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Preface to Volume 10 (1)

We welcome you to the tenth anniversary of our publication in volume number ten. While we are marching steady steps forward, despite the deep crises created by the ongoing conflict in our country today, we look forward for receiving high quality research articles in different fields of agricultural sciences from our clients. Within this publication you will find several research papers that consider many themes from a group of researchers pursue to address the problems of agriculture in its modern and traditional sectors or, more generally, the problems of small farmers and businessmen. A group of researchers from various agricultural research centers addressed the production and acclimatization of seedlings for different agricultural purposes. Among these articles is a research theme that examines three types of Acacia trees used in allay cropping and gifted symbiotic coexistence with microorganisms capable of biological nitrogen fixation. The article addressed them to serve the environment of arid lands lacking nitrogen, the most important nutritional element for plants. Another article examines the economic acclimatization of banana plantlets produced in tissue culture laboratories to serve farmers in the horticultural sector and banana farmers in the environment of the Gash River Basin, whose farmers complain of the scarcity of reliable seedlings in areas where nematodes are widespread, which deprives farmers of benefiting from traditional ways of banana propagation. The third article examines the ability of jackfruit seeds to germinate upon different storage periods after extraction. It is a fruit tree that is not widespread in Sudan, but it is common in environments similar to the Sudan climate in parts of the Asian continent.

Some of the problems observed in the modern agricultural sector were addressed in a research article that reviewed and examined the development and testing the efficiency of a tractor-mounted weeding machine. The crops of small producers and their problems in crop nutrition and searching for ways to add value to them were not absent from the minds of researchers, and this is what the rest of the research articles addressed.

Thanks to everyone who contributed to the publication of the issue. As we move towards the second decade of the journal, we will not forget colleagues who participated with us in editing issues of previous years, namely late Dr. Azhari Fath Al-Aleem and Dr. Abdul Rahman Ahmed Hiwait Allah, may God give rest to their soles.

Introduction

The Nile Journal for Agricultural Sciences (NJAS) is a research journal issued twice a year and aimed to publish original high quality research articles in the field of Agricultural Sciences that are not published or not being considered for publication elsewhere. The work for publication will be accepted either in English or in Arabic.

Aims and scopes:

The Nile Journal for Agricultural Sciences is devoted to providing an appropriate forum for the dissemination of high-quality and high-impact original balanced credible academic writings in all aspects of Agricultural Sciences. The journal invites original papers, review articles, technical reports and short communications. The scopes of the journal include the followings:

- Agricultural economics
- Agricultural engineering
- Animal production
- Apiculture
- Aquiculture
- Biotechnology
- Botany
- Climate change
- Crop nutrition
- Crop protection
- Crop science and agronomy
- Entomology and toxicology
- Environment and eco-system
- Extension
- Food science and technology
- Forestry
- Genetics
- Horticulture
- Irrigation and water management
- Land use
- Microbiology
- Plant breeding
- Plant pathology
- Plant virology
- Remote sensing
- Seed science and technology
- Soil sciences
- Sustainability
- Waste management
- Water resources
- Weed science
- Zoology

Editorial policies

Ethics

The statements and opinions expressed in the articles herein are those of the author(s) and not necessarily of NJAS editorial board. All biological experimental works (such as genetic engineering) should be ethically acceptable and be in accordance with the local and international guidelines provided for both animal and human. Authors must guarantee that the manuscript parts were not being considered for publication elsewhere.

Peer review policy and criteria of manuscript acceptance

Manuscript acceptability is based principally on the importance, objectives, originality, topicality, and appropriateness of the methodology and outcomes. All submitted manuscripts are screened by the editorial board to assure their satisfying the above criteria, and subsequently peer reviewed by two or more reviewers. Manuscripts accepted for publication are copy edited for grammar, punctuation, print style, and format.

Reviewers' selection is based on reputation and experience. However, the identity of reviewers is confidential, and manuscripts are considered private information. The editorial

board will be certain of not to allowing authors to realize reviewers' identities. Similarly, author(s) identities will not be unveiled to the referees.

Reprints

Following acceptance of a paper and prior to publication, 3 reprint copies and a pdf electronic copy will be sent to the corresponding author via post and e-mail, respectively.

Instructions to authors

The work for publication will be accepted either in English (American or British flair is accepted, but not a mixture of both) with an extra abstract in Arabic language or, in Arabic with an extra abstract in English. The manuscript should be written in clear, concise and grammatically correct language. Latin scientific names at all taxonomic levels are *italicized.* All scientific manuscripts will be reviewed by at least two reviewers. While submitting a revised manuscript, authors are requested to include a point-to-point response to reviewer's comments. The final decision relative to acceptance will be made by the editorial board. The corresponding author is considered the guarantor for the legitimacy and correctness of the manuscript as a whole.

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The submission of the manuscript and all correspondence, including notification of the Editor's decision and requests for revision, takes place electronically through the website: njas@nilevalley.edu.sd, or by post.

The following items should be handled in as printout hard copies and in electronically readable form in either a CD (IBM formatted) or via e-mail:

1. Cover letter:

The cover letter, as a supplement file should include; article title, type of article (full research, review, etc.), scope, author(s) name(s), higher qualification/academic degree(s), affiliations, and e-mail addresses. The name of the corresponding author with contact address, phone number, e-mail and fax number (if available) must be clearly listed. Acknowledgement, if any, could also be represented. Beside any special consideration regarding your submission.

2. Manuscript:

The manuscripts submitted to the journal must conform to all style requirements stated by the Editorial Board.

Types of articles:

Full length original scientific papers: regular scientific papers, should report the results of original research that have not being considered for publication elsewhere. A full research paper should have, in proper order, a Title, Abstract, Introduction, Materials and Methods, Results, Discussion, Conclusion and References.

***Review papers*:** in which authors should review the up-to-date developments in relevant field of an active current interest. They must be contemporary and comprehensive. Methods used for locating, selecting, extracting, and synthesizing data should be described. The abstract (250 words) should represent an accurate summary of the article.

***Short communication*:** is a concise, but completely documented, description of a limited research article. The contents should be exceptionally exciting, novel or timely. The maximum length should not exceed 7 pages. These short communications will be peer-reviewed in the same way as full papers.

Regular scientific manuscript formatting

Manuscripts should be kept to a minimum length (the whole article length should not exceed 20 pages. The language of manuscript must be simple and explicit. Times New Roman font style with 12 font size should be used. The whole manuscript should be typed double spaced (except tables), with all margins fixed at 2.5cm. Do not leave lines between paragraphs, but instead, indent the first line of each paragraph with one tab space. All pages should be numbered consecutively in the bottom center. Each heading should appear on its own separate line, aligned to the left and bold. The use of footnotes should be avoided.

Title and author information: The title and author information should be centered across the top of the first page. The title should give a concise designation of the paper topic, typed in 16 font style. Capitalize the first letter of all main words (Latin names in *italics*). Abbreviations should not be used. This should be followed by the name(s) of the author(s) displayed as first name, middle and last name (with no commas in between). Numbered and listed author's affiliations will be provided immediately after the authors line flush left. The name of the corresponding author should be underlined.

Abstract: The abstract, for reviews and research articles, as one paragraph, should be rational, informative and succinctly and clearly state the basic contents of the article with special focus on the scope, objectives, methods, and major findings. The abstract must be precisely and consistently briefed, not exceeding 250 words. References and citations to other works should not be included in the abstract.

Keywords: Key words (3-7 non generic words or phrases) should be provided directly below the abstract to express the article content. They should be written left aligned, arranged alphabetically, separated with commas, capitalize only the first letters of proper nouns, and do not end the list with a full stop.

Abstract translation: An abstract translation is to be prepared and assembled below the keywords, or at the beginning of the succeeding page. It should be precise and presents word-by-word translation.

The main text: The main text should be structured into paragraphs in the following order: **Introduction** including objectives, **Materials and Methods**, **Results**, **Discussion**, **Conclusion**, **Acknowledgement** (if any) and **References**. Results and discussion could be combined in one

paragraph. Each heading should be flush with the left margin and have the first letter of all main words capitalized. All major headings should be separated from the text by 1 line space above.

Introduction: The introduction is a brief review of literature which should supply sufficient background information on the importance of the topic, the research area of the study and the hypotheses tested in the study. The specific aims of the project should be identified along with rationale for the specific experiments and other work performed. All sub-headings, if any, should be left justified, bold and title case. Objectives of the research should be clearly stated.

Materials and Methods: This section must be concise and include sufficient details of the materials, equipment and techniques used. The sources of laboratory procedures should be cited and information on the equipment model, manufacturers name and address should be provided (if recommended). Measurements should be described precisely (all in SI units) and errors of measurements (if any) should also be included. While, previously published procedures may be indicated by a reference, new procedures should be described in detail. The statistical procedure used should be stated in this section.

Results – Discussion: They can be presented together (**Results and Discussion**) or in 2 different sections (**Results** followed by **Discussion**). All results obtained should be simply and concisely presented in a logical order in figures, tables, or text. Tables and figures, whether integrated into the main text, or alternatively, printed on separate pages before the reference section, each should be sequentially numbered and titled (above for tables and below for figures). Do not present the same information in both a table and a figure. All printed tables and figures must be referred to in the text. Tabular data, were recommended, could be accompanied by either standard deviation value, standard errors of the means. The number of replicate determinations used for making such calculations must also be included. Sufficient statistical verification should be provided to identify differences in significance such as least significant range or difference if means shows statistically significant trends.

The results at hand should be concisely discussed in relation to hypotheses advanced in the introduction section and interpreted to previously published works. It must not contain extensive reiteration of the Introduction and Results sections.

Conclusion: The main conclusions of how the results compared with the expected outcomes and what further predictions can be gleaned from the results should be presented in a short Conclusions section, which may stand alone or form a sub-section of the Discussion section.

Acknowledgments: The source of any financial or technical assistant received for the work being published must be indicated in the Acknowledgments section.

Citations and References

In-text citation: References should be included within the body of the text as they appear. Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Unpublished results and personal communications are not recommended in the reference list but may be mentioned in the text. The NJAS in-text citation format is the familiar "author, date" format, e. g. Ali (2003) or (Ali, 2003). If the article has two authors, their last names are used, separated by the word "and", e.g. Ahmed and Ali (2004) or (Ahmed and Ali, 2004). When there are more than two authors, only the first author's last name should be mentioned, followed by "*et al*.", e.g. Liu *et al.* (2006) or (Liu *et al.,* 2006). Multiple references at a single point in the text are separated by semicolons (Ahmed and Ali, 2004; Othman, 2009; Naji *et al.,* 2007 and Singh *et al.,* 2011). In a case where two or more sources cited at a given place shared the last name and date use first author's last name plus initial(s) (e. g. Zhang, Y., 2001 and Zhang, W., 2001). If the author(s) has had more than one published works cited within the same year, they

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References list: All articles cited in the text should be listed at the end of the manuscript, unnumbered, alphabetized by first author's last name. Author(s) name(s) are arranged as "last name, initials. ",. Individual authors names should be separated by semicolons. Followed by the year of publication (in brackets), a full stop, title of article, journal name, name of publisher, volume number, a semi colon, specific page numbers (Vol: Start page–End page). If more than one publication by the same author(s) were cited in the list, arrange publications by date, early to late. If more than one publication by the same author(s) published in the same year were listed, use a, b, c, ... to distinguish the articles cited. Type references flush left as separate paragraphs. The second and successive lines of a reference may be indented by 1 cm.

For books include: name of editor(s), edition and publisher. For articles from conference proceedings include: conference proceedings, publisher (if any) date (between brackets), pp. For citation from a thesis include: Thesis title. Degree level, Department, University.

For electronic citations: Websites are referenced with their URL and access date, and as much other information as is available.

Examples:

Article in a Journal:

Idris, T. I. M; Salih, S. E.; Eltahir, F. H. (2015). Impact of fertilization on growth attributes of tissue culture derived banana (*Musa* spp.). Sudanese Journal of Agricultural Sciences, 2: 56-60.

Book:

Fitter, A.H.; Hay, R.K.M. (2002). Environmental Physiology of Plants. (2nd Edition), Academic Press, London, pp. 120- 128.

Book chapter:

Jelen, P. (2003). Whey processing. In: Encyclopedia of Dairy Sciences; Roginski, H.; Fuquay, J.W. and Fox, P.F., Eds.; London Academic Press, London, UK, Vol. 4, pp. 2739-2751.

Conference proceedings:

Basu, P.S.; Brajesh, S., Minhas, J.S.; Sing, B.; Khurana, S.M.; Shekhawat, G.S; Pandey, S.K.; Sing, B.P. (2002). Nitrogen nutrition in potato: effect of photosynthesis and carbon partitioning. Proceedings of the Global Conference on Potato, Volume 2 (2002), pp. 857-860, New Delhi, India.

Tables and Figures: Tables should be self-explanatory and the data they contain must not be duplicated in the text or figures. Tables should be submitted in "Word" format (not in excel file) and should be printed single spaced in the main text (appear where should be cited) in numerical order, or otherwise at the end of the manuscript. Place a descriptive, comprehensive, but precise caption at the top of each table begins with the word "Table" followed by a number and a colon (:). Sufficient experimental details could be added in a legend below the table, if required. If a table is taken from other publication, then the reference is to be given below it.

Figures should be properly sized and cropped so that no unnecessary white space is left bordering the figure. Figures should be cited in the main text (appear where should be cited) in numerical order, or otherwise at the end of the manuscript. Figures should have titles set below the figure begins with the word "Figure or Fig." followed by a number and a colon (:). Legends with sufficient details could be added. Multipanel figures (figures with parts labeled a, b, c, d, etc.) should be assembled into a composite as their final form. For an illustration taken from other publication, the source is to be cited.

Abbreviations and Units: SI units (metre, kilogram, etc.) should be used. Consistency must be maintained throughout the text in the use of abbreviations and units. Use standard abbreviations, that are accepted and recognized as common scientific terminology (hr, min, sec, etc.) instead of writing complete words. Define all non-standard abbreviations the first time they are used, then subsequently use the abbreviation.

