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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
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- Remote sensing
- Seed science and technology
- Soil sciences
- Sustainability
- Waste management
- Water resources
- Weed science
- Zoology

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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.

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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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1. Cover letter:

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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.

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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.

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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

are then identified by letters 'a', 'b', 'c', etc. placed after the year of publication (e. g. Caballero *et al*., 2007a and Smith, 1987a, b).

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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Preface

Auditors of volume 10(2) have the great pleasure to present this issue, bearing in mind that it can assist with other journals in serving agriculture context to grasp basic concept of wise and sustainable farming, as well as availing some research findings and recommendations of technicality sound and economically feasible package of practices to post sciences and production.

Farming systems is not easy to develop, particularly in traditional systems of developing countries unless local situation is fully understood. Two distinct farming systems, irrigated and rain fed are both available in Sudan. However, more developed mechanization and traditional operation farming are both in need to extensive experimentation to develop new technologies that can suit local environmental conditions. Within this issue many articles address these themes.

Roselle one of crops used to make popular Sudanese drink and Soybean grown for testing their performance as intercropping and a sole crop under rain-fed conditions discussed in one of these articles that addressing problems of traditional farming in Blue Nile Savanna. In the same time no negligence of checking the effect of gamma radiation for seeking mutation breeding for new germplasm despite availability of types of domesticated and wild Okra since Sudan is believed to be the origin of this widely used plant.

An article in this issue also shed light on Umm glagil (*Aristolochia bracteolata*) which is one most used herb in African traditional medicine and believed to contain carcinogenic bioactive substances if mal used. It is chemical bioactive substances from the root and different parts of shoot system were stated as more effective against different types of harmful bacteria.

Garlic irrigation and tomato fruit quality for further determination of result obtained in value adding and processing are two other full text papers investigating important farming and value adding to this two valuable vegetable crops.

Updating of Sudan's flora may need to survey urban flora and capacity building to agriculture extension workers require to assess their tanning needs. That what was exactly portrayed by two other article in this issue.

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A Preliminary Survey of Wild Flora of Atbara City- River Nile State - Sudan

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Abstract

This study was conducted in Atbara City, River Nile State, with the primary objectives of compiling a preliminary checklist of wild plant species, analyzing their taxonomic diversity and growth forms, contributing to the updating of Sudan's flora, and providing baseline data to support future ecological and applied studies on urban flora in Sudan A total of 103 angiosperm species belonging to 33 families were recorded—29 dicotyledonous and 4 monocotyledonous families. The Fabaceae was the most represented family, comprising 12 species, followed by Poaceae (Gramineae) with 10.species, and both Amaranthaceae and Asteraceae with 8 species each.The majority of the recorded species (84.5%) were herbs, while trees and shrubs constituted 15.5%. The most dominant species observed in the study area were *Calotropis procera* (Aiton) Dryand., *Leptadenia arborea* (Forssk.) Schweinf., *Senna alexandrina* Mill.and *Senna italica* Mill. The outcomes of this research establish a baseline for future studies, including quantitative ecological assessments, and invasive species monitoring. It is recommended that future research focus on examining the ecological functions, ethnobotanical relevance, and potential economic.

Keywords: *Wild Flora, Survey, Atbara City, Sudan.*

مسح اولي لفلورا النباتات البرية بمدينة عطبرة، بولاية نهر النيل ، السودان

حنان حسن بابكر محمد

قسم علوم الحياة، كلية التربية جامعة وادي النيل

المستخلص

أُجريت هذه الدراسة في مدينة عطبرة بولاية نهر النيل، وهدفت بشكل رئيسي إلى إعداد قائمة أولية بأنواع النباتات البرية، وتحليل تنوعها التصنيفي وأشكال نموها، والمساهمة في تحديث فلورا السودان، فضلاً عن توفير بيانات أساسية تدعم الدراسات البيئية والتطبيقية المستقبلية حول النباتات الحضرية في السودان. وقد تم تسجيل عدد إجمالي بلغ 103 نوعًا من النباتات مغطاة البذور (كاسيات البذور)، تتبع 33 فصيلة نباتية، منها 29 فصيلة من ثنائيات الفلقة، و4 فصائل من أحاديات الفلقة. وكانت فصيلة البقوليات Fabaceaeهي الأكثرتمثيلا حيث شملت 12 نوعا تلتها الفصيلة النجيلية Poaeae ب 10 أنواع ثم كل من القصيلة القطيفية (Amaranthaceae) والفصيلة النجمية (Asteraceae) ب 8 أنواع لكل منهما. وأظهرت النتائج أن الغالبية العظمى(85.5%) من الأنواع المسجلة كانت من الاعشاب الأعشاب، في حين شكلت الأشجار والشجيرات ما نسبته (15.5%) وكانت الأنواع السلئدة في الدراسة *Calotropis procera* (Aiton) Dryand., *Leptadenia arborea* (Forssk.) Schweinf., *Senna alexandrina* Mill.and *Senna italica* Mill. تشكل نتائج هذه البحث أساسا للدراسات المستقبلية بما في ذلك تلك التي تتعلق بالتقيمات البيئية الكمية ومراقبة الأنواع الغازية. يوصى بأن تركز الأبحاث المستقبلية على دراسة الوظائف البيئية والأهمية الأثنونباتية والإمكانات الاقتصادية

الكلمات المفتاحية : *النباتات البرية ، مسح ، مدينة عطبرة .السودان*

Introduction

Flora represents the total composition of plant species in a given region and forms the basis for understanding biodiversity, ecological processes, and ecosystem services. Floristic studies are essential for documenting species richness, identifying ecologically important taxa, and providing baseline data for conservation and sustainable management (Nicolas *et al*., 2016) The first descriptive flora of the Sudan compiled by Broun and Massey (1929). The greatest compilation of the Sudan flora was achieved by Andrews **(**1950, 1952, 1956) which was considered as the standard reference of Sudan. . Recently, a great work has been done by Darbyshire, *et al.*(2015) Studies on regional floras include many works such as Hassan(1974) Wickens. (1976), El Ghazali (1985), Gumaa. (1988), Ibrahim (1996), Abdalla, (1997), Elsafori, (2000),Babiker (2001) Abdallah *et al.* (2016) Hamad (2020).

In Sudan, floristic surveys have traditionally focused on natural ecosystems such as riverbanks, islands, and valleys. However, urban flora remains largely understudied despite its increasing ecological relevance. Wild urban plants play a significant role in biodiversity conservation, support pollinators and birds, regulate urban microclimates, and act as bio indicators of environmental changes Kowarik, (2011) Mckinney (2008).

Urban plants come in two main forms: one cultivated by man and the other called spontaneous (Nicolas *et al*., 2016). Wild flora of cities composed of individual plants that grow independently, without being planted, and often without being cared for by people, such as wild grasses that can grow between the cracks in the ground; weeds that grow spontaneously in gardens where the soil has been turned over and trees or shrubs that grow on their own in empty lots.

In recent years, there has been growing scientific interest in the study of urban wild flora (Milica *et al.,*2017; Sadyrova *et al*., 2018; Alessandrini *et al*.. 2025). This interest is driven by the recognition that cities are home to the majority of the global population, and that urban vegetation provides essential ecosystem services such as air purification, temperature regulation, and enhancement of human well-being. Furthermore, research on urban flora contributes to our understanding of biodiversity conservation, tracks species' responses to urbanization and climate change, helps detect invasive species, and supports sustainable urban development in alignment with the Sustainable Development Goals (SDGs) (Aronson *et al.*, 2017). Therefore this study deals with investigation of the floristic composition and diversity of urban habitats in Atbara city. It represents the first systematic attempt to document the wild urban flora in a Sudanese city, focusing on Atbara, River Nile State. The aims of this study are to compile a preliminary checklist of wild plant species, analyze their taxonomic diversity and growth forms, also to contribute in updating the flora of Sudan, and to provide baseline data to inform future ecological and applied studies on Sudanese urban flora.

Materials and Methods

The Study Area

Atbara city is located in the River Nile State in northeastern Sudan, at the confluence of the Nile and Atbara rivers (17°42′7.9″ N, 33°59′11″ E).Atbara has a hot desert climate (Köppen climate classification *BWh*). The annual mean temperature reaches over 30 °C (86 °F) and the average highs exceed 40 °C (104 °F) during 7 months of the year. The annual average rainfall is 60 mm, mostly from July and August. The soil is **d**ark alluvial clays. The region also contains Aridisols/Calcisols (with calcretes, gypsum, and halite) and Vertisols (with characteristic slickensides and a large amount of smectite). These soils indicate past transitions between arid, semi-arid, and more humid climates.

