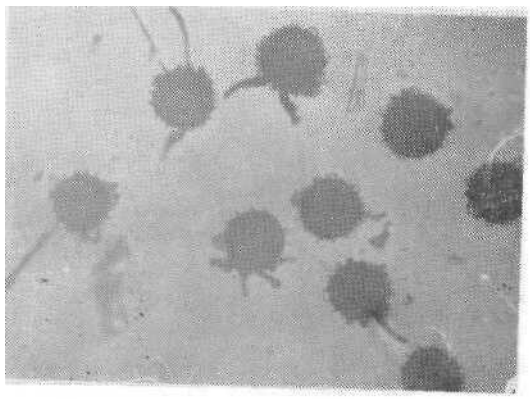
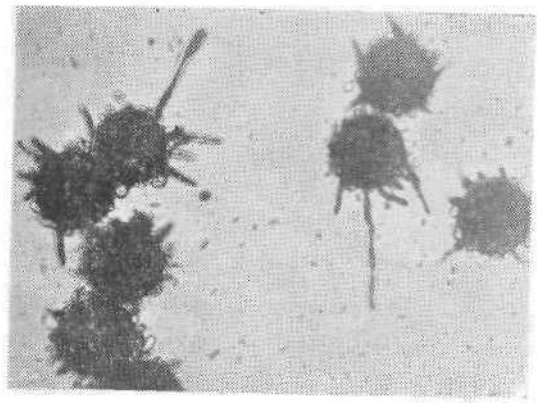


Plate II. Comparative study of pollen tube elongation of the four varieties of shoe flower in basic medium + 50 ppm. GA.

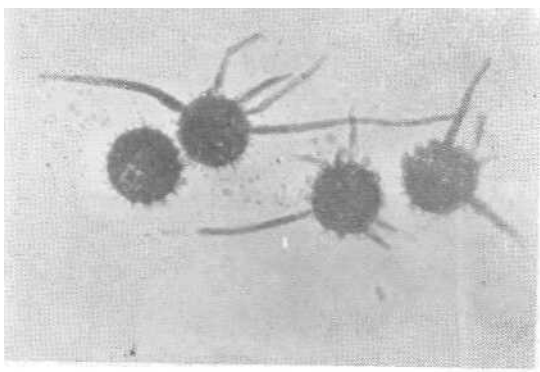
Variety 'rose'



Variety 'australian single'



Variety 'sunset'



Variety 'schizopetalus'

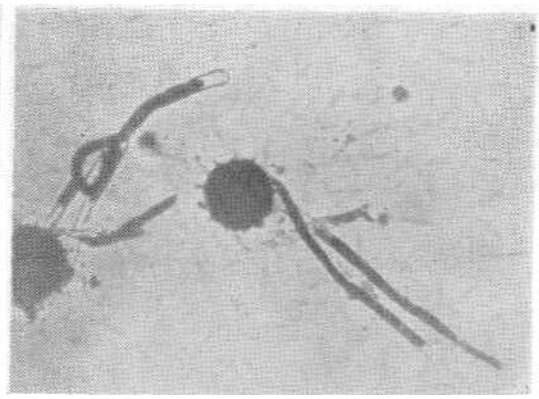
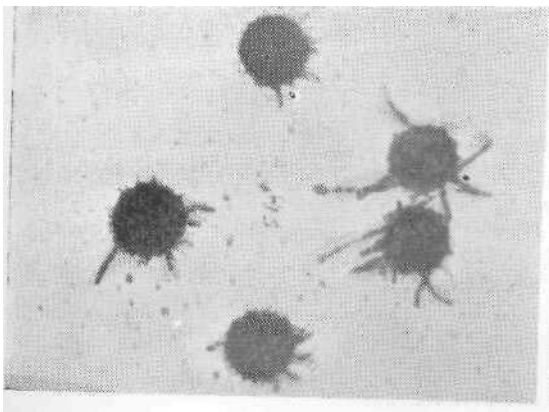
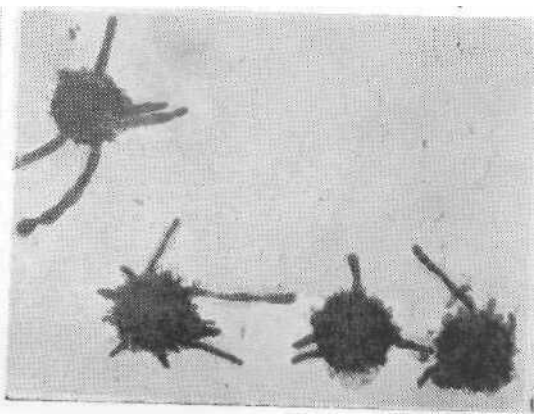


Plate III. Comparative study of pollen tube elongation of the four varieties of shoe flower in basic medium + 15 ppm. 3-IAA.