Examples of some common abbreviations: Time: min, hr, sec; Length: km, m, cm, mm; Mass: kg, g, mg, μg; Concentration: g/cm^3, g/L, mg/L, μg/L, ppm; Volume: cm^3, L, mL, μL

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Research paper

Performance Evaluation of Tractor Mounted Inter Row Weeder Provided with Three Different Types of Weeding Tools on Okra Production

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Abstract

Weeding is an important practice to be carried out during the initial stages of crop growth especially for controlling the weeds competing with the crop, stirring the soil for aerating the crop root zones and for burying the weeds into the soil. Efficient weeding aids and equipment for weed control seems highly necessary to minimize the time consumption, labor requirement and cost. The objective of the study was to evaluate a tractor operated inter-row weeder with three different types of blades for weeding in okra cultivation and compared to manual weeding method. The weeder is suitable for crops having considerable row spacing up to 80 cm, the width of the weeder is adjustable according to the crop row spacing. The modified weeder was evaluated at different test fields for okra plant and can be used in any vegetables plant with a maximum height of about 35cm. A randomized complete block design with three replications was used. Plot size was 4 m × 120 m. Results showed that there was highly significant difference (p=0.05) of weeding efficiency, grain yield and field efficiency. The weeding efficiency for V-shape lade1 was 93.7%, field efficiency was 83%, plant damage was 0.83 % and a yield of 365.7 kg/ha. Curved blade recorded 83.5 % weeding efficiency, 74 % field efficiency, 2.1% plant damage and a yield of 253.7kg/ha. The shank blade has a weeding efficiency of 59.2 %, field efficiency of 72 % and plant damage of 32 % and a yield of 127.2/ha. The manual weeding has a weeding efficiency of 99.9%, field efficiency of 35 % and damage factor of zero percent and a yield of 526.2kg/ha. These studies concluded and suggest that weed control on okra production could be best carried out by mechanical weeding method with V-shape blade and curve blade. For future study further research is needed to develop curve shaped blade with different design patterns and apply with different crops for better field efficiency and lower cost.

Keywords*: cultivation, Weed control, weeder, Field efficiency.*

تطويروتقييم أداء عز اقة بين الصفوف محمولة على الجراروزودة بثلاثة أنواع من الأسلحة على إنتاج البامية

علي و أيوبا إدريس[1]، أسامة عباس محي الدين[2] وعبدالكريم دفع الله الفاضل[3]

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المستخلص

العزيق عملية مهمة ويجب إجراؤها في الأطوار الأولى من نمو النبات خاصة للتحكم في الحشائش التي تنافس المحصول. وتحريك التربة من أجل تهوية منطقة الجذور ودفن الحشائش. معدات العزيق ضرورية لتقليل الزمن والعمالة والتكلفة. الهدف من هذه الدراسة هو تقييم أداء عزاقة بين الصفوف بثلاثة أسلحة مختلفة لعزيق البامية ومقارنتها بالعزيق اليدوي. العزاقة مناسبة للمحاصيل التي لها مسافة بين الصفوف حتى 80سم وعرض العزاقة قابل للضبط حسب المسافة بين الصفوف. تم تقييم العزاقة بعدد من الاختبارات الحقلية لمحصول البامية ويمكن استخدامها لمحاصيل الخضر الأخرى بأقصى ارتفاع **35**سم. تم اختيار التصميم العشوائي بثلاثة تكرارات. مساحة الحوض 4×120 متر. أوضحت النتائج فروق معنوية عالية (P=0.05) في كفاءة العزيق والإنتاجية والكفاءة الحقلية. الكفاءة الحقلية للسلاح شكل **V** كانت **93.7**% والكفاءة الحقلية **83**% ونسبة تلف النبات 0.83% والإنتاجية **365.7**كيلوجرام للهكتار. سجل السلاح المنحني كفاءة عزيق **83.5**% وكفاءة حقلية **74**% ونسبة تلف النبات **2.1**% والإنتاجية **235.7** كيلوجرام للهكتار. السلاح المستقيم أعطى كفاءة عزيق **59.2**% وكفاءة حقلية 72% وتلف النباتات 32% وإنتاجية قدرها 127.2كيلوجرام للهكتار. أعطى العزيق اليدوي 99.9% و 35**%** و 0% و 526.2 كيلوجرام للهكتار لكفاءة العزيق والكفاءة الحقلية وتلف النباتات والإنتاجية على التوالي. خلصت الدراسة انه يمكن التحكم في الحشائش في محصول البامية بالطرق الميكانيكية باستخدام سلاح على شكل V والسلاح المنحني. تقترح الدراسة تطوير السلاح المنحني بأنماط مختلفة وتجربته في محاصيل مختلفة لتحسين الكفاءة الحقلية وتقليل التكلفة.

كلمات مفتاحية: العزيق، التحكم في الحشائش، العزاقة، الكفاءة الحقلية

Introduction

Weeds are robbers and farmer has ton destroy them to save crop. Control of weeds and grasses are most labor and time intensive operations. Weed control in farms is a serious concern. Weeds pose major problem during warm and humid climate especially affecting crops. The problem of weed control is more acute in black soil during rainy season. Weed control is one of the most expensive operations in crop growth, (Swenson and Moore, 2009). Weeds waste excessive proportions of farmers' time, thereby acting as a brake for the development, (Nagesh *et al,* 2014)

Weeding is an important but equally labor-intensive agricultural unit operation. Weed control is one of the most expensive operations in crop growth. The high cost of weeding can be understood from a comparative study of the losses in the farm due to various causes.

Infection of weeds is more in rainy than in winter season. often weeding is incomplete or delayed as a result there is significant loss of 20% or more. Weeds increase cost of production and lower the quantity as well as the quality of the crop. Depending on the weed density, 20-30% loss in grain yield is the quite usual which may increase to 50%, when crop management practices are not properly followed. In production technology plant protection is a key in increasing the productivity of crop. Under plant protection, weed control plays an important role for increasing the yield. Weed alone was found to be reducing the yield to the extent of 58-85%. Weed control is generally neglected even though it's a crucial factor due to negligence in weed management crop yield loses 20-27% are recorded (Biswas *et al*. 2000).

Methods of weed control are grouped into cultural, mechanical, chemical and biological practice. Mechanical weeding is one of the oldest practices, but the most common methods of weed control in upland crops. Although it has undergone a spectacular advancement, yet hand weeding with simple weeders is common. These simple weeders are cheap, more efficient and suitable for farmer's situation to reduce the cost of crop production and improve crop yield to a great extent. It is not only safe to the environment, but also safe to the user. The physiological demand in using weeders was relatively higher than in manual weeding. However, the efficiency of the work in terms of area covered was significantly better with the weeder than with manual weeding. The energy demand in manual weeding is about 27%, whereas for weeding with different weeders the energy goes up to 56%. The strain was relatively less in case of wheel push type weeder (Rajasekar, 2002). However, performance evaluation of a

tractor multi row mechanical weeder to ensure that there is a suitable replacement to either energy sapping method of manual hoe of weeding operation or expensive foreign weeders which are beyond of peasant farmers to gain. Evaluation of performance of an implement shows the level of its effectiveness and it adoption to a particular function which indicates the output in relation to specific time, (Rajasekar, 2002). The objective of this article is to evaluated a modified tractor mounted inter row weeder provided with three different types of weeding tools.

Materials and methods

The work was carried out at the workshop of Agricultural engineering department and experimental farm of the Faculty of Agricultural Sciences, university of Gezira, Sudan, at a latitude of 14° 21' N, longitude 29° 33' E and altitude 405 m above mean sea level. The local climate of Gezira is classified as semi-arid, annual rainfall of about (342 – 424 mm) the mean temperature is about (25 -39^{o}c), for about 7 months of the year there is no rainfall. The site is composed of a heavy clay soil which develop deep crack during the dry season. The soil are alkaline with high pH of about (8.42 ± 0.21) with some saline patches and they are characterized by their high clay content of up to 50 to 70% silt between 15 to 30%, fine sand between 10 to 20%, high exchangeable sodium low permeability low Chroma in low lying spot (Ishag *et al.* 1985).

Equipment

To complete the following work various materials and equipments were used to fulfill the objectives.

Tractor

A Tafe tractor model no: 8502 was used to operate the weeders, and some of the tractor specifications are shown below.

Specifications of the tractor used in the test

No.	Parameters	Description
1	Manufacturer	Trademark of agro S.P.A
2	Power source	83.6 hp
3	Model no	8502
4	Drive wheel	2
5	Fuel	Diesel with an adjustable rear wheel tread
6	Cooling system	Water

The evaluated weeders

Three different types of cutting blades were used as the requirement of the weeding operation, which are made of cast iron. These blades were mounted to a light frame separately and adjusted according to the spacing between ridges. Each weeder includes four types of blades.

Other equipment and tools

An auxiliary tank was used to measure the fuel consumed during work. The tank was coupled with transparent tube at both terminals. **A** stopwatch was used to measure time required for one turn and turning of a tractor. Time measured in minutes and calculated for hours. **A** measuring tape was used for measuring and marking in the field. A steel foot ruler was used for measuring depth of operation, height of crop, height of weeds. A 100kN capacity Dynamometer for measuring draft required to operate the unit in the field. A sensitive balance to weigh the samples was used. Labors equipped with locally made hoes were hired for manual weeding. A metallic frame or steel quadrate $1m^2$ was used to count the number of weeds / m^2 and weed ground cover.

Experiment

The experiment consists of the mechanical weeding with V-shape blade (fig1.b), mechanical weeding with curve blade (fig.1b), mechanical weeding with shank type blade (fig.1c) and manual weeding.

Fi g.1a. V-shape blade

Fig.1.b Curve shape blade

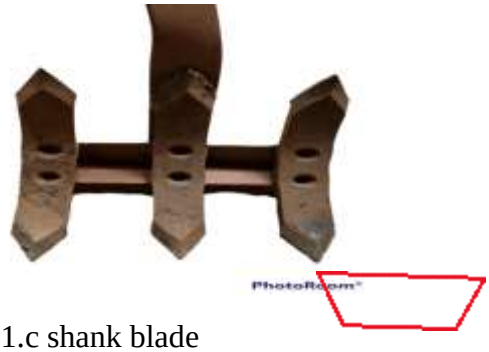

Fig. 1.c shank blade

Weeding Efficiency (WE %)

Weeding efficiency refers to the ratio of removed weeds to the total weed count and it can be found as follows:

$$WE = \frac{W1-W2}{W1} \times 100 \quad \ldots\ldots (1)$$

Where,

W_1 = Number of weeds before weeding

W_2 = Number of weeds after weeding.

Damage factor (DF %)

Quality of work done is the measure of damage on crop plants. While weeding operations is denoted by the expression given below:

$$DF\ \% = \frac{Q2}{Q1} \times 100 \quad \ldots\ldots (2)$$

Where

Q_1= Number of plants before weeding

Q_2= Number of plants after weeding.

Draft measurement

The draft required to operate the unit in the field was measured by using dynamometer of 5000 kg capacity, mounted in between the test tractor that hitched with weeder and hauling tractor. The test tractor was run in neutral position of transmission system with the PTO and the hydraulic system in fully operating conditions. The dynamometer was hitched to ensure horizontal pull. First, the draft required (F_2) to pull the test tractor along with weeder in working position was measured. Second, the draft required (F_1) to pull the tractor without any load was measured. (See plate1) Then, the draft required to operate the weeder was calculated as follows.

$$Draft\ (kg) = (F_2 - F_1) \quad \ldots\ldots (3)$$

Forward speed (S)

The forward speed of the tractor was calculated by measuring the distance covered and time taken to covered the same distance in seconds and was computed by the below formula:

$$S = \frac{D}{T} \quad \text{.....(4)}$$

Where: S = forward speed (m/s)

D= distance covered (m)

T= time taken in second (s)

Theoretical field capacity (FCT)

The theoretical field capacity was calculated based on the formula (5) given by (Nkakini *et al*., 2010)

$$FCT = s \times w \times 0.36 \quad \text{.....(5)}$$

Where: FCT = theoretical field capacity (ha/hr)

S= forward speed (m/s)

w = working width (m)

Measurement of Effective field capacity

The area cover during the test was calculated. The effective field capacity was then calculated by using following formula (Nkakini et al., 2010)

$$FC_e = \frac{A}{10^4} \times \frac{3600}{T} \quad \text{.....(6)}$$

Where: FC_e = actual field capacity (ha/hr)

A = area weeded (m^2)

t = time taken to weed (sec)

Measurement field efficiency

The field efficiency was calculated by dividing the effective field capacity by theoretical field capacity as described in the following equation:

$$FE = \frac{\text{effective field capacity}}{\text{theorotical field capacity}} \times 100 \quad \text{.....(7)}$$

Fuel consumption

Fuel consumption per hectare was measured for the mechanical weeding methods using the methods used by (Ibrahim, 2013). The tractor tank was substituted by an auxiliary graded fuel tank and it was filled to a specific level the auxiliary tank was equipped with a transparent hose. At the completion of the tested area, the drop in fuel level was measured with the aid of a plastic ruler. The consumed fuel was measured by converting the number of millimeters that

represented the drop in fuel level on the transparent tube to fuel volume. The fuel consumption in L/ha for the tested are determined by the equation 8 (Ibrahim, 2013).

$$f.c = \frac{v \times 10000(\frac{m^2}{ha})}{A(m^2)} \text{.....(8)}$$

f.c = Fuel consumed, (L/ha)

V= Volume of fuel consumed for Litter per plot area

A= Tested Plot Area m^2

Economic cost

The cost of operation of the weeder was estimated out and compared with manual weeding.

Results and discussion

Weeding efficiency at 4-5 weeks after sowing

The result of weed control percentage at 4-5 weeks and the analysis of variance for individual treatment and interaction effect on weeding efficiency according to the number of weeds before weeding and after weeding were summarized in Table 1. The analysis of variance showed that there was significant difference between the treatments. The highest weeding efficiency was recorded in manual weeding method which recorded 99.8 %. It was showed excellent result and followed by 93.7 % and 83.5 %weeding efficiencies when using V-shape blade and curve shape, respectively. However, the lowest weeding efficiency was 59.2% percent which was recorded on shank blade. These results evaluated as very good control according to the scale mentioned by Senthilkumar *et al*. (2014).

Weeding efficiency at 9-10 weeks after sowing

The analysis of variance for the number of weeds before weeding and after weeding at 9-10 weeks after sowing were summarized in (Table 2).The result shows that there was highly significant difference between the treatments in which that the highest percentage was recorded to manual weeding 99.9 % weeding efficiency which was an excellent result, followed by V-shape blade and curve shape which found to be 94.6% and 82.9% weeding efficiency, respectively. The lowest weeding efficiency was recorded by shank Blade which equal to 74.7 %.

Table 1. Weeding efficiency at 4-5 weeks after sowing

Treatment	No of weed bef weeding	No of weed a weeding	Weeding efficien %
Manual	4857	6	99.8 a
V-shape blade	5546	304	93.7 b
Curved blade	5165	914	83.5 c
Shank blade	5406	2106	59.2 d
LS			S
SE±			0.85
CV%			1.2

Where:
LS=level of significance at (0.05%). CV= coefficient of variation. LS= least significant difference.

Table 2 Weeding efficiency at 9-10 weeks after sowing

Treatment	No of weed before wee	No of weed a weeding	Weeding efficie
Manual	5206	3	99.9 a
V-shape blade	4611	201	95.6 b
Curved blade	5333	911	82.9 c
Shank blade	4965	1252	74.7 d
LS			S
SE±			0.75
CV			1.04

Where:
LS=level of significance at (0.05%). CV= coefficient of variation. LS= least significant difference.

Effect of weeding methods on damage factor

The results of okra on plant damage factor during weeding operation were shown in Table 3. The highest percentage of damage was recorded by shank blade which represents 23%, followed by curved blade and Blade1 were recorded 2.1 % and 0.84%, respectively. The manual weeding method recorded zero percent damage. This result is in line with the results obtained by Shekhar*et al*. (2010) and it was accepted as an excellent result.