Collection of materials and preparation of specimens:

Plant specimens were collected from different sites of the study area at different times of the year 2024 and 2025. The whole plant was collected in case of herbs and twigs with leaves and flowers and /or fruits in case of shrubs and trees.

The specimens were stretched to dry between newspapers and firmly pressed inside a herbarium press. Newspaper was continuously changed during the drying to avoid rotting of material. Subsequently, the specimens were mounted and labeled. Voucher herbarium specimens of different plant samples were deposited at the Herbarium of Biology Department, Faculty of Education, Nile Valley University.

Plants Identification Method:

Fresh specimens were examined through the aid of hand lenses and binocular dissecting microscope. The identification of plant specimens was confirmed using published keys by Andrews **(**1950, 1952, 1956) and by comparing specimens with those in "virtual herbaria" available online: https://www.gbif.orgThe identified species were compared with already identified herbarium specimens from herbarium of Biology Department, Faculty of Education, Nile Valley University. Name of the species with authority and family were verified by using the online database Tropicos (https://www.tropicos.org)

The vernacular names of species were recorded from local inhabitants within the study area and also extracted from Braun and Massey (1929), Andrews, (1949) and Wickens. (1976).

Photography:

The photography of selected plants was done with Smart Phone.

Data Presentation:

A table was prepared including scientific name, family, local name, and growth form for each species.

Results and Discussion

The present study revealed a total of 103 species of angiosperms belonged to 33 families (29 Dicotyledonous and 4 Monocotyledon). Results are shown in Table 1

Table: 1. List of the plant species in the study area

S. No	Family	Scientific Name	Vernacular name	Habit
1	**Acanthaceae**	*Ruellia tuberosa* L.	Tagtaq	Herb
2	**Aizoaceae**	*Glinus lotoides* L.	Terba	Herb
3	_	*Sesuvium sp*	_	Herb
4	_	*Trianthema portulacastrum* L	Danab el naga	Herb
5	_	Zaleya pentandra (L.) Jeffery	Al- raba'a	Herb
6	**AMARANTHACEAE**	*Aerva javanica* (Burm. f.) Juss. exSchult	Ras El- shayeb	Herb
7	_	*Alternanthera nodiflora* R. Br.	Abu tamra	Herb
8	_	*Amaranthus graecizans* L.	Lissan el Tair	Herb
9	_	*Amaranthus spinosus* L.	Lissan el Tair Abushouk	Herb
10	_	*Amaranthus viridis*	Lissan el Tair	Herb
11	_	*Chenopodium album* L.	_	Herb
12	_	*Chenopodium murale* L.	Efain	Herb
13	_	*Digera muricata* (L.) Mart.	Lablab ahmer	Herb
14	**Apocynaceae**	*Calotropis procera* (Aiton) Dryand.	Usher	Shurb
15	_	*Leptadenia arborea* (Forssk.) Schweinf.a	Lewais/ Sho'bait	Vine
16	_	*Oxystelma esculentum* (L. f.) Sm.	Lewis	Vine
17	**ARECACEAE (PALMAE)**	*Hyphaene thebaica*(L.) Mart	Dom	Tree
18	_	*Phoenix dactylifera* L.	Nakhil	Tree
19	**Aristoiochiaceae**	*Aristolochia bracteolata* Lam.	Umm Glagel	Herb
20	**Asteraceae**	*Ageratum conyzoides* (L.) L.	RehanElguroof	Herb
21	_	*Amborosia maritima* L.	Damseesa	Herb
22	_	*Eclipta prostrata* (L.) L.	_	Herb
23	_	*Pulicaria crispa* Sch.Bip.	Ghubeira	Herb
24	_	*Pulicaria undulata* (L.)Mey.	Al Tagar. Rabl	Herb
25	_	*Sonchus oleraceus* L.	Molita	Herb
26	_	*Sphaeranthus suaveolens* (Forssk) DC.	Sirr Elward	Herb
27	_	*Xanthium brasilicum* Wallr	Lusseig	Shrub
28	**Brassicaceae**	*Brassica nigra* (L.) K.Koch		Herb
29	_	*Lepidium niloticum* (Delile) Sieber	Rashad	Herb
30	_	*Morettia canescens* Boiss	Ghubeira	Herb
31	**Boraginaceae**	*Echium rauwolfii* Del.	_	Herb
32	_	*Heliotropium bacciferum* Forssk	Ghubeira	Herb
33	_	Heliotropium europaeum L	_	Herb
34	_	Heliotropium pallens	Zanab El Akrab	Herb
35	**Capparaceae**	*Capparis decidua* (Forssk.) Edgew	Tundub	Shrub

36	**CHENOPODIACEAE**	Salsola baryosma (Schult) Dandy	Abo Elfein	Herb
37	_	Salosla imbricate		
38	**Cleomaceae**	*Cleome gynandra* L.	Tamalaika	Herb
39	**Convolvulaceae**	*Convolvulus arvensis* L.	Al ulliq	Vine
40	**CUSCUTACAE**	*Cuscuta hyalina Roth*	Hamool	Vine
41	**Cucurbitaceae**	*Citrullus colocynthis* (L.) Schrad.	Hundal	Herb
42	_	*Cucumis melo* L.	Hummeid	Vine
43	**Cyperaceae**	*Cyperus michelianus* (L.) Link.	Siada	Herb
44	_	*Cyperus rotundus* L.	Siada	Herb
45	**Euphorbiaceae**	*Chrozophora plicata* (Vahl) A. Juss. Ex Spreng.	Tirba	Herb
46	_	*Euphorbia hirta* L	Um Lebaina	Herb
47	_	*Euphorbia hypericifolia* H.K.F.	Um Lebaina	Herb
48	_	*Euphorbia granulata* Forssk	Um Lebaina	Herb
49	_	*Euphorbia prostrate* Ait.	Um Lebaina	Herb
50	_	*Ricinus communis* L.	Khirwia	Shrub
51	_	*Phyllanthus niruri L.*	Al - Rageega	Herb
52	**Fabaceae**	*Alysicarpus monilifer* (L.) DC	Fraish	Herb
53	_	*Indigofera hochstetteri* Bak.	_	Herb
54	_	*Indigofera oblongifolia Forssk*	Dahasseir	Under shrub
55	_	*Mimosa pigra* L.	Al sit -El Mustahia	Shrub
56	_	*Pithecellobium dulce* (Roxb.) Benth.	Tamr Hindi	Tree
57	_	*Prosopis glandulosa* Torr	Mesquite	Shrub
58	_	*Rhynchosia minima* (L.) DC.	Adan El Far	Herb
59	_	*Senna alexandrina* Mill	Sanamaka	Herb
60	_	*Senna italica* Mill	Sanamaka	Herb
61	_	*Sesbania hepperi* J.Gillett..	_	Herb
62	_	*Tephrosia apollinea* (Delile) Link.	Amayoga	Under Shrub
63	_	*Tephrosia uniflora* Pers.	Amayoga	Herb
64	**Lamiaceae**	*Ocimum basilicum* L.	Rehan	Under shrub
65	**Lythraceae**	*Ammannia baccifera* L.	Tamar Alfar	Herb
66	**Malvaece**	*Abutilon figarianum* Webb.	Humbuk	Herb
67	_	*Abutilon pannosum* (G.Forst.) Schltdl	Hambuk/ Gargadan	Under shrub
68	_	*Corchorus depressus* (L.) Stocks	Suteiha	Herb
69	_	*Corchorus tridens* L.	Molokhia	Herb
70	_	*Hibiscus trionum* L	_	Herb
71	**Meliaceae**	*Azadirachta indica* Adr. Juss.	Neem	Tree
72	**Molluginaceae**	*Glinus lotoides*	Terba	Herb
73	**Nyctaginaceae**	*Boerhavia coccinia* Mill.	_	Herb

