

**IMPROVEMENT OF OKRA (*Abelmoschus esculentus*)
GROWTH, YIELD AND QUALITY BY USING
PLANT GROWTH REGULATORS IN VIVO
AND IN VITRO CONDITIONS**

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**FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
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ABSTRACT

Studies were conducted to investigate the effects of plant growth regulators on okra growth, yield and quality development using different techniques of application in a commercial vegetable field in Banting, Selangor, Malaysia. The experimental design employed on the commercial field was a randomized complete block design (RCBD). The different growth hormones were applied directly, internally, to the selected parts of the okra plant. In the flower injection treatment, injection was applied on the okra flower using IAA at different concentrations. The pod set percentage, and length was maximal in the 25 mg/l IAA treatment compared to the control. Higher percentage of healthy seed per plant was also recorded using 25 mg/l IAA followed by control and 50 mg/l IAA. However, a high concentration of IAA (200 mg/l) inhibited seed production and brought about Stenospermocarpy which resulted in 100% aborted seeds. Total soluble solids (TSS) and vitamin C content in the pod markedly increased as a result of IAA application at all the different concentrations. The highest K^+ content was found in 25 mg/l IAA treated plants. In addition, the iron (Fe) content increased significantly in IAA treatments at all concentrations compared to the control.

The flower injection method using different NAA concentrations showed higher percentage of pod setting in the 25 mg/l NAA treatment compared to the higher NAA concentrations. Pod weight increased in 25; 50 and 100 mg/l NAA treatments compared to the control. Healthy seed percentage was maximal in 25 mg/l NAA treated flowers whereas 100 mg/l NAA treated flowers exhibited a lower percentage of healthy seeds, but a higher percentage of aborted seeds. Using different GA_3 concentrations, the highest pod setting (100%) was

obtained at 100 mg/l GA₃. GA₃ at 50, 100 and 200 mg/l produced a higher percentage of healthy seeds per pod than 25 mg/l GA₃ and control. The highest TSS, vitamin C and K⁺ content was observed in the 100 mg/l GA₃ treatment.

With ovary injection, percentage of pod setting was maximal at 25 mg/l IAA and minimum at 100 mg/l IAA compared to the control. IAA at 25 and 50 mg/l concentrations increased pod diameter by 6-20% whilst 25 mg/l IAA was the best treatment for growth and pod parameters except for healthy seed production and Mg pod content. Ovary injection using different NAA concentrations produced higher pod set percentages (98.53 and 94.97%), TSS and vitamin C content at lower NAA concentrations (25 and 50 mg/l) compared to the control. Maximum healthy seed percentage per pod was recorded in the 25 mg/l of NAA treatment, while the highest aborted seed percentage was observed at 100 mg/l NAA. With regard to the application of different concentrations of GA₃, highest pod setting occurred in the 25 and 50 mg/l GA₃ treatment and the lowest was observed in 200 mg/l GA₃ and the control. GA₃ at 25 and 50 mg/l produced bigger pod size with higher pod weight than at other concentrations. Healthy seed percentage was highest at 50 mg/l GA₃ and lowest at 200 mg/l GA₃.

In the stem injection method, IAA at 100 and 200 mg/l produced taller plants than treatment at 25, 50 mg/l IAA and the control treatments, which meant that plants treated with 100 and 200 mg/l had the higher number of branches, leaves and pods than the other treatments. Chlorophyll content, quantum yield of chlorophyll fluorescence (Fv/Fm) and growth and pod parameters were not affected by the different concentrations of IAA. The tallest plant was obtained with the lowest concentration of NAA (25 mg/l) used compared to

other treatments. It was observed that different concentrations of NAA injected into the stem did not affect growth and pod parameters. Application of 100 mg/l GA₃ greatly increased plant height compared to the control. It was found that all concentrations of GA₃ used increased chlorophyll content per leaf by 37, 45, 60 and 55% compared to the control. The pod number per plant, pod length, pod diameter, pod size, pod weight and percentage of healthy seeds per pod were significantly affected by the different concentrations of GA₃.