Table 3. Effect of weeding method on damage factor in okra plant

Treatment	No of plant before w	No of plant after w	%Damage facto
Manual	801	801	0 a
V-shape blade	827	820	0.84 b
Curved blade	835	813	2.1 c
Shank blade	808	621	23 d

Where:
CV= coefficient of variation. Sig= level of significance of mean differences at (0.05%). .

Effect of weeding methods on plant population

The analysis of variance for individual and interaction effect of variables on plant population shows that there were no significant differences between them, as shown by LSD Test at significant difference of (p=0.05). This indicated that the weeding blades used have no effect on plant population for both weeding interval as shown in Table 4. This indicated that, blades used as a mechanical weeding had no effect on plant damage.

Table 4 Effect of weeding methods on plant population on okra plant at 4-5 And 9-10 weeks after sowing

Treatmen	Plant population (m^2)			
	4-5 weeks		9-10 weeks	
	No of plant Be	No of plant Af	No of plant Be	No of plant A
Manual	801	801 a	801	800 a
V-shape blade	827	820 a	820	813 a
Curved blade	835	813 a	813	789 a
Shank blade	808	621 a	621	587 a
Sig		NS		NS
SE±		33.63		19.95
CV%		16.19		9.22

Where:
CV= coefficient of variation. Sig= level of significance of mean differences at (0.05%).

Effect of Weeding Methods on Plant Height

The range of plant height that was measured is between 10 -13cm at first weeding and 18 -22cm for second weeding. In this regard the analysis of variance showed that there was no significant differences (p=0.05) among the mean. This shows that the methods of weeding had no effect on plant height before and after for the both weeding intervals as shown in Table 5. In this regard the highest plant height value 22cm was obtained with manual weeding method; this was due to its excellent weeding efficiency followed by a good result attained by V-shape

blade and curve shape blade at 19 cm, the lowest value of plant height was obtained by shank blade with 18cm.

Table 5 ANOVA for plant Height on okra at 4-5 and 9-10 weeks

Treatment	Plant height (cm)	
	4-5 weeks	9-10 weeks
Manual	12 a	22 a
V-shape blade	13 a	19 a
Curved blade	13 a	19 a
Shank blade	12 a	18 a
Sig	NS	NS
SE±	1.33	1.38
CV	13.24	19.917

Where:
Sig =level of significance at (0.05%). SE± = Standard error. CV% = coefficient of variation.

Effect of weeding methods on okra yield

The analysis of variance for individual and interaction effect of variables on okra yield is summarized in Table 6. The analysis shows that there were highly significant level of difference at (p=0.05) the highest yield was by manual method of weeding at (526.2kg) then followed by V-shape blade at (365.7kg/ha) then curved blade at (253.7kg/ha) then finally the least yield by shank blade at (127.2kg/ha).These results indicated that, the less weed, the higher the productivity of okra crop.

Table 6 Effect of weeding methods on okra yield

Treatment	Weeding efficiency	Plant yield (kg/ha)
Manual	99.9 a	526.2 a
V-shape blade	95.6 b	365.7 b
Curved blade	82.9 c	253.7 c
Shank blade	74.7 d	127.2 d
Sig	S	S
SE±	0.75	0.5949
CV	1.04	14.39

Where:
Sig =level of significance at (0.05%). SE± = Standard error. CV% = coefficient of variation.

Theoretical and effective field capacity

The analysis of variance for theoretical field capacity and effective field capacity is summarized in Table 7. The statistical analysis shows no significance difference between the mechanical treatments. The range of mechanical weeding blades on theoretical field capacity

was between 0.5- 0.7 ha/hr. Although the manual weeding method differs from the mechanical, but according to LSD All-Pairwise Comparisons Test still shows no significant difference between the treatments. Likewise in terms of effective field capacity, it ranged between 0.61-0.66 ha/hr.

Table 7 Machine theoretical field capacity and effective field capacity

Treatmen	Theoretical field ca (ha/hr)	Effective field capa (ha/hr)
Manual	0.045	0.016
V-shape blade	0.789	0.6648
Curved blade	0.842	0.6233
Shank blade	0.854	0.6149
Sig	NS	NS
SE±	0.012	0.0073
CV	2.35	1.87

Where:
Sig =level of significance at (0.05%). SE± = Standard error. CV% = coefficient of variation.

Field efficiency percentage

The analysis of variance for field efficiency is shown in Table 8. The analysis showed that all means were significantly different from each other with highest percentage for V-shape which represents 84% followed by curved blade at 74%, and then shank blade at 72%. The lowest percentage of field efficiency was recorded for manual weeding method at 35% due to low speed of the labor which consume too much time. This finding agrees with that stated by Shekhar *et al*. (2010).

Fuel consumption

The result of analysis of variance for fuel consumption as shown in Table 8 indicates that, there were highly significant differences between the treatments. The comparison of means for mechanical weeding methods showed that the highest consumption came from V-shape Blade (1.51 L/ha) followed by curve Blade with (1.4 L/ha) and then shank Blade (1.1 L/ha).

Table 8 Field efficiency and fuel consumption of the machine

Treatment	Field efficiency %	Fuel consumption
Manual	84 a	**
V-shape blade	74 b	1.51 a
Curved blade	72 c	1.4 b
Shank blade	35 d	1.1 c
Sig	S	
SE±	0.4082	0.0078
CV	0.75	2.70

Where:
Sig =level of significance at (0.05%). SE± = Standard error. CV% = coefficient of variation.

Time consumed during weeding

The result for analysis of variance on time consuming during weeding operation is shown in Table.9. The manual weeding method resulted in highest time consumption of 41.68 hr/ha, therefore to weed a hectare of land in a single day need 13 person or a single person need 13 days to weed a hectare of land. Mechanical Blade1 and Blade2 have the average time consumption of 0.755 to 0.710 hr/ha, whereas the Blade3 recorded the lowest time consumption with 0.68 hr/ha. This might be due to its low performance in weeding efficiency. These results indicated that the time consumed during weeding increases when using the hand labor and decreases when using the machines. The time saved when using mechanical weeding represent up to 98% in comparison of manual weeding. This result agrees with the finding of Rangaswamy *et al.* (1993).

Table 9 Effect of weeding method on time consumption

Treatments	Time consumption during weeding
Manual	41.68 a
V-shape blade	0.755 b
Curved blade	0.710 bc
Shank blade	0.68 c
Sig	NS
SE±	0.0412
CV	18.76

Where:
Sig =level of significance at (0.05%). SE± = Standard error. CV% = coefficient of variation.

Ridge height after sowing

The result showed that there was no significant difference (p=0.05) between the treatments on the ridge height after sowing as shown in Table 10.The result indicated that there was the homogeneity of seedbed preparation in the experimental area.

Ridge height after weeding

The statistical analysis showed that there were no significant difference between the treatment at (p=0.05) which was shown in Table 10. The height of the ridge was almost identical to each other with less difference between the treatments. The highest ridge shown in manual weeding (14cm) due to rebuild of the ridge when weeded by the labor, then Blade1 (13 cm) that rebuilt the ridge almost near to that of manual during weeding. The lowest ridge height was obtained by shank blade due to its low performance in weeding efficiency and couldn't be able to rebuild the ridge.

Table 10 Ridge height After Sowing and after Weeding

Treatment	Ridge height (cm)	
	After sowing	After weeding
Manual	15.5 a	14 a
V-shape blade	15.5 a	13 ab
Curved blade	15.2 ab	11 b
Shank blade	14.9 b	8 c
LS	NS	NS
SE±	0.2449	0.9129
CV	1.96	10.16

Economic cost

The economic cost was calculated based on the law of fix cost and variable cost as shown in Table 1.The result was compared between mechanical and manual weeding methods. The result showed that there was almost 48% saving in cost when using mechanical weeding in comparison to manual weeding. The finding agrees with that of Rangaswamy *et al.* (1993).

Table 11 Cost of mechanical weeding and manual weeding

Treatment	Estimated labor cost per hectar (USD)
Manual weeding	52,000
V-shape blade	20,000
Curved blade	29,000
Shank blade	29,000

Draft requirement

The draft requirement for the weeders was calculated with dynamometer device. And the result showed that lowest draft was recorded with curve shape blade 75.5kg due to its light weight and easy maneuvering, and then followed by shank blade 79.8kg and the highest draft force was recorded with V-shape blade 87.6kg.

Table 12 draft force requirement

Treatment	Draft force (kg)
V-shape blade	87.6
Curved blade	75.5
Shank blade	79.8

Where:

Conclusion

Base on the results obtained the following conclusions are stated as follow:

1. Mechanical weeding control with treatment with V-shape blade and curved blade give an excellent result compared to shank blade in terms of weeding efficiency, grain yield and plant damage.
2. All treatments gave higher weeding efficiency and improve yield when compared with shank blade.
3. Mechanical weeding control methods gave higher field efficiency and effective field capacity when compared to manual weeding.

Recommendation

1. Some of the major advantages of mechanical V-shape blade are high weeding efficiency, high grain yield, low plant damage but has high draft requirement. It's recommended to work in a minimizing draft requirement.

2. Major advantages of mechanical curve shaped blade are low initial cost, low time consumption and low draft force.

3. Curved blade is recommended in weeding as a new design because it resulted in higher weeding efficiency, low plant damage and high grain yield.

4. For future study further research needed to develop curve shape blade with different design pattern and apply to different crops for better field efficiency and low cost.

5. Study the effect of the optimum soil moisture content in good weeding operation.

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Research paper

The Effect of Light Intensity and Watering Interval on Growth and Development of Three Legume Tree Species Seedlings

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Abstract

The cultivation of tree seedlings in a controlled nursery environment is essential for successful aforestation in the semi-desert region of Sudan. Light intensity and water availability are the key factor for the growth and development processes of legume tree seedlings. The objective of this study was to examine the effect of light intensity and watering interval on the growth and development of three nitrogen fixing tree seedlings (*Sesbania formosa*, *Leuceana leucocephala and Sesbania sesban*). The experiment was carried out at the nursery of Hudieba Research Station, northern Sudan in April 2020. The treatments tested were arranged in a Split-Plot design with three replicates. The studied factors were light intensity (50%, and 100%) and watering interval (3, 6 and 9 days). The measurements were taken after three months successively and different growth parameters were evaluated. Seedlings survival percentage for the three tree species in 50% light intensity under the different watering intervals ranging between (90-100%), Leucaena seedlings exhibit sensitivity to 100% light intensity during germination and growth. The results showed significant interaction effects of the two factors on stem length and nodules, root and shoot dry weight, of the three tree species. The results proved that the best combination of these factors that resulted in the recommended plant able seedling size was; 50% light intensity, watering every 3 days for L. leucocephala; 100% light intensity, watering every 3 days for S. formosa and S. sesban.

Keywords*: N-Fixing trees, light intensity, watering intervals and nodules.*

تأثير شدة الإضاءة وفترات الري على نمو وتطور شتلات ثلاثة أنواع من الأشجار البقولية

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المستخلص

تُعتبر زراعة شتول الأشجار في بيئة مشاتل مناسبة أمرًا أساسيًا لنجاح نظم التشجير المختلفة في المناطق شبه الصحراوية في السودان. أُجريت الدراسة بمحطة بحوث الحديبة شمال السودان في أبريل 2020 بهدف دراسة تأثير شدة الإضاءة وفترات الري على نمو وتطور شتلات ثلاثة أنواع شجرية مثبتة للنيتروجين و هي شجرة السيسبان, الليوسينا و الفورموزا (*Sesbania formosa*، *Leucaena leucocephala* و *Sesbania sesban.*) تم ترتيب المعاملات وفق تصميم القطاعات المنشقة بثلاث مكررات. المعاملات التي تمت دراستها تضمنت الكثافة الضوئية (50% و100%) وفترات الري (كل 3، 6 و9 أيام). تم أخذ القياسات بعد الشهر الثالث من البذر.وجد ان نسبة بقاء شتلات الثلاث شجرات حية أعلي (90-100%) في نسبة أضاءة 50%، كما أظهرت الدراسة أن شتول شجرة الليوسينا حساسة للنمو والانبات في ضوء الشمس المباشر. أظهرت النتائج وجود اثر معنوي للمعاملات على طول الساق، عدد العقد البكتيرية، الوزن الجاف للعقد البكتيرية ,الجذور والمجموع الخضري (الساق والأوراق) للثلاث أشجار. أثبتت النتائج أن أفضل تركيبة من هذه العوامل أدت إلى حجم شتلات مناسب للزراعة كانت: شدة إضاءة 50% مع ري كل 3أيام لـ*L. leucocephala* ؛ وشدة إضاءة 100% مع ري كل 3 أيام لـ*S. formosa* و*S. Sesban*.

الكلمات المفتاحية: *الأشجار المثبتة للنيتروجين، شدة الإضاءة، فترات الري والعقد البكتيرية.*

Introduction

The semi-desert region of Sudan is particularly prone to desertification, coupled with harsh climatic conditions: i.e. hot and dry summers and scarce rainfall. Generally, tree seedlings are quite sensitive to environmental stresses especially water which is considered as the main limiting factor for successful plantation. Previous studies have reported that drought is a factor negatively influencing seedling survival and establishment (Bouda *et al*., 2013; Claudia *et al*., 2004).

Growing seedlings under such harsh conditions produces weak seedlings Therefore; the production of suitable seedlings necessitates protecting of the juvenile seedlings from the harsh conditions. Germination of many species requires specific light requirements, with species responding to slight variations in the light spectra associated with the season or shaded habitat, triggering or inhibiting germination (Fenner and Thompson 2005). Legume- fixing trees and shrubs play a crucial role in biodiversity dynamics. Also, they play a vital role in agroforestry system because of their multipurpose nature they provide a high quality fodder, nutrient rich mulch for crops, timber and fuel wood, human food and improving the microenvironment and their introduction in cropping systems may contribute to reducing the use of chemical fertilizers and the improved productivity of different soils and to ecosystems stability. The tree legumes most commonly used in agroforestry systems involve Acacia spp., Albizia spp., Calliandra calothyrsus, Faidherbia albida, Flemingia spp., Erythrina spp., Inga spp., Leuceana spp., Gliricidia spp., and Sesbania spp., which can develop symbiotic associations with a great variety of N2-fixing bacterial species (Gold, 2020; Sileshi *et al*., 2014). Despite the great potential of these trees, not much is known about their response to drought. To maximize the potential value of these legume trees, there is a need to understand the physiological responses to irrigation intervals and light intensity. Therefore; the objective of this study was to examine the effect of light intensity and watering interval on the growth of three tree species at the nursery stage.

Materials and Methods:

This experiment was conducted at Hudieba Research Station, Northern Sudan (17.57’N and 33.8’ E). The investigated tree species were *Sesbania formosa*, *Leuceana leucocephla* and *Sesbania sesban*. Every species was tested separately. The experiment was arranged in a spilt plot design with three replicates. The main plots were assigned to light intensity, and the sub-plot to

watering interval. The levels of light intensity factor were 50% (under plastic net) and 100% (under direct sun light); the watering intervals were 3, 6 and 9 days.