74	_	*Boerhavia erecta*	Terba	Herb
75	_	*Boerhavia repens* L	Shukal el kheil	Herb
76	**Orobanchaceae**	*Striga hermonthica* (Delile) Benth.	EL.Boda	Herb
77	**Papaveraceae**	*Argemone mexicana* L.	Khashkhash	Herb
78	**Poaceae**	*Chloris virgata* Sw.	Umm faru	Herb
79	_	*Cynodon dactylon* (L.) Pers	Nagil	Herb
80	_	*Dactyloctenium aegyptium* (L.) Willd.	Umm asabee	Herb
81	_	*Desmostachya bipinnata* (L.) Stapf	Halfa	Herb
82	_	*Dichanthium annulatum* (Forssk.) Stapf.	Umm Firada	Herb
83	_	*Digitaria ciliaris (*Retz.) Koeler	Umm Faru	Herb
84	_	*Dinebra retroflexa (*Vahl) Panz	Umm Mamleha	Herb
85	_	*Echinochloa colonum* (L.) Link	EL -Difra	Herb
86	_	*Eragrosits ciliaris* (L.) R.Br.	Zeal ALghed	Herb
87	_	*Polypogon viridis*	_	Herb
88	**Portulacaceae**	*Portulaca oleracea* L.	Regla	Herb
89	_	*Portulaca quadrifida* L.	_	Herb
90	**Rhamnaceae**	*Ziziphus spina Christi* (L.) Willd	Sider	Shrub
91	**Rosaceae**	*Potentilla supina* L.	Sifairt el Bahr	Herb
92	**Sapindaceae**	*Cardiospermum halicacabum* L	_	Vine
93	**Solanaceae**	*Datura innoxia* Mill.	Sakran	Undershrub
94	_	*Datura stramonium* L.	Sakran	Undershrub
95	_	*Physalis angulata* L.	_	Herb
96	_	*solanum Dubium* Fresen	Gubein	Herb
97	_	*Solanum nigrum* L.	Enab El Deep	Herb
98	_	*Withania somnifera* L.	Sem Alfar	Herb
99	**Typhaceae**	*Typha domingensis* Pers.	_	Herb
100	**Zygophylaceae**	*Balanites acgyptiaca* (L.) Del.	Higleeg - Laloub	Tree
101	_	*Fagonia indica* Burm. f.	Um-shweeka	Herb
102	_	*Tribulns pentandrus* Forssk	Deresia	Herb
103	_	*Tribulus terrestris* L.	Dereisa	Herb

The Fabaceae is the most common family with12 species in the study area. It followed by Poaceae (Graminae) with 10 species, then Amaranthaceae and Asteraceae with 8 species for each one. These families were well represented in the study area, which may be attributed mainly to the suitability of these habitats of the members belonging to these families, this result is in consistent with patterns observed in disturbed and xeric habitats in Sudan. In contrast, certain families were poorly represented, with some having only a single recorded species, while others were entirely absent. This discrepancy may reflect both ecological specificity and anthropogenic influences such as land-use change and habitat degradation (.Fig. 1) some species seen in their growth environments.

The majority of recorded species were ephemeral and annual herbs, accounting for approximately 87 species (84.5%), whereas trees and shrubs were represented by only 16 species (5 tree and 11 shrub species), making up to 15.5% of the total flora. The dominance of herbaceous and annual plants is indicative of their capacity to rapidly colonize disturbed soils and vacant urban plots, while shrubs and trees indicate species capable of tolerating arid conditions and human disturbances.

The abundant flora of Atbara city is particularly the following species: *Calotropis procera* (Aiton) Dryand, *Leptadenia arborea* (Forssk.) Schweinf, *Senna alexandrina* Mill and *Senna italica* Mill, the dominant above mentioned species of the wild flora in Atbara City can be attributed to their strong ecological adaptability to the semi-arid climate of the region. These species are drought-tolerant xerophytes that thrive under high temperatures and low rainfall conditions typical of northern Sudan (Hassan *et al*., 2015).

Senna alexandrina and *Senna italica* are legumes capable of tolerating poor, sandy soils while contributing to soil fertility through biological nitrogen fixation (Gutterman, 2002). *Calotropis procera*, on the other hand, is highly tolerant to salinity and nutrient-poor substrates, which gives it a competitive advantage in disturbed and marginal habitats (Sharma et al., 2010). These species also exhibit effective seed dispersal mechanisms: *Calotropis procera* and *Leptadenia arborea* produces light, hairy seeds dispersed by wind over long distances, while Cassia species produce hard-coated seeds that can remain viable under harsh conditions and germinate after rainfall. Hard or impermeable seed coat is a mechanism that insures the survival of Senna (Abdulazeez, 2016).

Although the current survey was conducted within Atbara, which is part of the four southern localities of River Nile State, earlier studies were conducted about 25 years ago and concentrated in documentation of plants natural habitats, including riverbanks, islands, valleys, and agricultural areas, while the present research targets urban habitats, such as streets, vacant lots, parks, and industrial zones. Accordingly, riparian Acacia trees along the Nile and Atbara rivers and grasses in large irrigated agricultural projects were deliberately excluded to focus on truly urban wild flora.

Comparison with historical data reveals notable differences in species composition and dominance. While families such as Fabaceae and Poaceae were abundant in both surveys, several species recorded previously in natural habitats are absent in the urban environment,

likely reflecting habitat modification, urbanization pressures, and altered ecological dynamics. This comparison underscores the emergence of unique urban plant communities and highlights the importance of documenting and monitoring urban flora as a distinct component of regional biodiversity.

Conclusion

This survey provides the first comprehensive documentation of wild urban flora in Atbara City, Sudan, recording around 103 species from over 33 plant families. The study highlights the resilience of urban plants in semi-arid environments and their contributions to biodiversity and urban ecological functions. While the current work focused on species presence and classification, it establishes a baseline for future studies, including quantitative ecological assessments, and invasive species monitoring.

Recommendations:

This study provides a comprehensive floristic inventory of wild plants in Atbara City, documenting species diversity, families, local names, and growth forms. It is recommended that further studies be conducted to analyze the ecological roles, ethnobotanical uses, and potential economic importance of the urban flora. Such follow-up research will complement the current inventory and provide a deeper understanding of the functional and applied aspects of Atbara's wild urban plants.

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Appendix (Fig. 1)

Hyphaene thebaica (L.) Mart

Tribulus terrestris L.

Corchorus depressus (L.) Stocks

Leptadenia arborea (Forssk.) Schweinf.a

Calotropis procera (Aiton) Dryand

Typha domingensis Pers

+Fig.1. Some species seen in their growth environments

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Chemical constituents study of Umm glagil (*Aristolochia bracteolata*) and antibacterial activity against *Salmonella typhi*

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Abstract

(Aristolochia bracteolata) is widespread used herb in African countries including Sudan. It is as one of the most effective plant for remedies of infectious diseases. The aim of the present study is to investigate the secondary metabolites of Umm glagil (*Aristolochia bracteolata*) in the root and different parts of shoot system such as leave , stems and bark, as well as to study of biological activity as antibacterial against important pathogenic bacteria (*Salmonella typhi*). Different solvents system and aqueous extracts with different concentration (50g/500/ml) and (0.00, 25.0, 50.0, 75.0 and 100 mg/ml) were used. Qualitative analysis were carried out to investigate phytochemical constituents of different parts then after, disc diffusion method (inhibition zone), was used to determinate the sensitivity of the bacteria to the extracts. The phytochemical analysis showed that the extracts of Umm glagil leaf and stem contained flavonoids at moderate concentration, while, flavonones/ flavonols and saponins recorded high concentration in stem. The Methanolic, ethyl acetate, ethanolic and petroleum ether extracts of Umm glagil were more effective against the bacteria than the other solvents giving (1.9, 1.7, 1.3, 1.2 cm) diameters, in order. This study indicated that Umm glagil can be used as antibacterial agents.

Keywords: *Aristolochiabracteolata, Salmonella typhi , antibacterial , Umm glagil , phytochemical.*

دراسة للمكونات الكيميائية لنبات ام جلاجل وفعاليتها المضادة لباكتيريا السالمونيلا

اشواق احمد عبدالرحمن محمد نور[1]، ولاء الدين حمدنا الله احمد[2] وصلاح احمد مصطفى[1]

المستخلص

يُستخدم نبات أم جلاجل (Aristolochia bracteolata) على نطاق واسع في الدول الأفريقية، بما فيها السودان، كأحد أكثر النباتات فعالية في علاج الأمراض المعدية. تهدف هذه الدراسة إلى دراسة المستقلبات الثانوية لأجزاء نبات أم جلاجل (Aristolochia bracteolata) مثل الأوراق والسيقان واللحاء، بالإضافة إلى دراسة نشاطه البيولوجي كمضاد للبكتيريا مثل بكتيريا السالمونيلا التيفية. استُخدمت مذيبات ومستخلصات مائية مختلفة (50 غ/500 مل) ثم بتركيزات مختلفة (0.00، 25.0، 50.0، 75.0 و100 ملغ/مل). أُجري تحليل نوعي لدراسة المكونات الكيميائية النباتية لأجزاء النبات المختلفة، ثم استُخدمت طريقة الانتشار القرصي (منطقة التثبيط) لتحديد حساسية البكتيريا للمستخلصات. أظهر التحليل الكيميائي النباتي احتواء مستخلصات أوراق وساق أم جلاجل على فلافونويدات بتركيزات متوسطة، وفلافونونات/فلافونولات، وصابونينات بتركيزات عالية في الساق. وأظهرت منطقة التثبيط أن مستخلصات الميثانول، وأسيتات الإيثيل، والإيثانول، وإيثر البترول من أم جلاجل كانت أكثر فعالية ضد البكتيريا من المذيبات الأخرى، حيث أعطت أقطارًا (1.9، 1.7، 1.3، 1.2 سم) على التوالي. كما أظهرت الدراسة أن أوراق وساق أم جلاجل أكثر نشاطًا من الساق. وأشارت هذه الدراسة إلى إمكانية استخدام أم جلاجل كمضادات للبكتيريا