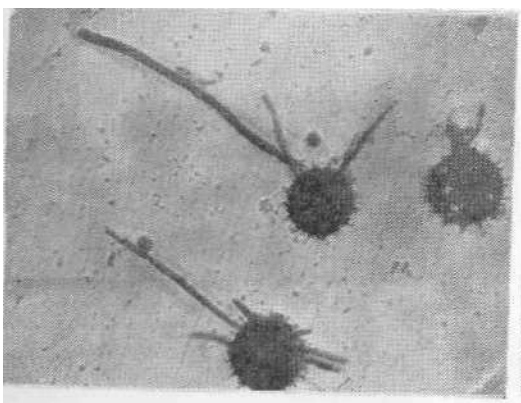
Variety ' rose



Varietry ' australian single '



Variety ' sunset '



Variety • schizopetalus '

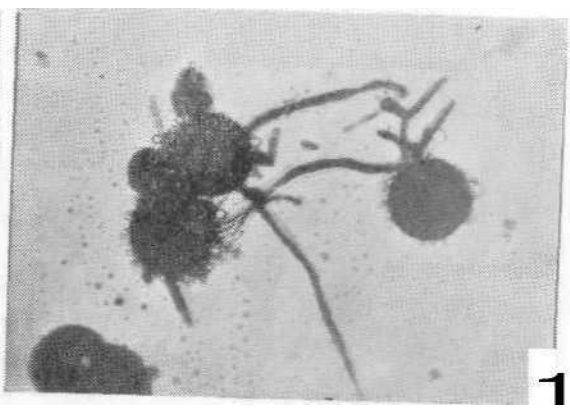
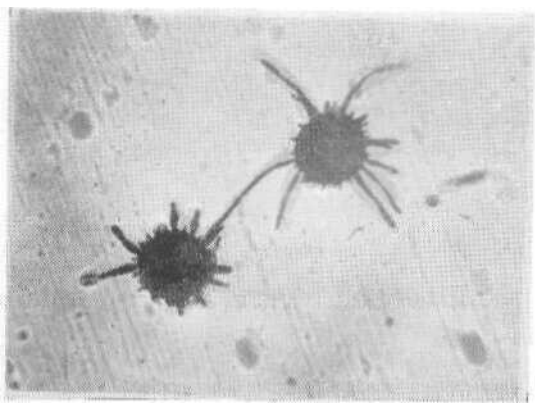
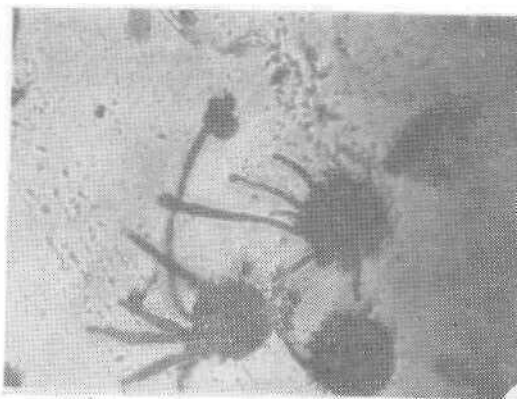


Plate IV. Comparative study of pollen tube elongation of the four varieties of shoe flower in basic medium + 100 ppm 2, 4—D.

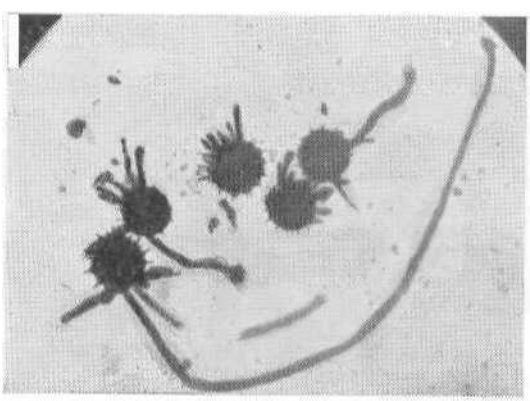
Variety ' rose '



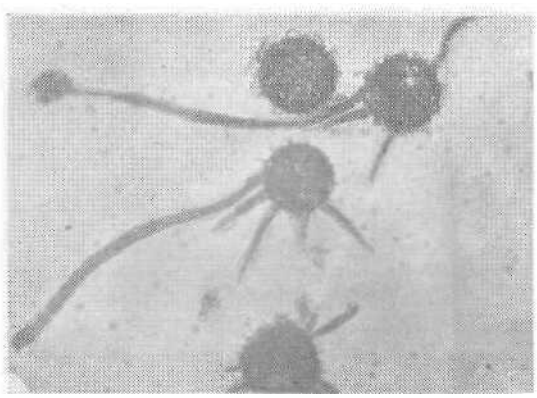
Variety ' australian single '



Variety 'sunsetj'



Variety ' schizopetalus '



increase in tube length, but beyond this stage, there is little or practically no tube elongation.