The seeds were treated using the recommended pretreatment method for each tree species. They were sown at the rate of three seeds per polythene bag of 15 X 20 cm size. The seedlings were irrigated every two days for three weeks, and then three irrigation intervals treatments were applied. The seedlings were thinned Three weeks after sowing, to one plant per polythene tube. The seedlings were left to grow in the nursery bed for three months. Then, they were carefully freed from the soil by gentle washing with water and nodules were carefully picked. Each plant further separated into shoot and root, and the shoot separated into leaf and stem. The fresh weight of each plant fraction was determined immediately. Data collected were, leaves and nodules number, stem length, shoot (leaves and stem), root and nodule fresh and dry weight (oven dried at 70 ^{0}C for 24 hr). The data were then statistically analyzed using the Genstat Package.

Results and discussion

As shown in Fig 1., the survival percentage of the three tree seedlings after three months in 50% light intensity under the different watering intervals ranging between (90-100%), the survival percentage of the two sesbania seedlings under full sun light and 3 days watering intervals was (87.5%). However, Leucaena seedlings exhibit sensitivity to 100% light intensity during germination and growth, even when watering intervals are reduced. Light availability is a major ecological factor influencing seed germination, seedling survival, and establishment (Guenni *et al*., 2008).The successful afforestation requires planting quality seedlings with optimal potential for high rate of survival and growth (height and basal diameter) overtime (Grossnickle and MacDonald 2017).

1- *Sesbania formosa*

The light intensity had a significant effect on *S. formosa* seedlings during their juvenile stage, and also stem length for seedlings under partial shade was significantly higher than in 100% light intensity, because seedlings search for sun rays, required for photosynthesis. There were no differences between shoot dry weights under the two light intensities. Root dry weight showed significant differences, although there were no differences in root length. As light intensity increased from 50 to 100%, root and nodule weight increased significantly (Table 1.1). All

parameters increased significantly as the watering interval decreased. There were highly significant differences in the dry weight of all parameters, root and nodules dry weight increased significantly as the watering interval decrease (Table 1.2). The combination of 100% light intensity, watering every 3 days treatments gave the highest shoot, root and nodules dry weight (Table 1.3). The study reveals that the optimal watering intervals of every three days led to excellent growth performance across all three species. For tree nurseries, regular watering is necessary to produce good quality seedlings at economical rate. This finding aligns with previous research indicating that both water availability and timing are critical factors influencing seedling development, Khan *et al*. (2005) studied the influence of four irrigation intervals (3, 6, 9 and 12) on the growth and yield of bell pepper (Capsicum annuum), and they found that 3 days of irrigation interval gave the highest shoot height compared to other treatments.

2- *Sesbania sesban*

Light intensity had a significant effect on *S. sesban* seedlings during their juvenile stage. The stem length of the seedlings under partial shade was significantly higher than under 100% light intensity. All growth parameters concerned were significantly increased as the light intensity increased from 50 to 100% except root length. Although there were no significant differences between the root lengths in the two light intensities, the dry weight of root length demonstrated highly significant differences between the two treatments (Table 2.1).

All parameters increased significantly as the watering interval decreased. There were highly significant differences in the dry weight of all parameters among different watering intervals (Table 2.2). *S.sesban* under direct sun light (100% light intensity) with the different watering interval gave the highest dry weight of shoot, root and nodule. The combination of 100% light intensity and watering every 3 days gave the highest shoot, root and nodules dry weight (Table 2.3). Our results indicated that the two species *Sesbania formosa* and *Sesbania sesban* performed optimally when planted directly under 100% light intensity, This fact indicates that two species are a light demanded and therefore the 50% light intensity is insufficient to offer the solar energy required for proper photosynthetic process.

3- *Leuceana leucocephala*

Under partial shade (50%) all growth parameters except for the root length, nodule fresh and dry weight significantly out yielded those under direct sunlight (Table 3.1). The study showed that there were highly significant differences between different watering intervals, as the watering interval increased from 3to 6 to 9 days all parameters decreased (Table 3.2). Sheikh and Khan (1985) demonstrated that in a nursery experiment the plant height, growth and biomass production of *Leuceana leucocephala* seedlings were improved with increasing irrigation. The results of the study indicate that stem length decreased as the light intensity increased, on average the stem length ranges between 17.3 and 6.1 under direct sunlight, whereas the stem length ranges between 61.5 and 39.3 cm under partial shade. Stem and root dry weight under partial shade significantly out yield those under direct sun light. The combination of 50% light intensity and watering every 3 days gave high stem length and high nodules, shoot and root dry weight (Table 3.3). Leuceana *leucocephala* seemed to be a shade demanded during its juvenile stage. In contrast, extended watering intervals negatively affected seedlings growth, likely due to water stress that hampers physiological processes such as nutrient uptake and photosynthesis. According to Bargali and Tewari (2004), the small size, shallow roots and little food storage make seedlings less tolerant to harsh environments.

Recommendations

More research is needed in the physiology and growth of legume trees to follow their field performance and adaptation is required. The study recommends the following combination of treatments for raising well established nursery seedlings of the 3 species:

- For Sesbania Formosa and Sesbania sesban it is recommended to sow seeds under direct sun light (100% light intensity) and providing watering every 3 days.
- For Leuceana leucocephala it is recommended to be sown under partial shade (50% light intensity) and providing watering every 3 days.

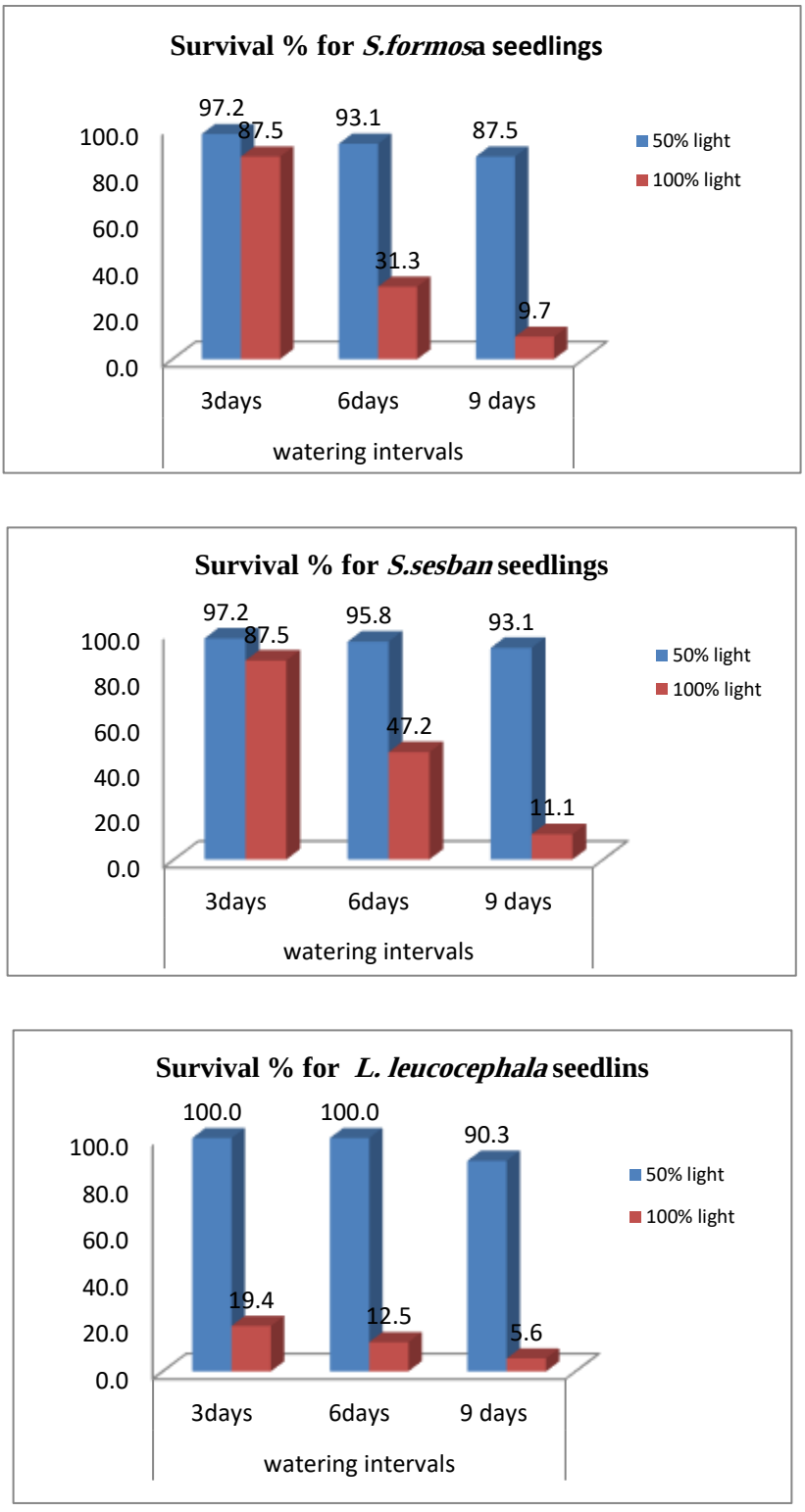

Fig. 1 Survival percentage of the three tree seedlings after three months

Table 1.1: Effect of light intensity on *Sesbania formosa* seedling growth parameters

Parameter	100% Light inte	50% Light inter	S.E+/-	Sig
Leave numbe	6.5	7.73	0.175	*
Stem length (cn	14.5	28.6	0.855	**
Root length (cn	26.6	26.2	3.0	Ns
Nodules numb	15.1	5.2	0.318	**
Fresh weight (g				
Leaves	2.49	1.74	0.103	*
Stem	4.4	3.12	0.272	*
Shoot	1.83	1.38	0.115	Ns
Root	2.61	0.523	0.075	**
Nodules	0.118	0.017	0.002	***
Dry weight (g)				
Leaves	0.61	0.472	0.054	Ns
Stem	0.360	0.357	0.017	Ns
Shoot	0.97	0.83	0.091	Ns
Root	0.924	0.303	0.056	*
Nodules	0.0573	0.0139	0.005	*

Ns: Not significant. *, **, *** Significant at $p \leq 0.05$, 0.01 and 0.001 respectively.

Table 1.2: Effect of watering intervals on *Sesbania formosa* seedling growth parameters

Parameter	Watering intervals			S.E+/-	Sig
	3-days	6-days	9-days		
Leave number	8.8	6.8	5.73	0.45	***
Stem length (cm	32.7	19.4	12.5	1.71	***
Root length (cm	31.1	25.2	23.03	1.47	**
Nodules numbe	20.7	6.05	3.67	0.86	***
Fresh weight (g)					
Leaves	4.27	1.06	1.022	0.159	***
Stem	8.03	1.82	1.42	0.314	***
Shoot	3.65	0.76	0.399	0.143	**
Root	3.88	0.51	0.31	0.17	***
Nodules	0.179	0.016	0.008	0.004	***
Dry weight(g)					
Leaves	1.072	0.311	0.24	0.064	***
Stem	0.809	0.210	0.056	0.024	***
Shoot	1.81	0.522	0.26	0.121	***
Root	1.36	0.341	0.14	0.044	***
Nodules	0.094	0.008	0.006	0.005	***

** , *** Significant at $p \leq 0.01$ and 0.001 respectively.

Table 1.3: Effect of light intensity, watering intervals on *Sesbania formosa* seedling growth parameters

Ns: Not significant. *, *** Significant at $p \leq 0.05$, and 0.001 respectively

Treatments	Growth parameters				Fresh weight (g/seedling)			Dry weight (g/seedling)		
Light*watering	Leave num	Stem lengt (cm)	Root lengt (cm)	Nodules nu	Shoot	Root	Nodul	Shoot	Root	Nodul
100X 3-day	9.2	23.6	30.2	29.7	9.56	6.5	0.318	2.2	2.02	0.15
100x6-day	5.23	12.7	25.1	8.3	1.91	0.85	0.020	0.5	0.042	0.012
100x9-day	5.93	7.1	24.5	7.3	1.73	0.49	0.015	0.26	0.21	0.011
50 x 3-day	9.33	41.8	31.9	11.8	6.51	1.26	0.039	1.61	0.69	0.04
50 x 6-day	8.33	26.1	25.2	3.8	1.73	0.177	0.012	0.55	0.14	0.003
50 x 9-day	5.53	18.0	21.6	0	1.12	0.127	0	0.33	0.072	0
S.E+/-	0.547	2.15	3.45	1.05	0.454	0.120	0.005	0.116	0.075	0.007
Sig	*	ns	Ns	***	***	***	***	*	***	***
C.V%	11	7	9.7	14.7	14.5	18.8	9.3	16.2	12.4	23.5

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Table 2.1: Effect of light intensity on *Sesbania sesban* seedling growth parameters

Parameter	100% Light inte	50% Light inter	S.E+/-	Sig
Leave numbe	19.6	13.2	1.24	*
Stem length (cn	33.3	53	1.24	*
Root length (cn	27.1	25.2	1.28	Ns
Nodules numb	20.4	2.8	1.25	**
Fresh weight (g				
Leaves	2.73	0.99	0.104	*
Stem	6.42	2.6	0.136	**
Shoot	3.69	1.6	0.037	***
Root	3.28	0.641	0.057	***
Nodules	0.079	0.033	0.005	*
Dry weight (g)				
Leaves	0.691	0.23	0.014	**
Stem	1.127	0.626	0.031	*
Shoot	1.82	0.85	0.05	*
Root	1.304	0.266	0.012	***
Nodules	0.044	0	0.005	0.027

Ns: Not significant. *, **, *** Significant at $p \leq 0.05$, 0.01 and 0.001 respectively.

Table 2.2: Effect of watering intervals on *Sesbania sesban* seedling growth parameters

Parameter	Watering intervals			S.E+/-	Sig
	3-days	6-days	9-days		
Leave number	24.1	13.4	12.4	0.99	***
Stem length (cm	59.6	40.2	29.7	0.99	***
Root length (cm	29.9	24.6	23.9	0.92	**
Nodules numbe	18.9	7.9	8	0.51	***
Fresh weight (g)					
Leaves	4.07	0.922	0.59	0.103	***
Stem	9.7	2.48	1.39	0.188	***
Shoot	5.59	1.56	0.79	0.098	***
Root	4.802	0.707	0.371	0.084	***
Nodules	0.151	0.009	0.009	0.005	***
Dry weight(g)					
Leaves	0.965	0.263	0.154	0.022	***
Stem	1.87	0.536	0.226	0.067	***
Shoot	2.83	0.79	0.38	0.084	***
Root	1.69	0.419	0.244	0.055	***
Nodules	0.048	0.013	0.006	0.001	***

** , *** Significant at $p \leq 0.01$ and 0.001 respectively.

Table 2.3: Effect of light intensity and watering intervals on *Sesbania sesban* seedling growth parameters

Ns: Not significant*** Significant at p ≤ 0.001.