الكلمات المفتاحية : *نبات ام جلاجل ، باكتريا السانمنيلا ، مضاد باكتيري ، كيماويات نباتيه.*

Introduction

Medicinal plants for thousands of years played a vital role in human life (Abdel Karim *et al*., 2022). Medicinal plants have provided the basic building blocks for a number of highly effective drugs (Alluri and Majumdar, 2014). They are used for discovering and screening the phytochemical constituents which are very much helpful for the manufacturing of new drugs (Tiwari *et al*., 2011). Phytochemicals are primary and secondary compounds and they are found as major constituents of some medicinal plants which are useful for healing as well as for curing human diseases (Nostro *et al*., 2000). Therefore, researchers are increasingly turning their attention to folk medicine, looking for new leads to develop better drugs against microbial infections (Benkeblia, 2004). However, *Aristolochia* is an important genus in the family of Aristolochiaceae.

The Aristolochiaceae Family consists of about 400 species. It is widespread through tropical areas of Asia, Africa, and South America (MacMillan, 2008) .*Aristolochia* species has been diverse biological functions include hypertension relief, rheumatism relief, edema therapy, leukocyte enhancement, as well as analgesic and diuretic effects (Tang and Eisenbrand, 1992).

Salmonella sp are found in the intestinal tract of wild and domesticated animals and humans. Some serotypes of *Salmonella*, such as *S. typhi* and *S.paratyphi* are only found in humans (Miller and Pegues, 2005). Some serotypes of *Salmonella* have become resistant to many antimicrobial drugs. The selection of effective antibiotics is critical for the treatment of invasive *Salmonella* infections, but has become more difficult as antibiotic resistance has increased, (Consumer reports, 2010).

Objective: To study the chemical constituents of Umm glagil (*Aristolochia bracteolata*) and its antibacterial activity against *Salmonella typhi*

Materials and methods:

Plant collection:

Samples of the plant of Umm glagil (*Aristolochia bracteolata*)leaves, Stems and root were collected from Wad Medani area .Sudan .

Phytochemical analysis:

General phytochemical examination of secondary metabolites (Qualitative analysis) were included the following tests:

Flavonoids : Five gram (5gm) of the dried powder of each part of the plant, was macerated in 1% of hydrochloric acid (50 ml) over night, filtered and the filtrate was subjected to the following tests:

a) Ten ml (10 ml) from each filtrate was rendered alkaline with sodium hydroxide (10%, w/v); if a yellow colour was formed that might indicate the presence of flavonoids.
b) Shinoda test: Five ml (5 ml) of each filtrate was mixed with concentrated hydrochloric acid (1ml) and magnesium turning was added. The formation of red colour indicates the presence of flavonoids, flavonones, and / or flavonols (Harborne. 1998).

Saponins: A known weight (5 gm) of the dried powder of sample was extracted with 20 ml ethanol (50%) and filtered. Aliquots of the alcoholic extracts (10 ml each) were evaporated to dryness under reduced pressure. The residue was dissolved in distilled water (4ml) and filtered. The filtrate was then vigorously shaken; if a voluminous forth is developed and persisted for almost one hour, it this an indication for the presence of saponins (Harborne. 1998).

Tannins: The dried powder of plant sample (5 gm), were extracted with ethanol (50%) and filtered. Ferric chloride reagent (5%, w/v in methanol) was added. The appearance of green color which changes to a bluish black color or precipitate, indicates the presence of tannins (Balbaa, 1974)

Sterols and /or triterpenes: The dried powder of plant sample (1 gm), were extracted with petroleum ether (10 ml each) and filtered. The filtrate was evaporated to dryness and the residue was dissolved in chloroform (10 ml). aliquots of chloroform extract (3 ml each) were mixed with concentrated acetic anhydride (3 ml), and a few drops of sulphuric acid were added. The formation of a reddish violet ring at the junction of the two layers, indicates the presence of unsaturated sterols and / or triterpenes (Harborne. 1998).

Alkaloids and / or nitrogenous bases: The dried powder of each parts plant (5 gm), were extracted with ethanol and filtered. Aliquots from the ethanolic extract (10 ml each) were mixed with aqueous hydrochloric acid (20 ml 10% v/v), and filtered. The filtrate was rendered alkaline with ammonium hydroxide and extracted with successive portions of chloroform. The combined chloroform extract was evaporated to dryness, the residue was dissolved in hydrochloric acid (2 ml 10% v/v) and tested with Mayers reagent, and Dragendorffs reagent, respectively. If a precipitate was formed, it indicates the presence of alkaloids and /or nitrogenous bases (Balbaa, 1974).

Microorganism's sources

The cultures of bacteria (*Salmonella* sp.) obtained from the medical laboratory, University of Gezira, Sudan.

Preparation of medium :

Nutrient agar (N.A) : Twenty-eight grams of (OXOID Ltd.), were dissolved in one litter of distilled water, and then dispensed into flasks (250 ml), and autoclaved at 121°C (15 lb/in^2) for 15 minutes, then poured into sterile Petri dishes, which were allowed to solidity and kept inverted position in a refrigerator before use.

Effect of plant extracts on bacterial growth:

Antibacterial activity was determined by the disc diffusion method (Rıos and Recio, 2005). Where standardized bacterial cell suspensions of *Salmonella typhi* were added to the solidified medium into the sterile Petri dishes. The plates were then incubated at room temperature for 72 hours and the inhibition zones were measured. According to this technique, micro-glass fiber discs of 0.5 in diameter were saturated with 20 µl/ disc crude extract, and placed on the middle of Petri-plates separately. The test organism was streaked on each test Petri-plate prior to the placement of the saturated disc on mid-plate. Treated plates (three replicas for each test) were incubated at room temperature. Zones of inhibition were determined at 24 h post-treatment.

Results and Discussion:

Phytochemicals are naturally occurring compounds that have defense mechanism and protect plants from various diseases. The plant parts containing some phytochemical components in different concentration. Result in Table (1) displayed that the plant'sleaf has high saponine concentration while in low concentration in stem, also it contain flavonoids in a moderate level in other tested parts and contain Flavonones/ flavonols in low concentration .The results were in agreement with that reported by Encarnacion *et al*.(1994). However, the results were differ to that obtained by (Thirumal et al, 2012), who reported that this plant contain alkaloids, tri-terpenoids, steroids, tannins, phenolic compounds and cardiac glycosides.

Table (1): Qualitative chemical screening of Umm glagil plant parts:

The symbol +++, ++,+,- indicate a compound present in high, moderate, low, and absent level, respectively

Plant species	Plant part	Flavonoids	Flavonones / flavonols	Saponins	Tannins	Sterols	Alkaloids
Umm glagil (*Aristolochia bacteolate*)	Leaf	++	+	+++	-	-	-
	Stem	++	+	+	-	-	-

The plant materials of *Aristolochia bracteolata* selected for the study to evaluate the formulation containing the extracts of these plants for their antimicrobial activity. Data in Tables (2 – 5) showed that the effect of the solvent extracts on the *S. typhi* by measuring the inhibition zone diameter(mm). From the results it is highly noticeable that all the tested parts of Umm glagil methanolic extracts have

reasonable effect against *S. typhi*. followed by ethyl acetate of Umm glagil leaf and stem at the high concentration (100%). On the other hand, methanolic extracts root were also show good effect against *S. typhi*. The presence of secondary metabolites in plants, produce some biological activity. *Aristolochia* is used in traditional medicine for the treatment of various diseases, including those associated with bacteria. Phenols and tannins known us possess antibacterial properties (Palombo, 2011). According to (Sampedro and Valdivia, 2014), alkaloids, phenylpropanoids, or flavonoids, and terpenoids, which include saponins, are significant plant antibacterial agents. El Dirdiri *et al*., (1987) reported that root extract have antibacterial activity

A positive control was conducted by using antibiotic disks for Gram positive and Gram negative bacteria. The test was done to compare the effect of these antibiotic with the plant extract under the present study.