All the three growth regulators are found to promote pollen tube elongation. This is comparable with the results obtained by Smith (1939) and Loo Tsung I e and Hwang Tsung Chen (1944) in 3-IAA, Thompson and Batjer (1950) in 2, 4-D and Kato (1935) and Bose (1959) in GA. 2, *4* I > produces the greatest tube length followed by 3-IAA and GA.

The lengths of the pollen tubes are found to be significantly different in the four varieties studied. Maximum length is met with in sunset followed by schizopetalus, rose and australian single. seems that the varieties have a differential response to the effect of growth regulators. A comparison of the performance of the four varieties in the control treatment (basic medium alone) reveals a significant difference between the varieties in the length of pollen tubes. But the varietal means in these two comparisons are strikingly dissimilar which makes possible to suggest the operation of an additional effect apart from the inter-varietal difference. Thus the inter-varietal variation for tube length in the different varieties may not only be due to a difference in the length of pollen tubes but may also be due to a differential response of varieties to growth regulators.

A comparison of the effect of each of the three growth regulators in individual varieties reveals that in all the varieties pollen tube elengation is promoted by the three growth regulators. In all varieties 2,4-D and 3-IAA are superior to GA in their effect on tube elongation. But the relative effects of 2,4-D and 3-IAA differ in individual varieties. In rose and australian single, greatest tube length is obtained in 2,4-D followed by 3-IAA, whereas in sunset and schizopetalus highest tube length is in 3-IAA followed by 2,4-D.

Though all the three growth regulators promote tube elongation, different concentrations of these are found to differ in their effects. 2, 4-D at 50 and 100 ppm is found to increase the pollen tube length. But at 150 ppm it has no effect at all. This is in agreement with the result obtained by Resnik (1958) in ' people orange '.

It is found that 3-IAA, in all the concentrations (15, 30 and 45 ppm) is effective in increasing tube elongation. But maximum length *is* obtained at 15 ppm. This is in agreement with the results reported by Dikshit (1956) in loquet pollen.

GA at all concentrations is found to increase the tube length. Maximum tube elongation is obtained at 50 ppm. This is comparable with the results obtained by Kato (1955) in lilium. The results of work done by Singh and Randhawa (1961) and by Madhava Rao and Abdul Khader (1962) indicate that GA is most effective at 50 ppm and its effect on pollen tube elongation gets reduced at higher concentrations.

C. Comparison of the effects of growth regulators an pollen germination and tube elongation

A comparative study of the effects of the three growth regulators on germination and tube elongation reveal that they differ in their specific effects. It is found that 3-IAA which has no effect on pollen germination promotes tube elongation considerably in all the varieties, whereas GA and 2, 4-D reduce pollen germination, but promote tube elongation. These results are in

agreement with the views of Addicot (1943) that germination of pollen and tube elongation are at least in part physiologically independent.

The results obtained in the present investigation also reveal a differential effect of various concentrations of the growth regulators on pollen germination and tube elongation. This is in favour of the views expressed by previous workers. 3-IAA increases the percentage of germination and tube elongation at 15 ppm. A progressive reduction is met with, in both the percentage of germination and rate of tube elongation, at higher concentrations. The behaviour of different concentrations of 3-IAA on the pollen of ' shoe flower' is comparable to the results obtained by Dikshit (1956) on loquet pollen. At 30 ppm it ceases to have any effect on germination, but the effect on tube elongation persists even upto 45 ppm GA at 25 and 50 ppm has no effect on germination but promotes tube elongation. 75 ppm GA, though reduces the percentage of germination, is found to increase the tube length. 2, 4-D reduces pollen germinability at 100 ppm but enhances tube elongation. Though at 50 ppm there is no effect on germination of pollen grains it is found to promote tube elongation. At 150 ppm 2, 4-D inhibits germination, but has no effect on tube elongation. So 2, 4-D at lower concentrations may be considered to have no effect on pollen germination but promotes tube elongation and at higher concentrations inhibits germination and has no effect on tube elongation.

Summary and Conclusions

The results obtained in the present investigation indicate that GA and 2, 4-D inhibit pollen germination, whereas 3-IAA does not produce any such effect. Thus only two of the growth regulators are found to affect pollen germination. But all the three growth regulators promote pollen tube elongation.

A comparative study of the effect of growth regulators on pollen germination and pollen tube elongation reveal that germination of pollen grains and tube elongation are at least in part physiologically independent. The different concentrations of GA, 3-IAA and 2, 4-D are found to differ in their effects on pollen germination and tube elongation.

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