Treatments	Growth parameters				Fresh weight (g/seedling)			Dry weight (g/seedling)		
Light*watering	Leave num	Stem lengtl (cm)	Root lengt (cm)	Nodules nu	Shoot	Root	Nodule	Shoc	Root	Nodule
100X 3-day	31.2	55.5	30.8	29.5	8.59	8.04	0.202	4.32	2.86	0.095
100x6-day	13.3	24.6	24.7	15.8	1.56	1.17	0.018	0.75	0.653	0.025
100x9-day	14.2	19.7	25.8	16	0.9	0.63	0.017	0.38	0.401	0.012
50 x 3-day	17	63.7	29	8.4	2.59	1.57	0.1	1.35	0.527	0.001
50 x 6-day	13.5	55.8	24.4	0	1.55	0.25	0	0.82	0.185	0
50 x 9-day	10.6	39.6	22.1	0	0.68	0.11	0	0.38	0.088	0
S.E+/-	1.21	1.68	1.66	0.9	0.168	0.159	0.011	0.10	0.091	0.008
Sig	***	***	Ns	**	***	***	***	***	***	***
C.V%	11	5.6	8.6	10.8	9	10.5	23.6	15.5	17.1	12.5

Table 3.1: Effect of light intensity on *Leuceana leucocephala* seedling growth parameters

Parameter	100% Light inte	50% Light inter	S.E+/-	Sig
Leave numbe	7.4	13.2	0.12	***
Stem length (cn	10.6	49.7	0.83	***
Root length (cn	26.6	29.5	1.48	Ns
Nodules numb	10.2	15.6	0.91	Ns
Fresh weight (g				
Leaves	0.89	2.86	0.093	**
Stem	0.52	1.88	0.103	*
Shoot	1.41	4.66	0.141	**
Root	0.76	1.37	0.028	**
Nodules	0.051	1.03	0.005	Ns
Dry weight (g)				
Leaves	0.3	1.15	0.033	**
Stem	0.24	1.02	0.039	*
Shoot	0.541	2.7	0.171	**
Root	0.37	0.79	0.041	*
Nodules	0.025	0.023	0.12	Ns

Ns: Not significant. *, **, *** Significant at $p \leq 0.05$, 0.01 and 0.001 respectively.

Table 3.2: Effect of watering intervals on *Leuceana leucocephala* seedling growth parameters

Parameter	Watering interval			S.E+/-	Sig
	3-days	6-days	9-days		
Leave number	14.2	8.9	7.7	0.61	***
Stem length (cm	39.4	28.3	22.7	1.09	***
Root length (cm	34.2	17.6	22.2	1.0	***
Nodules numbe	31.8	4.2	2.8	0.62	***
Fresh weight (g)					
Leaves	2.83	1.68	1.11	0.136	***
Stem	2.02	1.01	0.57	0.061	***
Shoot	4.73	2.69	1.68	0.149	***
Root	2.14	0.63	0.42	0.079	***
Nodules	0.11	0.01	0.002	0.002	***
Dry weight(g)					
Leaves	1.16	0.61	0.41	0.03	***
Stem	1.09	0.51	0.29	0.043	***
Shoot	2.247	1.117	0.703	0.055	***
Root	1.12	0.37	0.26	0.037	***
Nodules	0.064	0.005	0.004	0.0019	***

*** Significant at $p \leq 0.001$

Table 3.3: Effect of light intensity, watering intervals on *Leuceana leucocephala* seedling growth parameters

Treatments	Growth parameters				Fresh weight (g/seedling)			Dry weight (g/seedling)		
Light*waterir	Leave num	Stem lengt (cm)	Root lengt (cm)	Nodules nu	Shoo	Root	Nodule	Shoo	Root	Nodul
100X 3-day	14	17.3	39.7	29.8	3.35	2.0	0.15	1.27	0.94	0.074
100x6-day	3.9	8.5	21.9	0.9	0.63	0.17	0.004	0.25	0.11	0.001
100x9-day	4.2	6.1	18.1	0	0.27	0.1	0	0.11	0.07	0.001
50 x 3-day	14.4	61.5	28.8	33.8	6.12	2.3	0.07	3.2	1.3	0.054
50 x 6-day	13.9	48.2	33.3	7.4	4.76	1.09	0.017	1.99	0.62	0.008
50 x 9-day	11.3	39.3	26.3	5.6	3.1	0.74	0.004	1.3	0.44	0.006
S.E+/-	1.07	1.51	1.88	1.16	0.22	0.1	0.005	0.1	0.06	0.004
Sig	**	*	***	Ns	*	Ns	***	**	Ns	**
C.V%	14.6	8.9	8.8	11.8	12	18.2	13	10	15.6	19.5

Ns: Not significant. *, **, *** Significant at $p \leq 0.05$, 0.01 and 0.001 respectively.

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Research paper

Effect of Different Rates of NPK Fertilizer on Growth and Hardening of Banana Plantlets

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Abstract

The experiment was carried out to improve the quality of banana cv. Grand Nain plantlets produced by tissue culture in greenhouse during January to April of 2022 and 2023. Five doses of NPK (20:20:20) viz: 0, 2, 4, 6 and 8 g/plant were applied. The treatments were replicated 3 times in randomized complete design (RCD) and each plot encompassed 4 plants. The results showed that the different rates of NPK affected growth parameters, roots length and number of roots per plant of banana plantlets. The highest values of plant height, plant girth, number of leaves per plant, roots length, root girth and number of roots per plant were obtained with 6 g/plant compared to control for the two seasons. Using of NPK fertilizer at rate of 6 g/plant was the most stable and economically feasible treatment.

Keywords*: plantlets, banana, hardening, grand nain.*

اثر جرعات مختلفة من السماد المركب NPK علي نمو وتاقلم نبتات الموز

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المستخلص

نفذت التجربة لتحسين نوعية نبتات الموز صنف القراند نين المنتجة نسيجيا بزراعة في البيوت المحمية خلال الفترة من يناير إلى أبريل من عام 2022 و 2023. تم تطبيق خمس جرعات من سماد NPK (20:20:20) وهي: 0، 2، 4، 6 و 8 جم / نبته. تم تكرار المعاملات 3 مرات في التصميم العشوائي الكامل وتضمنت كل قطعة 4 نبتات. أظهرت النتائج أن الجرعات المختلفة من سماد NPK أثرت على مؤشرات النمو وطول الجذور وعدد الجذور لكل نبته من نبتات الموز. تم الحصول على أعلى قيم لطول النبتات، سمك النبتات، عدد الأوراق لكل نبته، طول الجذور، سمك الجذر وعدد الجذور لكل نبته عند 6 جم/نبته مقارنة بالشاهد في الموسمين. كان استخدام سماد NPK بمعدل 6 جم/نبته هو العلاج الأكثر استقرارًا والأكثر جدوى اقتصاديًا.

كلمات مفتاحية: *نبتات, الموز, الاقلمة, قراند نين.*

Introduction

Banana is classified economically as the fifth most important agricultural crop in global trade which is significant fruit crop cultivated in the tropical and sub-tropical regions (Tarek, *et al*., 2022). Banana fruits have excellent nutritional value due to their high content of carbohydrates, minerals, and vitamins.

In Sudan banana is a popular fruit and is an important commercial fruit crop. It is the cheapest and plentiful fruit throughout the year (Ehassan *et al*., 2005).

Banana need high requirement of NPK-fertilizers for maximum yield production. Meanwhile, fertilization aims to provide nutrients for optimal plantlet productivity through the application on the leaves or the soil (Rina, 2021).

Integrated nutrient applications not only ensure the supply of essential nutrients to plants but also have some positive interactions to increase nutrient use efficiency and reduce environmental hazards (Bewuket *et al*., 2017). The application of all needed nutrients through fertilizers is known to have deleterious effect on soil fertility leading to unsustainable yields, while integration of fertilizers is able to maintain the health, productivity and fertility of the soil (Yadav *et al*., 2017).

Acclimatization of banana plantlets it very important step and there is need to study the effect of different rates of NPK fertilizer on the quality of the banana plantlets. Therefore, the objective of this study was to evaluate the effects of different rates of NPK on growth of banana plantlets under greenhouse.

Material and Methods

The objective of this study was to determine the effect of different rates of NPK on growth of banana plantlets under greenhouse during January to April of 2022 and 2023. The sources of plant material employed in the study were *in vitro* plantlets of 'Grand Naine' banana cultivar produced in the Tissue Culture Laboratory of Kassala and Gash Research Station. The plantlets were uniform in size and raised in 18×20cm black polyethylene bags. Five doses of NPK (20:20:20) *viz*: 0, 2, 4, 6 and 8 g/ plant were applied to the plantlets at 2 weeks after transplanting in the greenhouse. The treatments were replicated 3 times in randomized complete design (RCD) and each plot encompassed 4 plants.

The plant height (cm), plant girth (cm), number of leaves/plant, leaf length (cm) and leaf width (cm) were recorded at 1.5 month and at the end of experiment. Root length (cm), root girth (cm) and number of roots per plant were recorded at the end of experiment.

Marginal rate of return was analyzed according to CIMMYT (1988) and used the field information and data collected for evaluation.

Data was subjected to analysis of variance procedures. Treatment means were separated using Duncans Multiple Range Test at 5% level of significance.

Results and Discussion

Effect of different rates of NPK fertilizer on plant height, plant girth and number of leaves per plant of banana plantlets

Plant height, plant girth and number of leaves per plant of banana plantlets showed highly significant differences in both seasons at 6 and 12 weeks after planting (Table 1 and 2). The highest values of plant height, plant girth and number of leaves per plant were recorded under 6 g/NPK/plant, while the lowest were obtained with control (0 g/NPK/plant) on both seasons at 6 and 12 weeks after planting (Table 1 and 2). The values of plant height, plant girth and number of leaves per plant were increased with NPK rates until 6 g/plant and then decreased. The improvement on plant height, plant girth and number of leaves per plant might be due the effective role of NPK fertilizer in enhancing the growth of banana planets. These results are supported by those of Xiukang and Yingying (2016) who reported that the rates of NPK fertilizer has very significant influence on plant height, stem diameter and number of leaves of tomato. Moreover, Abdallah and Mohammed (2021) found that NPK fertilizer improved plant height, plant girth and number of leaves.

Table 1. Effect of different rates of NPK fertilizer on plant height, plant girth and number of leaves of banana plantlet cv. Grand Nain after 6 weeks from planting

NPK rates (g/plant)	Plant height (cm)		Plant girth (cm)		No. of leaves/plant	
	Season one	Season Two	Season one	Season two	Season one	Season two
0	8.5d	7.4d	0.83c	0.58d	2.3c	2.6e
2	9.0cd	8.3c	0.93c	0.68c	2.5bc	3.9d
4	9.5c	8.7c	1.10b	0.74c	2.6bc	4.4c
6	12.4a	10.5a	1.30a	1.10a	3.10a	5.8a
8	10.5b	9.6b	1.20ab	0.98b	2.8ab	5.3b
Significant level	***	***	***	***	**	***
$SE^{\pm}$	0.26	0.20	0.04	0.02	0.13	0.11
CV%	4.50	3.95	7.26	4.50	8.26	4.37

*** and ***indicate significance at P< 0.01 and P< 0.001, respectively.*

Table 2. Effect of different rates of NPK fertilizer on plant height, plant girth and number of leaves of banana plantlet cv. Grand Nain after 12 weeks from planting

NPK rates (g/plant)	Plant height (cm)		Plant girth (cm)		No. of leaves/plant	
	Season one	Season Two	Season one	Season two	Season one	Season two
0	27.0d	26.0c	3.3d	1.9d	5.0d	5.3d
2	28.0d	27.0c	3.6c	2.8c	8.0c	6.3c
4	30.0c	31.3b	3.9b	3.8b	8.7bc	7.8b
6	34.0a	43.7a	4.5a	4.8a	10.0a	8.5a
8	32.0b	35.0b	4.3a	4.5a	9.3ab	8.3a
Significant level	***	***	***	***	***	***
$SE^{\pm}$	0.58	1.17	0.08	0.09	0.42	0.13
CV%	3.31	3.60	3.73	4.52	8.91	3.01

****indicate significance at P< 0.001.*

Effect of different rates of NPK fertilizer on leaf length and leaf width of banana plantlets

Results obtained showed significant differences in leaf length and leaf width in both seasons at 6 and 12 weeks after planting (Table 3 and 4). The leaf length and leaf width were increased with increased NPK rates and there is no significant differences between 6 g/NPK/plant and 8 g/NPK/plant (Table 3 and 4). This could be attributed to adequate nutrient supply which might improve cell enlargement and cell division. These results are in agreement with Khalid and Rashid, (2009) who reported that leaf parameters of non-fertilized control plants were not significantly different when compared to fertilized banana plants. Khalifa *et al*. (2021) who reported that leaves parameters were increased with NPK doses of cucumber.

Table 3. Effect of different rates of NPK fertilizer on leaf length and leaf width of banana plantlet cv. Grand Nain after 6 weeks month from planting

NPK rates (g/plant)	Leaf length (cm)		Leaf width (cm)	
	Season one	Season two	Season one	Season Two
0	3.6d	6.7c	2.1d	3.3d
2	4.4c	8.0b	2.7c	4.3c
4	4.8c	8.5ab	3.2b	5.0bc
6	6.8a	9.5a	3.8a	6.0a
8	5.8b	9.0ab	3.3b	5.5ab
Significant level	***	***	***	***
$SE^{\pm}$	0.13	0.32	0.12	0.24
CV%	4.35	6.75	6.74	8.79

****indicate significance at P< 0.001.*

Table 4. Effect of different rates of NPK fertilizer on leaf length and leaf width of banana plantlet cv. Grand Nain after 12 weeks from planting

NPK rates (g/plant)	Leaf length (cm)		Leaf width (cm)	
	Season one	Season two	Season one	Season Two
0	12.7c	17.3b	6.3d	7.8d
2	13.0c	18.7b	9.7c	10.3c
4	17.0b	19.0ab	10.8b	11.4b
6	21.0a	22.0a	12.0a	12.5a
8	19.0ab	20.0ab	11.6a	11.6b
Significant level	***	*	***	***
$SE^{\pm}$	0.75	0.95	0.15	0.15
CV%	7.81	8.52	2.57	2.48

*** and ****indicate significance at P< 0.05 and P< 0.001, respectively.*

Effect of different rates of NPK fertilizer on roots length, root girth and number of roots per plant of banana plantlets

Table 5 showed very high significant differences in roots length, root girth and number of roots per plant in both seasons at 12 weeks after planting. The highest values of roots length, root girth and number of roots per plant were recorded under 6 g/NPK/plant compared to control (0 g/NPK/plant) (Table 5 and 6). This finding indicated that using of NPK fertilizer has great effect on root length, root girth and number of roots per plant of banana plantlets. These results are in conformity with the findings of Abdallah and Mohammed (2021). Moreover, Idris *et al*. (2015) reported that, nitrogen combined with sulphur resulted in significantly higher roots length, roots number and root girth compared to control of banana plantlets.