Table (2) : Effect of Umm glagil plant parts extracts obtained by different solvents on *S . typhi.*

Solvents	Plant parts		
	Leaf (mm)	**Steam(mm)**	**Root(mm)**
Ethyl acetate	17	15	05
Ethanol	13	09	05
Hexane	05	05	05
Methanol	18	19	17
P. ether	09	12	05
Water c	05	05	05

Table (3) : Effect of different concentrations of *Umm glagel* Ethayl acetae extracts on *S. typhi* .

Concentration %	Plant parts		
	Leaf(mm)	Steam(mm)	Root(mm)
0	05	05	05
25	10	05	05
50	14	11	05
75	16	12	05
100	17	15	05

Table (4) : Effect of different concentrations of *Umm glagel* Methanol extracts on*S. typhi*

Concentration %	Plant parts		
	Leaf	Steam	Root
0	05	05	05
25	13	14	12
50	15	15	13
75	17	17	15
100	18	19	17

Table (5) : Effect of different concentrations of *Umm glagegl* P.ethar extracts on*S. typhi*

Concentration %	Plant parts		
	Leaf (mm)	Steam(mm)	Root(mm)
0	05	05	05
25	05	07	05
50	06	08	05
75	08	10	05
100	09	12	05

Using gram negative antibiotic disk, the test was done to compare the effect of these antibiotic with the plant extract under study. The results are presented on table (6) which showed that the plant extract have an almost similar effect of inhibition as a standard antibiotics Piperacillin/ Tazobactam (TZP),Chloramphenicol (CH) and Tetracycline (TE). The plant extract recorded better effect than Co-Trimoxazole (BA) , Ciprofloxacin (CP) and Ceftizoxime (CL).

Table(6) : Effect of Gram negative antibiotic (on inhbition zone-cm) against *S. typhi*

Antibiotic	*S.typhi*
Ampicillin/ Sulbactam (AS)	2.0
Co- Trimoxazole (BA)	1.0
Cefotaxime (CF)	0.0
Piperacillin/ Tazobactam (TZP)	1.7
Chloramphenicol (CH)	1.8
Ciprofloxacin (CP)	1.0
Ceftizoxime (CL)	1.0
Tetracycline (TE)	1.2
Ofloxacin (OF)	2.5
Gentamicin (GM)	3.00
Amikacin (AK)	2.0
Levofloxacin (LE)	2.3

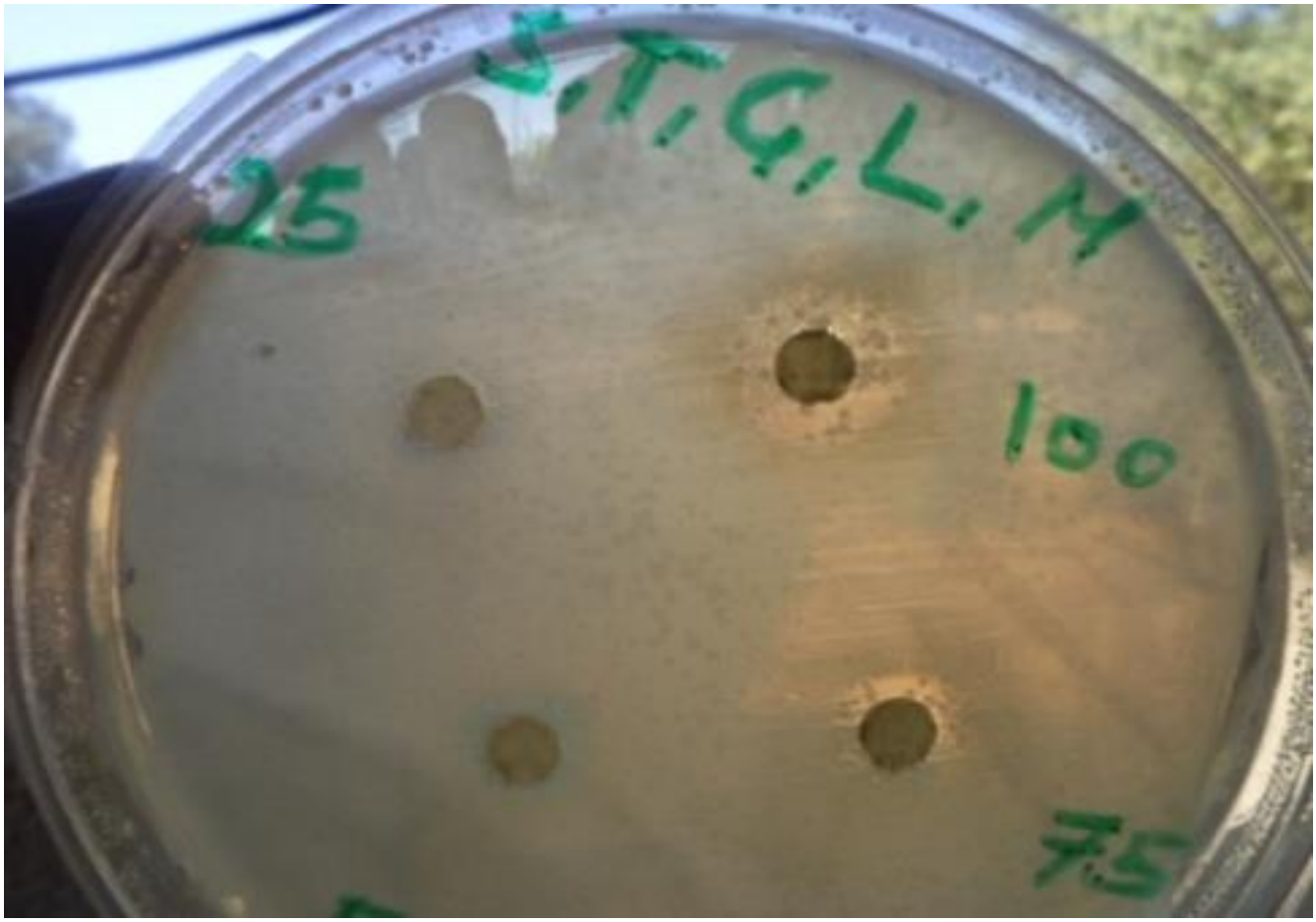

Figure (1) : photograph of umm glagil methanolic leaf extract against *S. typhi*

Conclusion

It could be concluded that , *Aristolochia bracteolate* regarding the present study this plant has active phytochemical compounds as antibacterial activity of all tested parts to mainly against *salmonella typhi.*

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Effects of Gamma Radiation on Germination, Plant Height and Seed Viability of Okra (*Abelmoschus esculentus*)

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Abstract

This experiment was conducted to evaluate the effects of different doses of gamma radiation on germination at 15 days after sowing, plant height at 15 and 30 days after sowing, and seed viability in okra. Seeds were exposed to 0 (control), 200, 300, 400, and 500 Gy of gamma rays. Significant differences ($P \leq 0.01$) were observed in plant height at 15 days after sowing, and highly significant differences ($P \leq 0.001$) in germination and plant height at 30 days after sowing. However, high gamma doses of 400 and 500Gy markedly decreased the number of viable seeds while increasing unviable seeds. Low doses (200 and 300Gy) had no significant effects on seed viability compared to the control. A strong linear relationship was found between radiation dose and seed viability ($R^2 = 0.94$) and between dose and seed unviability ($R^2 = 0.95$). Increasing radiation doses significantly ($P \leq 0.05$) reduced and delayed seed viability, resulting in a 27% decline (from 100% in the control to 73% at 500 Gy). The results indicate that low doses of gamma radiation are non-detrimental to seed viability, while higher doses substantially impair germination and early growth in okra. Overall, these findings suggest that high gamma doses (≥ 500Gy) are detrimental to germination and growth, while moderate doses (200-400Gy) maintain viability and can even enhance growth through hormetic effects. Such information is valuable for optimizing gamma irradiation in mutation breeding programs aimed at generating variability without severely compromising seedling performance.