In the seed soaking method, the highest germination percentage and tallest stem were achieved with 25 mg/l IAA compared to the control. Chlorophyll content and the quantum yield of chlorophyll fluorescence (Fv/Fm) were higher in the 25 and 50 mg/l IAA treatments, compared to the control. Maximum healthy seed percentage was obtained with 25 mg/l IAA while the lowest was obtained in 200 mg/l IAA treatment. Likewise, 25 mg/l NAA gave the highest germination percentage (100%) compared to control (77.5%). Application 25 and 50 mg/l NAA brought about a highly significant effect on plant height compared to the control. Vitamin C and K⁺ were affected significantly by the different concentrations of NAA. The highest plant height was recorded in 200 mg/l GA₃ (check this out?). The highest chlorophyll content and quantum yield of chlorophyll fluorescence (Fv/Fm) was found in the 200 mg/l GA₃ treatment. However application of 100 and 200 mg/l GA₃ improved okra growth parameters, seed production and mineral element content compared to the other treatments.

In the seed soaking method with *in vitro* culture, the germination percentage was highest in 25 and 50 mg/l IAA treated plants compared to the control. The chlorophyll content, chlorophyll fluorescence Fv/Fm yield, number of pods and pod size per plant were higher in 50 mg/l IAA treated plants compared to the control. On the other hand, for seeds soaked using different concentrations of NAA, the highest germination percentage (100%) and plant

height was obtained with 25 mg/l NAA. The tallest plants, highest number of pods and biggest pod size were obtained with seeds soaked in 200 mg/l GA₃.

From the results, it can be concluded that lower concentrations of auxins (25 and 50 mg/l, IAA, NAA) and a higher concentration of GA₃ (100 and 200 mg/l) were the best treatments for okra growth and development. In addition to that, it can be summarized that the innovative flower and ovary injection methods improved growth, plant production and pod quality. Furthermore, the seed soaking technique (*in vivo*) was better than the *in vitro* application injection techniques. The stem injection method did not show any effect except with GA₃ application.

ABSTRAK

Kajian telah dijalankan untuk menyiasat kesan kawalan selia pertumbuhan pada bendi hasil pertumbuhan dan pembangunan kualiti yang menggunakan teknik permohonan yang berbeza dalam bidang sayur-sayuran komersial di Banting, Selangor, Malaysia. Reka bentuk uji kaji di bidang komersial adalah reka bentuk blok rawak lengkap. Hormon pertumbuhan yang berbeza diterapkan secara langsung dalam bahagian-bahagian yang dipilih loji bendi. Dalam rawatan suntikan bunga, suntikan telah digunakan pada bunga bendi menggunakan IAA pada kepekatan yang berbeza. Peratusan set pod dan panjang maksima 25 mg/l IAA rawatan berbanding sample kawalan. Peratusan lebih tinggi daripada benih yang sihat setiap loji adalah juga direkodkan menggunakan 25 mg/l IAA diikuti dengan sample kawalan dan 50 mg/l IAA. Walau bagaimanapun, penumpuan yang tinggi IAA (200 mg/l) menghalang pengeluaran benih dan membawa *Stenospermocarpus* yang menghasilkan biji-biji digugurkan. Jumlah pepejal larut (TSS) dan kandungan vitamin C dalam pod yang ketara meningkat sebagai hasil permohonan IAA pada semua kepekatan yang berbeza. K⁺ tertinggi kandungan ditemui dalam 25 mg/l IAA berbanding tumbuh-tumbuhan yang dirawat. Di samping itu, kandungan besi (Fe) meningkat dengan ketara dalam rawatan IAA di semua kepekatan berbanding sample kawalan.