Table 5. Effect of different rates of NPK fertilizer on root length, root girth and number of roots per plant of banana plantlet cv. Grand Nain after 12 weeks from planting

NPK rates (g/plant)	Root length (cm)		Root girth (cm)		Number of roots/plant	
	Season one	Season two	Season one	Season two	Season one	Season two
0	17.0d	15.0e	0.35c	0.20d	9.7d	10.0d
2	18.0d	17.0d	0.45b	0.24d	12.7c	13.0c
4	20.0c	19.0c	0.45b	0.30c	13.7c	14.0c
6	29.3a	26.0a	0.70a	0.53a	21.7a	27.0a
8	25.0b	24.0b	0.65a	0.35b	18.0b	19.7b
Significant level	***	***	***	***	***	***
$SE^{\pm}$	0.49	0.58	0.22	0.01	0.75	0.83
CV%	3.90	4.95	7.42	6.31	8.53	8.59

****indicate significance at P< 0.001.*

Economic evaluation

In determining the most economically acceptable treatment, partial, dominance and marginal analysis were conducted for data of banana cv. Grand Nain plantlets produced by tissue culture in greenhouse using market prices for plantlets and NPK fertilizer. All costs and returns were calculated on per-1000 planets basis in SDG. Results showed treatment of application of NPK at 6 g/plant resulted in the highest return of investment. Return to investment in this treatment was estimated in the form of marginal rate of return (MRR), which came out to be 64.4 for 1000 planets at price 2000 SDG for 1 planets (Tables 6 to 8).

Therefore, the economic evaluation based on partial budget and marginal analysis indicated that using of NPK fertilizer at rate of 6 g/plant was the most stable and economically feasible treatment.

Table 6 Effect of different rates of NPK fertilizer on economic analysis of banana plantlets

No	Particulars	NPK rates (g/plant)				
		0	2	4	6	8
1	Variable cost (SDG/1000plantlets)					
	Total fertilizer (kg) for 1000plantlets	0	2	4	6	8
	Fertilizer	0	6400	12800	19200	25600
	Fertilizer application	0	1250	2500	3750	5000
2	Total Cost (SDG/1000plantlets)	0	7650	15300	22950	30600
	Plantlets height (cm)	27	28	31	39	34
	Plantlets price (SDG)	1000	1000	1500	2000	1500
3	Gross return (SDG/1000 plantlets)	1000000	1000000	1500000	2000000	1500000
4	Net return (SDG/1000 plantlets)	1000000	992350	1484700	1977050	1469400

Table 7 Partial and dominance analysis for banana plantlets produced in greenhouse

Total fertilizer (kg) for 1000plantlets	Gross return (SDG/1000 plantlets)	Total variable Cost (SDG/1000 plantlets)	Net return (SDG/1000 plantlets)	Dominated
0	1000000	0	1000000	
2	1000000	7650	992350	D
4	1500000	15300	1484700	
6	2000000	22950	1977050	
8	1500000	30600	1469400	D

Table 8. Marginal analysis for banana plantlets produced in greenhouse

Total fertilizer (kg) for 1000plantlets	Gross return (SDG/1000 plantlets)	Total Cost variable (SDG/1000 plantlets)	Net return (SDG/1000 plantlets)	MC	MR	MRR
0	1000000	0	1000000			
4	1500000	15300	1484700	15300	484700	31.7
6	2000000	22950	1977050	7650	492350	64.4

Conclusion

The highest growth parameters, roots length, root girth, number of root per plant and highest marginal rate of return of banana plantlets were obtained under 6 g/NPK/plant.

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Research paper

Effect of Seed Storage Period and Seed bed Covering Methods on Jackfruit (*Artocarpus heterophyllus* Lam.) Germination under River Nile State Conditions

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Abstract

The study was carried out at Hudeiba Research Station (HRS), River Nile state, Sudan during the period July – December of 2023. to evaluate jackfruit seed germination as affected by post extraction storage period and the best seed bed covering for proper seed germination. Best germination and growth results obtained from the shorter seed storage period without or with mango leave covering.

Keywords: *Jackfruit, germination, seed storage, seed bed covering*

تأثير فترة تخزين البذور وطرق تغطية مهد البذور على إنبات الجاك فروت(*Artocarpus heterophyllus* Lam.) تحت ظروف ولاية نهر النيل

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المستخلص

أجريت الدراسة في محطة أبحاث الحديبة بولاية نهر النيل بالسودان خلال الفترة من يوليو إلى ديسمبر 2023 لتقييم إنبات بذور الجاك فروت بعد فترات تخزين مختلفة ما بعد الاستخلاص وأفضل غطاء لمهد البذور يمكن من أنبات البذور بشكل صحيح .تم الحصول على أفضل نتائج الإنبات والنمو من فترة تخزين البذور الأقصر بدون أو مع تغطية أوراق المانجو

الكلمات المفتاحية: *الجاك فروت، الإنبات، تخزين البذور، تغطية مهد البذور*

Introduction

Jackfruit, *(Artocarpus heterophyllus*) belongs to family Moraceae. It is native to tropical Asia and widely grown throughout the wetland tropics for its huge edible fruits and robust wood. The unripe fruit is cooked as a vegetable. However, ripped fruit become brown in color and eaten fresh for the sweetly acid but insipid pulp surrounding the seeds. Seeds may be also cooked and eaten. Jackfruit is considered a staple food crop in Bangladesh and other areas in South and Southeast Asia. Canned or processed jackfruit has gained popularity as a meat substitute in some places **)**Petruzzello 2023). The tree reaches 15 to 20 meters tall at maturity. The leaves are large and stiff lustrous and green, 15 to 20 cm long. Flowers are small unisexual borne on compact inflorescences that emerge directly from the trunk and branches. The tree is from the largest fruit tree in the world and its fruit reach up to 60 cm long and weighing up to 18 kg. ellipsoidal and aggregate in shape, composed of multiple "bulbs" of seed-containing flesh around a gristly core, all of which is enclosed by a rough rind, which is green or yellow and spikey. The pulp inside the fruit smells and tastes in aroma between pineapple and bananas (Petruzzello 2023). Seeds are plenty and may reach up to 500 in the fruit. Each can reach an inch and a half in length. There are two main types of jackfruits. One is small and mushy. It tastes sweet, but it's slimy. The other type of jackfruit has crisp, crunchy flesh that's not as sweet as the small one. (Kathleen *et al*. 2021). The plant is considered promising to bridge the gap of food shortage and nutritional security. (Ojwang *et al*., 2022).

Information about jack fruit germination is meager and limited. Loss of seed viability in short storage period is encountered in Jack fruit. Jackfruit Seeds rapidly lose their viability due to seed desiccation or moisture loss. Poor germination will soon be a result from even a short period delay in pre planting seed storage. Jackfruit seeds are said to be recalcitrant in nature. Recalcitrant seeds are relatively containing high moisture content and possess a characteristic feature of losing their viability during desiccation (Chin and Roberts, 1980).

Gawankar and Haldavanekar, (2020) Studied the critical moisture loss percentage for viability of jackfruit seeds under ambient storage condition for 15, 30, 60, 90, 120 and 150 days revealed that maximum germination percentage (53.25 %) was recorded with minimum water loss (18.51 %) when jackfruit seeds stored at 15 days storage period.

The objective of this study is to evaluate jackfruit seed germination as affected by post extraction storage period and the best seed bed covering for proper seed germination.

Materials and methods

Nursery experiment was carried out at Hudeiba Research Station (HRS), River Nile state during the period July – December of 2023. Site coordinates are 17˚34' N and 23˚56' E with an altitude of 351 meter above sea level. The climate is described as hot climate with only a short (100-110 day) winter season. The experiment was laid in factorial experiment (RCBD) with three replicates,

covering methods as main factor (without covering, white plastic and mango leaves coverings) and time after extraction (storage period) as second factor (one week, four week and seven weeks after extraction). Seeds were planted in plastic bags 50X40 cm diameter and in 2.53 cm depth and irrigated 2 time weekly. Soil mix was river loam and sand 2 to 1, Thirty-six seed were planted in each treatment. All germinated plants per treatment were used for measurement of vegetative growth parameters as follows:-.

Germination percentage, germination index, plant height (cm) after 6 months in nursery, number of leaves/plant 45 days after planting, number of leaves/plant 6 months after planting. Leaf length and leaf width 6 months after planting.

Seed Germination was counted two times The first one after 30 days and the second one After 6 months. The germination index was counted as+ No. of seed germinated at first count divided by No. of days pus Seed germinated at second count divided by no. of days.

The data collected were statistically analyzed using M Stat computer software and means were separated by Duncan Multiple range Test (DMRT) Weber *et al*. (1966). **Results and Discussion**

Results in Table (1) showed that there was significant difference in germination % due to different seed storage periods and seed bed covering. The highest germination percent resulted from seeds planted after one week storage without covering treatment (80.0) followed by the 4 weeks storage without overing and one week storage with mango leaves covering (45.0). Plastic covering registered zero germination with all seed storage periods.

The results obtained agree with Chaudhari *et al.*, (2022) who reported that Jack fruit germination was affected by storage period and the germination percentage ranged between 81.6 for zero days to 53. For 10 days storage period. (Elevitch and Hareley, 2006) also obtained similar results. On the other hand, Gawankar *et al.* (2019) reported that growing media affected germination percentage, number of leaves, leaf girth and all vegetative growth of jackfruit. Zero germination may indicate that it keeps seed bed too moist and hot for normal germination.

Table (1): Effect of seed storage period and seed bed covering on Jack fruit germination percentage under River Nile State Conditions

Seed bed covering	**Planting after seed storage period**			
	At one week	**At 4 weeks**	**At 7 weeks**	**Mean**
Without covering	80.0	45.0	0.0	41.0
Mango leaf covering	45.0	13.0	0.0	19.0
White plaslic covering	0.0	0.0	0.0	0.0
Mean	41.0	19.0	0.0	
CV%	83.37			
Sig level	A***	B***		
SE±A	5.66			
SE±B	5.66			
SE±AB	9.81			

Results in Table (2) showed that there were significant differences in germination index as affected by seed storage periods and methods of covering. The highest germination index resulted from sowing after one week storage without covering treatment (0.031) followed by the 4 weeks storage period without covering and first week sowing with mango leaves covering (0.017). Plastic covering registered zero germination indexes from the three seed storage planting. Results obtained were in line with that of (Begum and Hague 2017) who found that the germination index significantly affected by the seed storage period.

Table (2): Effect of seed storage period and methods of seed bed covering on Jack fruit seed germination index after 6 months under River Nile State Conditions

Seed bed covering	**Planting after seed storage period**			
	At one week	**At 4 weeks**	**At 7 weeks**	**Mean**
Without c	0.031	0.017	0.000	0.016***
Mango leaf c	0.017	0.005	0.000	0.007**
White plaslic c	0.000	0.000	0.000	0.000***
Mean**	0.016	0.007	0.000	***
CV %	83.3			
Sig level	***	***		
SE± for facter A	0.0022			
SE± for facter B	0.0022			
SE± for AXB	0.0022			

Results in Table (3) indicated that number of leaves as counted 45 days after sowing were significantly affected by different seed storage period and covering methods, first week sowing without covering and with mango covering showed the highest number of leaves (4.0) followed by 4 weeks storage period (2.7). Chaudhari *et al.* (2022) obtained a greater number of leaves (6.8 to 5.8) in shorter storage period. He stated that number of leaves and germination percentage usually affected by seed storage period. Results obtained was also in line with Gawankar *et al.* (2019) who reported that growing media affected number of leaves, leaf girth and all vegetative growth of jackfruit.

Table (3): Effect of seed storage period and seed bed covering on Jack fruit number of leaves after 45 days under River Nile State Conditions.

Seed bed covering	**Planting after seed storage period**			
	At one week	**At 4 weeks**	**At 7 weeks**	**Mean**
Without c	4.0	2.7	0.0	2.2
Mango leaf c	4.0	1.3	0.0	1.8
White plaslic c	0.0	0.0	0.0	0.0
Mean	2.7	1.3	0.0	
CV%	79.06			
Sig level	***	***		
SE ± A	0.3514			
SE± B	0.3514			
SE±AB	0.3514			

Table (4) showed number of leaves as counted 6 months after sowing. There were significant differences between different periods of seed storage and covering methods, first week sowing without covering and with mango covering showed the highest number of leaves (9.667 and 9.333) followed by 4 weeks storage period without seed bd covering (7). Better growing conditions of uncovered and mango leave covered seed bed with good aeration may enhance increased number of leaves.

Table (4): Effect of seed storage period and seed bed covering on Jack fruit number of leaves after 6 months under River Nile State Conditions

Seed bed covering	Planting after seed storage period			
	At one week	At 4 weeks	At 7 weeks	Mean
Without c	9.667	7.000	0.000	6.667
Mango leaf c	9.333	3.000	0.000	5.444
White plaslic c	0.000	0.000	0.000	0.000
Mean	5.6	3.1	0.000	
CV%	85.95			
Sig level	***	****		
SE±A	0.9550			
SE± B	0.9550			
SE± AB	1.6541			

Results in table (5) showed that plant height (cm) as taken 45 days after sowing was significantly differing according to different periods of seed storage and covering methods, One week storage sown seeds without covering showed the highest plant height (51.7 cm) followed by one week stored seeds with mango covering. This result seems to be in line with that registered by (Elevitch and Hareley 2006) who reported that jackfruit reached 25 cm height within 3-4 moths and also agree with Gawankar *et al.* (2019) who reported that growing media affected all vegetative growth of Jackfruit and plant height range from 38-62cm at 60 days.

Table (5): Effect of seed storage period and seed bed covering on Jack fruit plant height (cm) after 6 months under River Nile State Conditions

Seed bed covering	Planting after seed storage period			
	At one week	At 4 weeks	At 7 weeks	Mean
Without c	51.7	36.0	0	29.2
Mango leaf c	38.3	18.7	0	19.0
White plaslic c	0.0	0.0	0.0	0.0
Mean	30.2	18.0	0.0	
CV%	104.50			
Sig leve				
SE± A*	5.554			
SE± B N.S	5.554			
SE± AB	9.6948			

Leaf width (cm) as counted 6 months after sowing was significantly differ according to periods of seed storage and covering methods (Table6), one week stored seeds with mango covering showed the highest leaf width (4.8) followed by one week stored seeds without covering (4.7).