***Keywords**: Gamma radiation, hormetic effects, linear relationship, mutation breeding, okra, seed viability*

تأثير أشعة غاما على الانبات، طول النبات وحيوية البذور في نبات البامية (*Abelmoschus esculentus*)

المستخلص

أجريت هذه التجربة لتقييم أثر جرعات مختلفة من أشعة غاما على الإنبات بعد 15 يوما من الزراعة، إرتفاع النبات بعد 15 و30 يوما من الزراعة، وحيوية بذور البامية. تعرضت البذور لجرعات صفرية (المجموعة الضابطة) و 200 و300 و400 و500 غراي من أشعة غاما. لوحظت فروقً معنوية ($P\leq 0.01$) في ارتفاع النبات بعد 15 يومًا من الزراعة، وفروقًا معنوية عالية ($P\leq 0.001$) في الإنبات وارتفاع النبات بعد 30 يومًا من الزراعة. مع ذلك، أدت جرعات غاما العالية (400 و500 غراي) إلى انخفاض ملحوظ في عدد البذور القابلة للحياة، مع زيادة في عدد البذور غير القابلة للحياه.لم يكن للجرعات المنخفضة (200 و300 غراي) أي آثار معنوية على حيوية البذور مقارنة بالمجموعة الضابطة. وجدت علاقة خطية قوية بين جرعة الإشعاع وحيوية البذور ($R^2= 0.94$) وبين الجرعة وعدم الحيوية ($R^2= 0.95$). أدت زيادة جرعات الإشعاع بشكل ملحوظ ($P \leq 0.05$) إلي إنخفاض قابلية البذور للنمو وتأخيرها، مما أدى إلى انخفاض بنسبة 27٪ (من 100٪ في المجموعة الضابطة إلى 73٪ عند 500 غراي). تشير النتائج إلى أن الجرعات المنخفضة من أشعة غاما لا تؤثر سلباً على قابلية البذور للنمو، بينما تُضعف الجرعات العالية بشكل كبير الإنبات والنمو المبكر في البامية. بشكل عام، تشير هذه النتائج إلي أن جرعات غاما العالية (≤ 500 غراي) تضر بالإنبات والنمو، بينما تحافظ الجرعات المعتدلة (200 و400 غراي) علي قابلية النمو، بل ويمكنها تعزيز النمو من خلال التأثيرات الهرمونية. تعد هذه المعلومات قيّمة لتحسين إشعاع غاما في برامج تربية الطفرات الهادفة إلي توليد تباين دون المساس الشديد بأداء الشتلات.

الكلمات المفتاحية: *إشعاع جاما، التأثيرات الهرمونية، العلاقة الخطية، تربية الطفرات، البامية، حيوية البذور*

Introduction

Okra [Abelmoschus esculentus (L.) Moench] belongs to the genus Abelmoschus, which belongs to the family Malvaceae that consists of twelve species (Kisher *et al*., 2016). *A. esculentus*, commonly known as okra or lady's finger, is a warm-season crop cultivated throughout the tropical and warm temperate regions of the world (Surendran *et al*., 2017). It has the highest chromosome number among vegetables (2n=130). It is a self-pollinated vegetable crop that is mainly propagated by seeds (Osawaru *et al*., 2014).

Okra originated in tropical Africa and is native to northeastern Africa, mainly Ethiopia and Sudan (Oyelade *et al*., 2003; Santos *et al*., 2012). The optimum growth temperature range is between 24°-27°C, and it is highly tolerant to high temperatures and drought conditions (Surendran *et al*., 2017). Okra fruit is primarily eaten raw or cooked, and it is a significant source of vitamins A, B, and C, as well as minerals like phosphorus, potassium, sulfur, calcium, iron, and iodine. However, it is also said to be low in salt, saturated fat, and cholesterol (Kendall and Jenkins, 2004).

Global okra production rose from 1,107,430 tonnes in 1961 to 11,523,290 tons in 2023, with an average annual growth rate of 4.01%. India leads as the world's top okra producer, producing 7.16 million tons annually with an average growth rate of 3.70%, accounting for 62.1% of global production. Nigeria ranks second with an annual production of 1.87 million tons, growing at 5.53% per year and contributing 16.3% to global production. Sudan ranks fourth in okra production, with output having increased from 263,000 tons in 2012 to 303,150 tons in 2023, reflecting an average annual growth rate of 2.31% (FAO, 2024).

In Sudan, okra is the most traditionally popular vegetable; it is grown in all areas of the country throughout the year, where both cultivated and wild types are known (Mohamed, 2023; Schippers, 2002). In addition to the introduced varieties such as Clemson Spineless and Pusa Swani, there are a number of local varieties, e.g., spiny types called Khartoumia, Karrari, Kassala, Medani, Sinnar, and others.

In certain cases, the desired trait does not exist in germplasm collections of a crop, and hence mutation breeding can be efficiently employed as an alternative valuable method to generate and develop new varieties with such desired characteristics (Reddy and Dhaduk, 2014). A mutation is a sudden, heritable change in the DNA of a living cell that is not caused by genetic segregation or recombination. (Van Harten, 1998). Mutation induction has been proven to be an effective method to increase genetic variability in crops (Surendran *et al*., 2017). Inducing variation through mutation is common and has been found to be successful in okra (Ashadevi *et al*., 2017).

A primary application of induced mutations is the improvement of polygenic traits in crop plants by introducing desirable mutants directly into commercial cultivars or using them indirectly through crossbreeding (Jadhav *et al.,* 2012). According to the International Atomic Energy Agency (IAEA) database (http://mvgs.iaea.org), there are more than 3,300 officially released mutant varieties of 170 different species in more than 60 countries around the world that not only increase biodiversity but also provide material for plant breeding (Jankowicz-Cieslak *et al.,* 2017). Mutation induction can be carried out using chemical or physical mutagens (Shahab *et al.,*

2018). Some of the agronomic traits generated as a result of mutation induction included increasing 3Deoxyanthocyanidin accumulation in leaves (Petti *et al*., 2014), dwarfism, early flowering, high protein digestibility, and high lysine content, which have been widely used in sorghum breeding (Shu *et al.,* 2011).

Therefore, this study aimed to study the effects of gamma radiation on germination, plant height and seed viability of okra.

Study Site

Experiment was conducted during the winter season of 2017-2018 at Shambat Research Station Farm (latitude 15°36'N and longitude 32°32'E and elevation 380m). Gamma rays radiation was carried out in the International Atomic Energy Agency (IAEA), Austria.

Materials and Methods

Experimental Design

Experiment was conducted using a randomized complete block design (RCBD) with three replications. Local cultivar of okra seeds was used in this study. Land was prepared by deep ploughing and harrowing twice in opposite directions and then leveled; thereafter, 70 cm ridges were prepared. Seeds were sown at 30 cm intra-row spacing and 2 to 3 seeds per hole, then thinned to one plant per hole. The experiments were irrigated weekly and hand weeded whenever necessary. All the recommended cultural practices were followed to maintain good crop stand.

Genetic Material and Irradiation of Seeds

A widely cultivated local okra landrace from Kasala was used in this study. Seeds were exposed to gamma radiation doses of 0, 200, 300, 400, and 500 Gy, using a radiation source with a capacity of 3000 Ci and a delivery rate of 7200 r/min.

Data Collection

Data on morphological traits included germination at 15 days after sowing and plant height at 15 and 30 days after sowing. Twenty-five plants were randomly selected from each plot for assessment of plant height at 15 and 30 days after sowing.

For the assessment of seed viability, fruits from the M_1 generation (plants grown from irradiated seeds) were harvested, and seeds of the M_2 generation (progeny of M_1 plants) were extracted. A total of ninety fruits were then randomly selected for viability testing. The extracted seeds were cleaned, air-dried, and stored under ambient laboratory conditions until analysis. Percentage of the number of seeds was calculated as follow;

Number of viable seeds (%) = (Number of viable seeds／Total number of seeds) × 100

Number of unviable seeds (%) = (Number of unviable seeds／Total number of seeds) × 100

For determining seed germinability, the seeds of the M_2 generation (progeny of M_1 plants) were sown in moist soil under controlled conditions. The number of germinated seeds was recorded daily for 15 days, and the percentage of germination for each treatment was calculated using the formula:

Germination (%) = (Number of germinated seeds／Total number of seeds sown) × 100

Seedling survival was monitored and recorded from the 10th day onward after sowing.

Data Analysis

All data were subjected to an analysis of variance, with mean comparisons performed using Fisher's protected least significant difference (LSD) test at P≤0.05 (Steel and Torrie, 1980). Least square means for all genotypes were generated using analysis of variance (ANOVA) option of GenStat 18th Edition (VSN International Ltd., UK)

Results

Analysis of variance (Table 1) showed significant differences (P≤ 0.01) for plant height at 15 days and highly significant differences (P≤ 0.001) for germination and plant height at 30 days.

Table 1: Analysis of variance (ANOVA) of germination and plant height of okra (*Abelmoschus esculentus*) genotypes exposed to five gamma radiation doses in winter season (2017-2018)

Source of variation	Df	Germination	Plant height at 15 DAS (cm)	Plant height at 30 DAS (cm)
Rep	2	1620.6	8.132	710.38
Dose (Gy)	4	9603.2***	8.274**	84.082***
Residual	8	188	1.249	2.56
Total	14			

= significant difference at P≤0.01, *= highly significant difference at P≤0.001.

DAS= days after sowing.