Kaedah bunga suntikan menggunakan kepekatan NAA berbeza menunjukkan peratusan yang lebih tinggi setting pod iaitu 25 mg/l NAA rawatan berbanding dengan kepekatan NAA yang lebih tinggi. Berat pod meningkat pada 25, 50 dan 100 mg/l NAA rawatan berbanding dengan sample kawalan. Peratusan benih yang sihat adalah maksima pada 25 mg/l NAA bunga yang dirawat manakala 100 mg/l NAA dirawat bunga menunjukkan peratusan yang

lebih rendah yang menghasilkan benih yang sihat, tetapi peratusan benih digugurkan adalah lebih tinggi. Menggunakan kepekatan GA3 yang berbeza, tetapan pod tertinggi (100%) telah diperolehi pada 100 mg/l GA3. GA3 pada 50, 100 dan 200 mg/l menghasilkan peratusan benih yang sihat setiap pod yang lebih tinggi daripada 25 mg/l GA3 dan sample kawalan. TSS tertinggi, vitamin C dan K+ kandungan diperhatikan dalam 100 mg/l rawatan GA3.

Dengan suntikan ovari, peratusan tetapan pod maksima pada 25 mg/l IAA dan minimum pada 100 mg/l IAA berbanding sample kawalan. IAA pada 25 dan 50 mg/l kepekatan meningkat diameter pod oleh 6-20% manakala 25 mg/l IAA rawatan yang terbaik untuk pertumbuhan dan parameter pod kecuali untuk pengeluaran benih yang sihat dan Mg pod kandungan. Suntikan ovari menggunakan kepekatan NAA yang berbeza yang dihasilkan lebih tinggi peratusan pod (98,53 dan 94,97%), TSS dan kandungan vitamin C pada kepekatan NAA yang lebih rendah (25 dan 50 mg/l) berbanding kawalan. Peratusan benih yang sihat maksimum setiap pod dicatatkan pada 25 mg/l NAA rawatan, manakala peratusan benih digugurkan tertinggi diperhatikan pada 100 mg/l NAA. Dengan mengambil kira permohonan kepekatan yang berbeza GA3, penetapan pod tertinggi berlaku pada 25 dan 50 mg/l rawatan GA3 dan yang paling rendah telah diperhatikan dalam 200 mg/l GA3 dan kawalan. GA3 pada 25 dan 50 mg/l yang dihasilkan saiz pod yang lebih besar dengan berat pod yang lebih tinggi berbanding pada kepekatan yang lain. Peratusan benih yang sihat adalah tertinggi iaitu 50 mg/l GA3 dan paling rendah pada 200 mg/l GA3.

Dalam kaedah suntikan batang, IAA pada 100 dan 200 mg/l yang dihasilkan tumbuhan yang lebih tinggi daripada rawatan di 25, 50 mg/l IAA dan rawatan kawalan, yang bermakna bahawa tumbuh-tumbuhan yang dirawat dengan 100 dan 200 mg/l mempunyai bilangan yang

lebih tinggi cabang, daun dan buah berbanding rawatan lain. Kandungan klorofil, hasil jumlah pendarfluor klorofil (Fv/Fm) dan pertumbuhan dan parameter pod tidak dipengaruhi oleh kepekatan yang berbeza IAA. Kilang tertinggi telah diperolehi dengan kepekatan terendah NAA (25 mg/l) yang digunakan berbanding rawatan lain. Ia dapat diperhatikan bahawa kepekatan yang berbeza NAA yang disuntik ke dalam batang tidak menjejaskan pertumbuhan dan parameter pod. Permohonan 100 mg/l GA3 ketinggian tumbuhan bertambah dengan banyaknya berbanding dengan kawalan. Di dapati bahawa semua kepekatan GA3 menggunakan kandungan klorofil yang semakin meningkat setiap daun 37, 45, 60 dan 55% berbanding kawalan. Bilangan pod satu tumbuhan, panjang pod, diameter pod, saiz pod, berat pod dan peratusan benih yang sihat setiap pod ketara dipengaruhi oleh kepekatan yang berbeza-GA3.