Results obtained seem to agree with Gawankar *et al.* (2019) who reported that growing media affected all vegetative growth of jackfruit

Table (6): Effect of seed storage period and seed bed covering on Jack fruit leaf width (cm) in 6 months after planting under River Nile State Conditions

Seed bed covering	Planting after seed storage period			
	At one week	At 4 weeks	At 7 weeks	Mean
Without c	4.7	3.3	0.0	4.0
Mango leaf c	4.8	1.3	0.0	3.5
White plaslic c	0.0	0.0	0.0	0.0
Mean	4.75	2.3	0.0	3.75
CV%	75.49			
Sig level	***	***	**	
SE±A	0.3961			
SE± B	0.3961			
SE±AB	0.6861			

Results in Table (7) showed significant differences between leaf length as affected by seed storage period and seed bed covering. The greater leaf length (18.0 cm) resulted in one week storage with mango leaves covering, followed by one week storage without covering. Result obtained agree with that of)Petruzzello 2023) who reported the jackfruit tree has large stiff glossy green leaves about 15 to 20 cm long and with Gawankar *et al.* (2019).

Table (7): Effect of seed storage period and seed bed covering on Jack fruit leaf length (cm) in 6 month after planting under River Nile State Conditions

Seed bed covering	Planting after seed storage period			
	At one week	At 4 weeks	At 7 weeks	Mean
Without c	15.0	10.0	0.0	8.3
Mango leaf c	18.0	4.7	0.0	7.6
White plaslic c	0.0	0.0	0.0	0.0
Mean	11.0	4.9	0.0	
C.v	76.59			
Sig level	***	***	**	
SE±A	1.3521			
SE± B	1.3521			

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Research paper

Effects of Urea Fertilizers and Chicken Manure on Growth and Yield of Carrot (*Dacaus carota* L)

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Abstract

This study was carried out at Dongola Research Station farm during winter season of 2015 / 16 and 2016/17 to evaluate the effect of chicken manure rate and urea fertilizer on growth and yield of carrot. treatments consisted of 12 levels of urea and chicken manure each alone or in combinations and untreated control. Results showed that all fertilization treatment effect on growth parameter (leaves number and leaves length) although positive was only statistically significant in season 2016/17. The combination of chicken manure and urea affected positively vegetative growth and root yield.

Keyword: *Fertilizer, organic manure, yield components, carrot*

تأثير أسمدة اليوريا وروث الدواجن على نمو و إنتاجية الجزر(*Dacaus carota* L)

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المستخلص

أجريت هذه الدراسة في مزرعة محطة أبحاث دنقلا خلال موسمي الشتاء 16/2015 و17/2016 لتقييم تأثير معدل سماد الدواجن وسماد اليوريا على نمو وإنتاجية الجزر .تكونت المعاملات من 12 مستوى من اليوريا وروث الدواجن كل على حدة أو في مجموعات ومعاملة حاكمة غير معالجة. أظهرت النتائج أن جميع معاملات التسميد تؤثر على مؤشرات النمو (عدد الأوراق وطول الأوراق) على الرغم من كونها إيجابية إلا أنها كانت ذات دلالة إحصائية فقط في موسم 17/2016 .أثر مزيج سماد الدواجن واليوريا بشكل إيجابي على النمو الخضري وإنتاجية الجذور .

الكلمات المفتاحية: التسميد، السماد العضوي، مكونات الغلة، الجزر

Introduction

Carrot (*Daucus carota L*) is a member of the family Umbelliferae. The carrot is one of the most important vegetable crops and the most widespread crop in the world compared to the crops of other species such as the White carrots, parsley, cactus, coriander, celery etc.(F.A.O, 2000). The crop originated in Southwest Asia and later spread throughout China and the Mediterranean basin (Kwabena, 2011). Carrot fleshy roots are used as vegetables for salads, soups and are also steamed or boiled in other vegetable dishes (Amjad *et al*., 2005). Besides the food value it is used for different medicinal purposes due to a wide range of reported pharmacological effects (Rossi *et al.*, 2007). Productivity and quality parameters of carrot root yield depend on cultivar, climatic, soil, and agronomic factor (Martin *et al*., 2004). However, the Carrots are reported to be high antioxidants and contain a lot of pro-vitamins A which can help to maintain the eyesight (CALU, *2007*).

Kristensen and Kristensen, (2002) reported that in sandy soil, combination of organic and inorganic fertilizers improves the soil structure and apart from this it also allows the shoulder of carrots to expand with ease. Manure is key factor in restoring the productivity of degraded soils as it supplies multiple nutrients, decreasing soil pH and improves soil organic matter, which in turn improves the physical and microbial properties of the soil (Zingore *et al.*, 2007). Generally, most carrot growers use organic and inorganic fertilizers to realize higher yields as opposed to the unfertilized fields, also organic manure likes cow dung improves soil texture, structure and aeration, inorganic fertilizer in combination with organic manures also increases the carrot yield (Rumpel *et al*.,1998).

The objective of this study is to investigate the effect of organic manure and urea on growth and yield of carrot cultivars namely (*Dacaus carota l)***.** And to determine the best dose of fertilizers which influence the yield and root characteristics.

Material and Methods

The experiment was conducted during the seasons of 2015/16 and 2016/17 in Dongola research station farm in the Northern state of Dongola locality (16^{o} :22 N and 20^{o}:32 E), Sudan. The soil was sandy clay loam in texture, deficient in nitrogen and phosphorus as well as low in organic matter. It was also found that the soil contained relatively moderate quantity of calcium carbonates and pH value of 7.11.

In this study carrot seeds variety (Chantenay Red Cored) produce of U.S.A was used for planting. The experimental design was randomized complete block design (RCBD) with four replications, treatment was designed into four replications. Each block was divided 12 plots distributed at random. Urea and chicken manure alone or in combination were applied.

Treatment were; control, 100,150 and 200 urea kg per ha, 1.2 and 2.4 tons of chicken manure per ha, combination of urea and chicken manure 2.4t/ha+ urea 100 kg, 2.4t/ha + urea 150 kg, 2.4t/ha + urea 200 kg.

chicken manure fertilizer, which was applied before planting. Spread in each plot and being incorporated thoroughly into the soil. Urea fertilizer was applied in two doses, the first dose one month after sowing and the seconds dose is one month after the first dose.

In each season the experimental site was tilled and ploughed, using disc harrow, then, leveled and divided into ridged plots. The seeds were sown during the 4th week of November in each season by hand on 70 cm ridge using spacing of 10 cm between plant. Irrigation and other cultural practices done as recommended by researchers.

The data collected were leaves length (cm), Number of leaves per plant, root length (cm), root diameter (cm), yield, from root yield randomly selected plants at harvest at the 50% flowering stage. The recorded data from agriculture till harvest was statistically analyzed, the means values for all the parameters were calculated and the analysis of variance for the characters was accomplished by F variance test, the significant of difference between pair of means was tested by the least significant difference (LSD), test at 5% and 1% levels of probability (Gomez and Gomez 1984).

Results and Discussion

Table (1) shows the effect of fertilizers on vegetative growth parameters. The result in season 2015/16 showed no significant differences between all treatments. However, in season 2016/17 results was significant. Most fertilizer treatments increased significantly leave length compared to the control, in season 2016/17 the result showed that, the highest leaves length (36.1 cm) was obtained by 1.2-ton chicken manure + 150 kg urea and the greater leaves number (16) was registered by 2.4 tons chicken manure + 200 kg urea. Such results agreed with that obtained by Robin, *et al* (2001) who reported higher rate of plant growth due to increased nitrogen supply, Brima (2007) who indicated positive effect of NPK and also agree with, Maurya and Goswamy (1985) they reported significant Increase in leaves length in carrot with the application of higher dose of nitrogen. Mbatha, (2008) also observed increased leaves length and leaf numbers of

carrots subjected to higher rates of different organic fertilizers (chicken, kraal and compost). Saad, (2009) found also significant effect of nitrogen fertilizer on mean leaves length.

Table (2) showed the effect of fertilizers on yield and yield component. Differences in length and diameter of carrot root were not significant in both seasons as affected by feralization treatments. However, root yield showed significant differences as affected by fertilizer application. The highest root yield was 36. 4 tons ha^{-1} obtained from 1.2 tons of chicken manure + 150 kg urea ha^{-1} in season 2015/16 and 34. 063 tons ha^{-1} obtained from 1.2 tons of chicken manure + 200 kg urea ha^{-1} in season 2016/17.

Dechassa *et al*., (2003); Mog (2007); Dawuda *et al*., **(**2011) obtained similar results of increased yield of carrot due to fertilizer application. Results also agree with the findings of Abdel-Mawly (2004) who stated that an increase in nitrogen rate increased yield and Ali *et al*., (2003) who stated that high rate of nitrogen and phosphorus increased the root yield of carrot.

Although results were not statistically significant, slight increase in root length and root diameter were noticed due to application of manure and urea. Findings of Rani and Reddy (2007), Kirad *et al*. (2010), Azad (2000) indicated similar enhancement in root diameter and root length with integrated use of organic manure which led to increased yield of roots.

In the current study, increased root yield in both season was a result of treatments affected positively green leaves which in turn direct photosynthetic assimilates into root growth as a result of increased nutrient content. Kang *et al*. (1990) discussed similar findings that high crop yield can be obtained with judicious and balanced NPK fertilization combined with organic matter accumulation.

Table (1) Effects of chicken manure and urea fertilizers on the vegetative growth (leaves length, number of leaves), of carrot crop:

Treatment	**Leaves length (cm)**		**NO. of leaves**	
Fertilizer rate	**first season**	**second season**	**First Season**	**second season**
Control	21.55	29.50	10.5	13
urea 100 kg/ha	30.025	34.56	11	13.75
urea 150kg/ha	27.50	31.36	11.25	12.75
urea 200kg/ha	31.125	34.48	10.75	13
1.2 t/ha manure	27.95	31.70	11	13.75
1.2t/ha + urea 100 kg	31.85	35.71	10.25	13.5
1.2t/ha + urea 150 kg	31.42	36.100	11.5	13.75
1.2t/ha + urea 200 kg	26.85	33.855	11.75	13.25
2.4 t/ha manure	26.80	30.37 8	12.25	13
2.4t/ha+ urea 100 kg	29.62	30.875	11.5	14
2.4t/ha + urea 150 kg	25.90	31.135	10.25	13.75
2.4t/ha + urea 200 kg	28.27	32	11.25	16.25
CV%	12.78%	%10.29	8.92%	13.78%
SE±	1.8467	1.688	0.4951	0.9402
LSD	5.313	4.858	1.424	2.705
Sig level	Ns	**	Ns	*

*.Mean significant difference**Means with high significant difference ,NS= Means with no significant difference

Table (2) Effect of chicken manure and urea fertilizers on yield and yield component of carrot roots

Treatment	Root length(cm)		Root diameter(cm)		Yield Ton h^{-1}	
Fertilizer rate	**first season**	**second season**	**first season**	**second season**	**first season**	**second season**
Control	21.125a	14.95	2.265	2.22	20.5bc	15.625c
urea 100 kg/ha	21.332	16.075	2.642	2.805	31.55abc	30.625a
urea 150 kg/ha	21.275	16.95	2.527	2.345	23.325bc	30a
urea200 kg/ha	21.813	15.575	2.728	2.495	33.988ab	32.813a
1.2t/ha manure	21.3	13.575	2.697	2.495	27.138abc	16.25bc
1.2t/ha+urea100 kg	19.65	14.4	2.743	2.81	30.4abc	30.938a
1.2t/ha+urea150 kg	20.563	14.85	2.993	2.645	36.512a	30.313a
1.2t/ha+urea200 kg	21.387	19.075	2.462	2.4	20.737bc	34.063a
2.4t/ha manure	22.175	17.175	2.665	2.913	23.2bc	21.875abc
2.4t/ha+urea100 kg	20.088	16.65	2.775	2.855	23.413bc	27.813ab
2.4t/ha+urea150 kg	21.7	16.3	2.64	2.848	18.713c	22.813abc
2.4t/ha+urea200 kg	22.113	17.625	3.053	2.665	21.775bc	22.875abc
CV%	8.10%	18.80%	13.26%	13.74%	31.07%	27.65%
SE±	0.8588	1.5138	0.1778	0.1803	4.0291	3.6407
LSD	2.471	4.355	0.511	0.519	11.59	10.48
Sig level	NS	NS	NS	NS	*	**

Means in columns followed by the same letter (s) are not significantly different at P≤ 0.05, according to Duncan's Multiple Range Test.*Mean significant different.**Means with high significant difference,NS Means with no significant differenc**e**

Conclusion:

Combined effect of chicken manure and urea fertilizer lead to enhanced vegetative growth, yield and yield components, application of (1.2 th^{-1}chicken manure + 150 kg urea h^{-1}) seem to be more suitable dose compared to use urea or chicken manure each alone.

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Note paper

Use and Evaluation of Commercial Starch and Gum Arabic Blends as Low-cost Gelling Materials for Tissue Culture Banana Propagation

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Abstract

The study was conducted to assess the efficiency of blend of different quantities of commercial starch and Gum Arabic as media solidifying material and banana plantlets healthy growth as a substitute for high cost conventional gelling materials (agar, agarose and gelrite). Nine blends of these materials from them other using some conventional agar were tested. Result indicated that adding 20-40 grams of commercial starch with 0-5 grams of Gum Arabic to one liter of prepared medium component resulted in sufficient gelling results, with reasonable pH and satisfactory explant growth.

Keywords**:** *Low cost alternatives, Gelling agent, Commercial starch, Gum Arabic, Growth efficiency*

استخدام وتقييم خلائط النشا التجاري والصمغ العربي كمواد تصلد منخفضة التكلفة لإكثار الموز بزراعة الأنسجة

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المستخلص

أُجريت هذه الدراسة لتقييم كفاءة خلط كميات مختلفة من النشا التجاري والصمغ العربي كمواد تجميد للوسط ، ولنمو سليم لنباتات الموز، كبديل لمواد التصاد التقليدية عالية التكلفة (الآجار، الآجاروز، والجيلريت). تم اختبار تسعة خلائط من هذه المواد منها أخرى باستخدام الآجار التقليدي. أشارت النتائج إلى أن إضافة 20-40 غرامًا من النشا التجاري مع 0-5 غرامات من الصمغ العربي إلى لتر واحد من مُكوّن الوسط المُحضر أدى إلى نتائج تصلد كافية، مع درجة حموضة معقولة ونمو مُرضٍ للنباتات.

الكلمات المفتاحية: *بدائل منخفضة التكلفة، مادة التصلد، النشا التجاري، الصمغ العربي، كفاءة النمو*

Introduction

Bananas are one of the most important tropical fruit crops worldwide. They occupy a significant position in global trade, and playing important role in the economies of many countries. They are also highly valued by consumers, particularly due to their sweet taste and distinctive flavor. They are also well-known from compared to other fruits by their year-round availability, as well as their ability to be transported, traded, and stored (Osman and Daffalla, 2015; Saad and Mustafa, 2009).

Bananas are vegetatively propagated; due to such fact the potential for pathogens and parasites transmission with seedlings from contaminated agricultural areas is high. Those interested in growing the crop have found that using tissue culture to provide clean and affordable banana seedlings is the best option.