Mean performance of germination at 15 days after sowing and plant height at 15 and 30 days after sowing showed differences among irradiation doses. The 500Gy treatment showed the lowest mean number of germination seeds at 15 days after sowing (95.70) while the control had the highest (237.5), followed by 200Gy (197.5) and 300Gy (152.5), respectively. Regarding plant height at 15 and 30 days after sowing, the control had the highest plant height at 15 and 30 days after sowing (19.8 cm & 57.4 cm, respectively), followed by irradiation dose 400Gy (18.9 & 51.3, respectively), while irradiation dose 300Gy showed the lowest plant height at 15 and 30 days after sowing with 15.7cm and 43.2cm, respectively (Tale 2).

Table 2: Mean performance of germination at 15 days after sowing and plant height at 15 and 30 days after sowing of okra seeds planted in winter (2017-2018)

Dose (Gy)	Germination at 15 DAS	Plant height at 15 DAS (cm)	Plant height at 30 DAS (cm)
Control	237.5±7.9	19.8±0.7	57.4±0.9
200	197.5±7.9	17.6±0.7	48.2±0.9
300	152.0±7.9	15.7±0.7	43.2±0.9
400	125.3±7.9	18.9±0.7	51.3±0.9
500	95.70±7.9	16.7±0.7	47.3±0.9
LSD (p≤0.05)	25.8	2.10	3.01
SED (p≤0.05)	11.2	0.91	1.31
CV%	8.50	6.30	3.20
Grand mean	161.6	17.7	49.5
Minimum	91.0	15.1	36.8
Maximum	272	22.8	72.2

DAS= days after sowing.

Differences between viable and unviable seeds are presented in Plate 1. In this study, most seeds were viable, although a few were unviable, especially at the higher irradiation doses (300, 400 and 500Gy). The viable seeds were round and brown to green color, whereas the unviable seeds were small, wrinkled, and dark green to black in color.

To determine seed germinability, seeds were sown in moist soil, and the number of germinated seeds was counted daily for 15 days. The germination percentage for each treatment was then calculated, and seedlings survival was recorded from the 10th day onward after sowing. Results showed that the percentage of viable seed germination was 100%, while unviable seeds did not germinate (0%).

Plate1. Differences between viable and unviable seeds resulting from 400Gy dose

Analysis of variance (Table 3) showed significant differences (P≤0.001) among viable and unviable seeds. No significant differences in total seed number.

Table 3: Analysis of variance (ANOVA) of seed viability of okra (*Abelmoschus esculentus*) genotypes exposed to five gamma radiation doses in winter season (2017-2018)

Source of variation	Df	Number of viable seeds	Number of unviable seeds	Total number of seeds
Rep	2	810.2	48.13	470.2
Dose (Gy)	4	4457.2***	7272.11***	522.2ns
Residual	443	145.8	12.07	152.9
Total	449			
LSD (P≤0.05)		3.5	1.0	3.60

***= highly significant difference at P≤0.001, ns=non-significant difference.

The percentage of viable and unviable seeds is presented in Table 4. The number of viable seeds was highest in the control (62.0) and decreased progressively with increasing radiation doses. Treatments at 200Gy (59.9) and 300Gy (57.9) showed a moderate reduction, while 400Gy (50.0) and 500Gy (45.3) resulted in a pronounced decrease. The 500Gy treatment produced a significantly lower number of viable seeds than all other treatments, as indicated by the mean separation letters (LSD, P ≤ 0.05). Conversely, the number of unviable seeds increased with increasing radiation dose, ranging from 0.0 in the control to 2.4, 11.6, 21.3, and 35.5 at 200Gy, 300Gy, 400Gy, and 500Gy, respectively. The total number of seeds per treatment varied slightly, ranging from 62.4 at 200Gy to 67.3 at 500Gy.

Table 4: Percentage of seed viability from okra exposed to various doses of gamma radiation

Dose	Viable seed number	Viable percentage	Unviable seed number	Unviable percentage	Total seed number
0	62.0 d	100	0.00 a	0.00	62.0
200	59.9 cd	96.6	1.50 b	2.40	61.4
300	57.9 c	93.3	7.20 c	11.6	65.1
400	50.0 b	80.6	13.2 d	21.3	63.2
500	45.3 a	73.0	22.0 e	35.5	67.3
LSD (P≤0.05)	3.50		1.00		3.60
SE±	1.30		0.40		1.30
SED (P≤0.05)	1.80		0.50		1.80
CV%	22.0		39.4		19.4
Grand mean	55.0		8.80		63.8
Minimum	15.0		0.00		24.0
Maximum	95.0		36.0		105.0

The percentage of viable and unviable seeds response to gamma radiation doses is presented in Figure 1. Linear regression analysis revealed a strong negative relationship between radiation dose and seed viability (R^2=0.94) and a strong positive relationship between radiation dose and seed unviability (R^2=0.95), indicating that 94% and 95% of the variation in these parameters, respectively, was explained by the applied radiation doses.

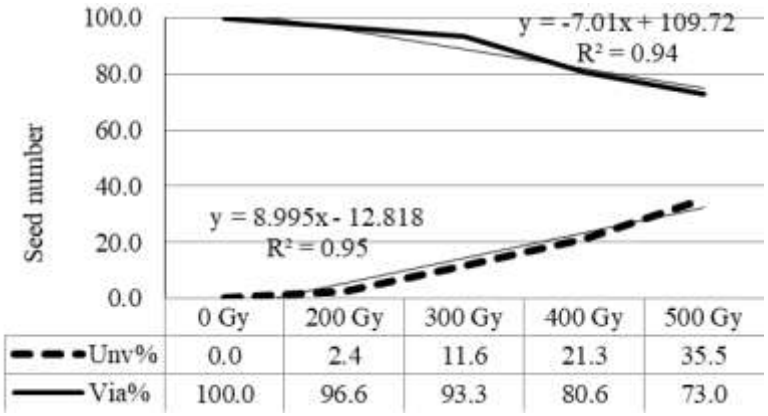

Figure 1: Percentage of viable and unviable seeds of okra in response to gamma radiation doses.

Discussion

Gamma irradiation significantly affected germination, plant height, and seed viability in okra (*Abelmoschus esculentus* L.) in a dose-dependent manner.

Germinated seeds decreased progressively with increasing irradiation, from the highest in the control (237.5) to the lowest at 500Gy (95.7). This reduction is likely due to radiation-induced damage to embryonic cells or inhibition of key germination enzymes, as reported in okra (Dhankhar and Dhankhar, 2004) and other crops including chickpea (Toker *et al*., 2005; Umavathi and Mullainathan, 2016), lima bean (Kumar *et al*., 2003), sweet potato (Tabares and Talavera, 2003), and cowpea (Seema *et al*., 2003). Likewise, Asare *et al*., (2017) observed that gamma irradiation above 400 Gy delayed and reduced germination and seedling growth compared with controls.

Reduced growth has been attributed to auxin destruction, changes in ascorbic acid content, and physiological and biochemical disturbances (Gunckel and Sparrow, 1954). However, the stimulating effect of lower doses of gamma irradiation on the growth of okra plants might be due to the stimulation of cell division and processes that affect the synthesis of nucleic acids (Pitirmovae, 1979).

Plant height at 15 and 30 days after sowing showed a non-linear trend. , A decline occurred when the irradiation dose was increased to 200Gy (17.6cm & 48.2cm) and 300Gy (15.7cm & 43.2cm) compared to the control (19.8cm & 57.4cm), while plant height at 15 and 30 days after sowing increased when the irradiation dose was increased to 400Gy (18.9cm & 51.3cm), and then decreased when the irradiation dose was increased to 500Gy (16.7cm & 47.3cm). The highest plant height at 15 and 30 days after sowing was observed for the control which was closely followed by 400Gy, while 300Gy recorded the lowest plant height at 15 and 30 days after sowing.

This non-linear pattern suggests a possible hormetic response, where moderate radiation doses stimulate growth while higher doses are inhibitory, a phenomenon widely reported in plants exposed to abiotic stressors including gamma radiation (Calabrese and Baldwin, 2003; Vaiserman *et al*., 2021). Similar findings were reported by Hegazi and Hamideldin (2010), who observed maximum plant height at 400Gy compared with 300Gy and 500Gy gamma-ray treatments.

Likewise, high gamma irradiation doses have deleterious effects on plant height (Loch, 1977; IBPGR, 1991; Singh *et al.*, 2000 and Ochatt *et al.*, 2001). The reduction in plant height observed in the current study may be attributed to a reduction in mitotic activity of meristematic tissues (Khalil *et al.*, 1986). Iqbal, 1969 and Walther, 1969 reported that the reduction in plant height may be attributed to damage to the processes of cell division and cell elongation as a result of mutagenic treatment. This is because irradiation causes DNA breakage in plant cells, further leading to various types of damage to plant cell division and development processes, and plant growth (Amirikhah *et al*., 2019; Li *et al*., 2021).