Dalam kaedah benih jering, peratusan percambahan yang tertinggi dan batang tertinggi telah dicapai dengan 25 mg/l IAA berbanding kawalan. Kandungan klorofil dan hasil kuantum pendarfluor klorofil (Fv /Fm) adalah lebih tinggi pada 25 dan 50 mg/l IAA rawatan, berbanding dengan kawalan. Peratusan benih yang sihat yang maksimum diperolehi dengan 25 mg/l IAA manakala terendah telah diperolehi dalam 200 mg/l IAA rawatan. Begitu juga, 25 mg/l NAA memberi peratusan percambahan yang tertinggi (100%) berbanding kawalan (77,5%). Permohonan 25 dan 50 mg/l NAA membawa kesan yang amat ketara pada ketinggian tumbuhan berbanding dengan kawalan. Vitamin C dan K⁺ terjejas dengan ketara oleh kepekatan yang berbeza-NAA. Ketinggian tumbuhan tertinggi dicatatkan dalam 200 mg/l GA3 (check out ini?). Kandungan klorofil tertinggi dan hasil kuantum pendarfluor klorofil (Fv/Fm) telah dijumpai dalam 200 mg/l rawatan GA3. Walau bagaimanapun,

sebanyak 100 dan 200 mg/l GA3 telah membawa pertumbuhan yang lebih baik bagi bendi iaitu pengeluaran benih dan kandungan unsur mineral berbanding kaedah rawatan lain.

Dalam kaedah biji benih direndam dalam larutan *vitro*, peratusan percambahan yang tertinggi dalam 25 dan 50 mg/l IAA tumbuhan dirawat berbanding kawalan. Kandungan klorofil, klorofil pendarfluor Fv / Fm hasil, bilangan buah dan saiz pod setiap loji adalah lebih tinggi dalam 50 mg/l IAA tumbuh-tumbuhan yang dirawat berbanding kawalan. Sebaliknya, bagi benih direndam menggunakan kepekatan yang berbeza NAA, yang peratusan percambahan tertinggi (100%) dan tumbuhan yang tinggi telah diperolehi dengan 25 mg/l NAA. Tumbuh-tumbuhan yang tertinggi, jumlah tertinggi buah dan terbesar saiz pod diperolehi dengan benih yang direndam di dalam 200 mg/l GA3.

Melalui hasil kajian tersebut, dapat disimpulkan bahawa penurunan kepekatan auxins (25 dan 50 mg/l, IAA, NAA) dan kepekatan yang lebih tinggi GA3 (100 dan 200 mg/l) adalah rawatan yang terbaik untuk pertumbuhan dan pembangunan bendi. Selain itu, boleh dirumuskan bahawa bunga inovatif dan kaedah suntikan ovari meningkatkan pertumbuhan, pengeluaran loji dan kualiti pod. Tambahan pula, teknik benih jering (*in vivo*) adalah lebih baik daripada teknik suntikan permohonan *in vitro*. Kaedah suntikan batang tidak menunjukkan apa-apa kesan kecuali dengan permohonan GA3.

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ABBREVIATIONS

IAA	Indole Acetic Acid
NAA	Naphthalene Acetic Acid
GAs	Gibberellins
GA3	Gibberellic Acid
PGRs	Plant Growth Regulators
cm	Centimeter
mg/l	Milligram per liter
Fig	Figure
Fv/Fm	A parameter widely used to indicate the maximum quantum efficiency of Photosystem II
DMRT	Duncan Multiple Range Test
RCBD	Randomized Complete Block Design
ppm	Part per million
TSS	Total soluble solids
No.	Numbers
Cm ²	Square centimeters
mg/100	Milligram per 100 gram
%Brix	Measuring the approximate amount of sugars in fruits, vegetables and juice
In vitro	Latin: Within glass
MS	Murashige and Skoog's medium
<i>In vivo</i>	Latin for : " Within the living"
SPAD value	numerical SPAD value which is proportional to the amount of chlorophyll
K	Potassium
Fe	Iron

Mg Magnesium

Ca Calcium

Na Sodium