The high cost of the media components in tissue culture makes seedlings partially expensive for small producers. This has led scientific platforms to search for low-cost options and develop ideas to reduce seedling production costs. The advantages of tissue culture seedling production compared to traditional propagation methods (suckers) in bananas include higher propagation rates, the production of pathogen free, and uniform planting material, and the reduced space required to produce a large number of plants. Tissue culture plantlets are lighter than plants produced by traditional ways, especially if light pots and rooting mixes were used instead, which makes transportation easier. Plantlets are also develop much faster, seedlings grow faster and more vigorously, have a shorter and more consistent production cycle, produce more leaves and offshoots, and are more uniform than traditional plant offshoots. Banana plants produced by tissue culture flower more abundantly and produce a uniform harvest, leading to better marketing. They also offer a 20-50% higher fruit yield across all components of yield, such as the number of hands, the number of fingers per hand, finger length, finger circumference, and pseudo stem circumference (Anonymous, 2004; Rakshi, *et al*., 2017; Wilson and Tenkouano, 2020). The main drawbacks of tissue culture seedling production are its requirement for specialized skills, sophisticated equipment, and high capital expenditures, which are not readily available to farmers. Furthermore, contamination rates can be still as high as 15% compared to scientific laboratories, mostly caused by fungi, yeasts, and bacterial contaminants. Still, tissue cultured plants are often tender and require more care during the first two months after planting. To mitigate these limitations, attention has focused on modifying the composition of the growing medium to reduce costs and produce large quantities of plantlets and seedlings. One way to reduce the costs of in vitro culture in developing countries and make it more affordable is to gradually replace most of the expensive components with lower-cost alternatives without significant loss in intermediate and final yield (Wilson and Tenkouano, 2020).

Many different gelling materials, such as agar, agarose, and gelrite, are marketed under trade names and are used to give culture media the desired solidifying degree. Gelrite, one of the

traditional standard gelling materials, is very expensive, while a common alternative to gelrite, agar, is slightly less expensive. Agar is the most widely used gelling agent in plant tissue culture. Since its introduction over a century ago, it has remained the most widely used solidifying material in culture media for both microbes and plants. The properties of agar that make it the most widely used solidifying material in tissue culture are its stability, reasonable transparency, and resistance to metabolic changes. Due to its high price, attempts have been made to identify suitable alternatives (Jain and Babbar, 2002). Furthermore, although agar was once thought to be biologically inert and non-toxic, its adverse effects, such as embryonic abortion and reduced culture yield, have been reported. On the other hand, gelrite often causes vitrification or over hydration of cultures (Wilson and Tenkouano, 2020). Due to its stability, reasonable transparency, non-toxicity, and metabolic inactivity, agar extracted from red algae has been the most widely used media solidification material. Although the cost of medium preparation constitutes a small portion of the total cost, obtaining guaranteed culture medium components is not easy and expensive, especially agar in plant tissue culture laboratories, which is commonly used for woody plants. Tested alternatives include Isubgol, derived from the seeds of some plants, guar gum, and several types of starches produced from some plants like wheat, cassava, corn and potato, (Fira *et al*., 2013).

Agar, as traditional gelling agent, has said to have several drawbacks that negatively affect growth and differentiation in many cases. Variability among different agar types, causing vitrification, and the presence of impurities and growth-inhibiting compounds limits its use as a propagation medium in tissue culture (Palanyandy *et al*., 2020). Possible cheaper alternatives to agar include various types of starch. Agar has been tested in commercial micro propagation, and a mixture of starch and gelrite has been found to be effective instead of each of them alone. A mixture of washed starch, potato starch, and semolina (2:1:1) has also been used, and it has been found to reduce the cost of the gelling agent by 70-82%.

Despite its drawbacks, which negatively affect growth and differentiation in many cases as stated by Palanyandy et al., (2020), agar forms a gel that liquefies at 60-100°C and solidifies at 45°C. Therefore, agar gels are stable at all possible incubation temperatures. Furthermore, gels do not react with media components and not broken down by plant enzymes and easy to be dispensed at higher temperatures. The gelling ability of agar gel is regulated by the concentration, shape, and pH of the agar powder used in the culture medium.

Several attempts have been made to identify suitable and cheaper alternatives to expensive agar as a solidifying agent for microbial and plant tissue culture media, such as potato starch and gum extracted from some plants. Similar work has been reported for tissue culture of chrysanthemum (Asad UIIah *et al*., 2013; Asad UIIah *et al*., 2015).

Gums represent one of the most abundant raw materials due to their sustainable and bio safe properties. The term gum is used to describe a group of natural polysaccharides that have wide-ranging industrial applications due to their ability to create viscous solutions or stabilize

emulsion systems. Gum exudates are complex polysaccharides produced by tree species in the genera Acacia and Prosopis. Gum exudation is produced under conditions of heat and drought, as part of the normal metabolism of plants or as a result of protective mechanisms against mechanical or microbial injury (Lelon *et al*., 2010).

Gum Arabic is an exudate obtained from the stems and branches of Acacia trees, which are grown in Sudan as a cash crop in agroforestry systems. The international standards used to assess the quality of Gum Arabic in the global market are based on Sudanese gum extracted from the *Acacia senegal* variety Senegal (Ali and Daffalla, 2018).

Gum Arabic is used as an emulsifier and stabilizer in the food and pharmaceutical industries, as well as in other industrial products that utilize gum products, including adhesives, textiles, printing, lithography, paints, paper sizing, and pottery and glass polishing. Its high solubility, high acidity (pH≈4.5), and low viscosity make Gum Arabic a medium thickener rather than a solidifier (Ali and Daffalla, 2018; Lelon et al., 2010). Rheological properties and pH are considered important factors due to their role in regulating the solubility of medium nutrients and their uptake by cultures. The highest rate of branching in Amelanchier canadensis resulted from a medium containing guar gum as a hardener, while the longest shoots resulted from a medium containing starch as a solidifier. Approximately four times the number of sprouts was obtained on media containing guar gum compared to the weaker results found on media hardened with Isubgol, as a comparison of different gelling agents. Different gelling agents were used, including 6.8 g/L 1-1 fibrous agar, 50.0 g/L 1-1 wheat starch, 20.0 g/L 1-1 guar gum, 15 g/L Isubgol, or 50.0 g/L wheat starch mixed with 0.5 g/L Phytagol (Fira *et al*., 2013).

Several starch sources (cassava, rice, corn, and potato starch) were tested as solidifying agents compared to agar. They found that 60 grams of l-1 cassava starch-agar mixture added to Murshigi and Ascog's medium resulted in the highest number of regenerated seedlings. Corn starch or potato starch-agar mixtures were also highly effective for micro propagation of potato (Daud *et al*., 2011). By studying the effect of gels such as agar, cassava starch, their combinations, and liquid media on fresh weight, nodule number, and seedling survival in potato seedlings, Correa et al. found that the number of nodules was significantly lower on gel media containing agar, and that the fresh weight was higher on the medium.

From a study of the effect of gels such as agar, cassava starch, their mixtures, and liquid media on the fresh weight, tuber number, and survival rate of potato seedlings, Kuria *et al*. (2008) found that the number of tubers was significantly lower on agar-containing gel media and that the fresh weight was higher on liquid media, while the survival rate was higher on gel media. In all studies considered, media mixed with 10% cassava starch proved to be the most effective in culture performance (Kuria *et al*., 2008). Three banana genotypes (tetraploid hybrids PITA 14 (AAAB) and BITA 3 (AAAB) and the cooking banana (ABB) Cardaba genome) were grown on gelrite and compared with the use of an alternative gelling agent made from cassava starch in

three steps of micro propagation initiation, propagation, and regeneration. The number of buds revealed in BITA 3, PITA 14, and Cardaba did not differ significantly between gelrite and starch as a gelling agents during shoot initiation. During both the growth and regeneration stages, there were no significant differences in the effect of gelrite and cassava starch on the number of buds produced by BITA 3 and Cardaba. However, the banana hybrid PITA 14 produced significantly more buds in gelite than in cassava starch at both stages. Cardaba had significantly fewer buds than the hybrid at all stages (Wilson and Tenkouano, 2020). In another study, bananas were found to be affected by the type and concentration of solidifying agent during tissue culture, primarily due to their effect on the variation in the physical properties of the medium. Plant growth and proliferation were higher on solidified media containing 0.9 g L-1 gelrite compared to those on media containing 4–8 g L-1 agar or 2–6 g L-1 gellan gum. Most shoots cultured on 0.7 g L-1 gelrite or 4 g L-1 agar and on liquid media showed poor growth and proliferation due to replication. High concentrations of gellan gum (6 g/L and 8 g/L agar) did not support shoot growth, which was explained by reduced water and mineral salt uptake (Buah *et al*., 1999).

In some recent study Ebile, *et al*. (2022) indicated that some substrates, such as xanthan, had good gelling properties, but their cost was too high (5.98 Euro per liter) to be considered low-cost. Other such as cassava starch, did not have suitable gelling properties; however, the cost was low (0.99 Euro per liter). They also indicated that two other gelling alternative, mung bean, and Isabgol, had suitable gelling properties with less than one euro cost.

Objectives of this study attempted to evaluate effectiveness of different blend concentrations of commercial starch and Gum Arabic as safe and low cost alternative for medium gelling materials in banana micro propagation

Materials and Methods

Experimental site

This experiment was conducted in the tissue culture laboratory of Al Rajhi Kaffaa Company, 5 km from Berber. Berber is located in the center of River Nile State, on the eastern bank of the Nile River, parallel to the course of the Nile. The locality is between latitudes 17.40 and 18.30 and longitudes 32.20 and 34.20. It is bordered by Atbara Locality and to the north by Abu Hamad Locality.

Plant Source:

Grand Nain banana offshoots were brought from the University of Gezira farm, east of Wad Medani, to the tissue culture laboratories of the Kafaa Project in Berber.

Experimental Methods:

The plants were washed for cleaning under running water, and the corms were brought to the company's tissue culture laboratory. They were cleaned and surface sterilized with sodium

hypochlorite, followed by pre cultivation treatments and incubation as stated in the steps bellow. Regenerating Shoots were subsequently taken for further studies according to the proposed experimentation treatments

In the first stage, Murashige and Skoog's (1962) medium salts were used as concentrated solutions. Gelrite was added at a rate of 2 grams per liter as a medium solidifying agent. The pH of the medium was adjusted to 5.8 using both potassium hydroxide and hydrochloric acid. Sucrose was used as a carbon source, and a growth regulator was added. Finally, 30 ml of the medium was poured into 250 ml containers and covered with Teflon caps. The containers were placed in an autoclave at 121°C and 15 psi for 30 minutes to sterilize the medium. The containers were then incubated for 4 days in a dark room at 27°C and examined for contamination before planting. The plant parts were then planted in the culture medium under a sterilization cabinet (hood). The cultures were then incubated at 27°C in complete darkness and transferred to a fresh medium every month for three months. They were then transferred to the multiplication medium specified for each experimental treatment.

The media components and their concentration were shown in Table (1). Solidifying materials used were starch + Gum Arabic.

Table (1) Concentrations of added starch, gum and agar as safe gelling agents

Treatment	MS salt strength	Sucrose concentration g/L	Benzyl adenine concentration mg/L	Added starch in grams	Added gum in grams	Added agar in grams
1	3/4 MS	30	5	8	1	1
2	3/4 MS	30	5	9	1	0
3	3/4 MS	30	5	10	0	0
4	3/4 MS	30	5	20	5	0
5	3/4 MS	30	5	20	0	0
6	3/4 MS	30	5	40	5	0
7	3/4 MS	30	5	40	0	0
8	3/4 MS	30	5	80	5	0
9	3/4 MS	30	5	80	0	0

Results and discussion

Table (2) shows the growth efficiency, degree of solidify of the medium and its degree of reaction (pH) when starch and gum were added to the medium, when it contained Morshigi salts, growth regulators, and sugar. The results showed that media Nos. 1, 2, and 3, from which a full liter was prepared, had varying degrees of liquidity, with 1 and 2 being completely liquid. Media 3 was slightly firm, but after incubating the medium for four days, it was observed that media 3

had become completely liquefied. As for media Nos. 4, 5, 6, 7, 8, and 9, a quarter liter (250 ml) of each was prepared. The higher the amount of starch added, the higher the pH reading. The addition of gum also leads to some cohesion between the components of the culture medium.

Regarding growth efficiency

Readings taken after four weeks of cultivation in solidified media ranged from poor, good to average. The best readings resulted from the addition of 20 grams of starch. It was noted that media containing high levels of starch increased the degree of solidifying and reduced growth efficiency. Kuria *et al*., (2008) indicated that the starch addition should not exceed 10%. The results obtained differ somewhat from those obtained by Wilson and Tenkouano (2020) on banana hybrids and are somewhat similar to the results of Kuria *et al*. (2008) on potatoes. Daud *et al*., (2011) and Fira et al., (2013) also achieved good performance using some gums and starch as additives to the medium as gelling agents.

From the above it can be concluded that some physical, chemical and biological attributes of the culture media can be adjusted to be suitable for use according to their capability of supporting plantlets growth and their parts development and differentiation. Such findings are similar to what have been reported by Wilson and Tenkouano, (2020). Partially firmness and viciousness is desirable in the medium to let plantlets float with normal respirations while its partially liquefied properties can help plantlets to absorb water and required nutrients and later to develop penetrating roots deep inside the media.

Capability of forming firm rheological phase is a factor of different conditions; the most prominent of it is medium pH and incubation room temperature. Gums remain highly viscous in high concentration regardless of change in incubating room temperature and with relatively low pH values. However it is chemically inert material. Commercial starch as solidifying gelling materials has some drastic impact on plantlets development if exceeds more than 10-15 % concentration although having good dispensing qualities in higher temperatures and excellent solidification properties at incubating temperatures. Different blending concentration of these materials tried to decrease adverse and makes use of good properties of the two materials.

Wilson and Tenkouano, (2020) reported different response of different banana type to the same culture media. That may indicates the expected reaction of different genetic combination to the tested medium blend

Table (2) The Degree of solidifying as an effect of using mixture of commercial starch and gum as gelling agents with or without agar

Treatment	Ms Salt strength	Sucrose concentration g/L	Benzyl adenine concentration mg/L	Added starch in grams	Added gum in grams	Added agar in grams	Solidifying degree *	Medea pH	Growth efficiency **
1	3/4 MS	30	5	8	1	1	3	5	-
2	3/4 MS	30	5	9	1	0	1	5	-
3	3/4 MS	30	5	10	0	0	1	5	-
4	3/4 MS	30	5	20	5	0	5	5.7	3.6
5	3/4 MS	30	5	20	0	0	6	5.75	3.6
6	3/4 MS	30	5	40	5	0	6	5.74	3.2
7	3/4 MS	30	5	40	0	0	8	5.75	2.4
8	3/4 MS	30	5	80	5	0	8	5.69	3.2
9	3/4 MS	30	5	80	0	0	8	5.70	2.2

*Solidifying degree; 1-5 Liquid, 5-7 Liquid gel, 8-10 Solid gel

**Growth efficiency as described by Bottino, (1981); 1 Death, 2 Weak (Living tissue without growth) 3 Average (growth and doubling not completed)

4 Good (vigorous growth and doubling)

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