Seed viability was significantly reduced at higher doses (400-500Gy), while unviable seeds increased. This decline can be attributed to several biological mechanisms. Ionizing radiation induces lethal mutations in the embryo's DNA, such as chromosomal breaks, deletions, and rearrangements that compromise embryo development (Baek *et al*., 2005; Kovacs and Keresztes, 2002). It may also damage the endosperm-the primary nutrient source for germination-or disrupt cellular integrity, including membranes and organelles (Melki and Dahmani, 2009; Sangwan and Mehta, 2010). Moreover, gamma radiation triggers oxidative stress through the generation of reactive oxygen species (ROS), which further damage nucleic acids, proteins, and lipids (Kim *et al*., 2004; Wi *et al*., 2007; Zaka *et al*., 2002). For practical purposes, viable okra seeds should be harvested once they reach the proper maturation stage, typically when seeds transition from green to brown, as seeds continue to enlarge on the plant until fully developed. High radiation doses accelerate loss of viability, emphasizing the importance of dose optimization for mutation breeding and seed preservation.

Linear regression analysis revealed a strong negative relationship between radiation dose and seed viability ($R^2 = 0.94$) and a strong positive relationship between dose and seed unviability ($R^2 = 0.95$). This indicates that 94 % and 95 % of the observed variation in these parameters, respectively, were explained by radiation dos. For instance, actual viability declined from 62.0 % to 45.3 %, representing a reduction of ~ 26.9 %.

These results are consistent with earlier studies showing that germination and viability decline proportionally with increasing gamma dose (Asare *et al*., 2017; Melki and Dahmani, 2009; Toker *et al*., 2005). The strong linear relationships observed confirm that radiation dose is a key determinant of seed viability, though the magnitude of reduction must be interpreted based on actual percentage changes rather than R^2 values.

Overall, these findings suggest that high gamma doses (≥ 500Gy) are detrimental to germination and growth, while moderate doses (200–400Gy) maintain viability and can even enhance growth through hormetic effects. Such information is valuable for optimizing gamma irradiation in mutation breeding programs aimed at generating variability without severely compromising seedling performance.

Conclusion

Low doses of gamma radiation showed no adverse effects on seed viability in okra, suggesting potential for safe use in mutation breeding. However, higher doses significantly reduced germination and plant growth. Further research is needed to clarify the physiological and molecular mechanisms behind radiation-induced changes and seed aging in okra.

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Impact of Drip irrigation Regimes and Surface Irrigation on the Yield and Water Productivity of Garlic (*Allium sativum* L.) in Khartoum State, Sudan

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Abstract

Irrigation water management practices are the main strategies for improving water productivity. The objective of this study was to investigate the effect of drip irrigation systems with three irrigation levels of total water requirement (100%, 75%, and 50%) on the water productivity of two varieties of garlic (V1 Baladi and V2 Egyptian) compared with furrow irrigation (control). The treatments are two irrigation type furrow irrigation (C) and 3 level of drip irrigation system (D1 100, D2 75and D350). The field experiment was arranged in a split plot design with three replicates. The results showed that taller plant and the highest number of leaves were recorded with drip irrigation of 100% ETc for both seasons compared to other treatments. Higher yields were produced with 100% ETc under drip irrigation, while the lowest yields were recorded with 50%ETc and surface irrigation in both seasons. Moreover, the highest values of water productivity and economic water productivity were obtained under 50% ETc. Drip irrigation with 100% ETc was the most economic and had a higher net benefit.

Keywords: *drip irrigation, water requirement, Crop evapotranspiration, water productivity and economic water productivity*.

أثر مستويات الري بالتنقيط والري السطحي على الانتاجية و انتاجية الماء في الثوم تحت ظروف في ولاية الخرطوم، السودان

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المستخلص

ممارسات إدارة مياه الري هي من الاستراتيجيات الرئيسية لتحسين إنتاجية المياه. الهدف من هذه الدراسة هو الحصول على تأثير نظام الري بالتنقيط بثلاثة مستويات للري من إجمالي الاحتياجات المائية (50 %,75%,100%) على إنتاجية المياه لصنفين من الثوم (V1 بلدي و V2 مصري) مقارنة مع الري السطحي (Control). المعاملات عبارة عن نوعين من الري، السطحي بالسرب (C) و 3 مستويات من نظام الري بالتنقيط ($D_1$100% ، D_2 75%، $D_3$50%). تم ترتيب التجربة الحقلية في تصميم القطع المنقسمة بثلاث مكررات. أظهرت النتائج أن أكبر طول نبات وأكبر عدد من الأوراق تم الحصول عليه مع الري بالتنقيط بنسبة ET_c 100% لكلا الموسمين مقارنة بالمعاملات الأخرى. اعلي انتاجية تم الحصول عليها في 100% ET_cتحت الري بالتنقيط بينما سجلت أقل انتاجية في ET_c 50% تحت الري السطحي في كلا الموسمين. علاوة على ذلك، تم الحصول على أعلى قيم إنتاجية المياه والإنتاجية الاقتصادية للمياه تحت ET_c 50%. كان الري بالتنقيط بنسبة ET_c 100%هو الأكثر اقتصادا وكان له فائدة صافية أعلى.

***الكلمات المفتاحية :** الري بالتنقيط ، الاحتياجات المائية ، نتح بخر المحصول ، انتاجية المياة والانتاجية الاقتصادية للمياة .*

Introduction

Garlic (*Allium sativum L.*) is the second most vital cultivated *Allium* species after onion worldwide regarding its production and economic value. It is used as a seasoning in many foods worldwide (Ministry of Agriculture, River Nile State, 2018). There are several varieties grown in Sudan such as: Baladi varieties (Selim, Al-Hasa, and Zalingei) characterized by small bulbs and strong flavor, the Chinese variety, distinguished by lobes with large size, a white peel interspersed with a pink color, and the imported varieties (Egyptian, Syrian, Turkish and Ethiopian) characterized by large lobes and proven successful, especially the Ethiopian variety, which is grown in the Berber region of River Nile State (Ministry of Agriculture, River Nile State, 2018). The production ranges between (4.8–9.5) t ha^{-1}, depending on the variety grown (Ministry of Agriculture, Khartoum State 2018).

Irrigation water management refers to polices to conserve water supplies, reduce impact on water quality and improve the net economic returns of crops by applying less water than the crop required (deficit irrigation), shifting to alternative crops or high yield varieties of the same crop that use less water, or adopting more efficient irrigation technologies (Patil *et al*., 2015). The water efficient use at the field level will lead to saving water and improving the quantity and quality of crop production as mentioned by Panigrahi, *et al.* (2012).

Drip irrigation may help to achieve water conservation by reducing evaporation and deep percolation when compared to other types of irrigation such as surface irrigation or overhead sprinklers because water can be more precisely applied to the plant roots. A drip irrigation system ensures higher water use efficiency (Ghaemi and Sadri, 2012). Agriculture is the largest water consumer, but overall irrigation efficiency in the case of surface irrigation at the farmers, fields is very low or insufficient (Tshenyego, *et al*., 2017). This water scarcity is a major problem in many areas of the world; in this case, studying alternative mechanisms to solve this problem is essential (Soomro, *et al*., 2022). Drip irrigation reduces evaporation from the soil surface, minimizes runoff and deep percolation, and enables even application of water in fields, consequently increasing irrigation efficiency (Chomsang, *et al*., 2021).

Increasing the irrigation level from 60% to 100% of ET_c significantly increased plant height, leaf number and pod production in bean varieties (Hegab, *et al*., (2014). Mandefro and Quraishi (2015) found that using a drip system and applying a 100% ET_c regime improved the growth parameters, yield and yield contributing parameters of garlic and has more efficiency than surface irrigation. The application of the drip irrigation system produced the highest WUE water-use efficiency with an average of 5.2 kg m^{-3}, while the obtained WUE under the furrow system averaged 2.7 kg m^3, and the water saved by the drip relative to the furrow system was about 44% to 55%. In this direction, Ghadami *et al.,* (2010) and Gyanendra *et al.,* (2016) reported that the drip irrigation system has a significant influence on garlic productivity. The garlic vegetative growth and water use efficiency values were the highest under 75% of the pan evaporation treatment and declined with increasing irrigation amounts to 100 and 125% of the pan evaporation. Abd El-Hady and Ebtisam (2016) reported that a drip irrigation system has a recognized impact on increasing growth characteristics, garlic yield, and water productivity. Therefore, the objective of this study was to

examine the effects of a drip irrigation system on the water productivity and yield of garlic in Khartoum state, Sudan.

Materials and methods

The field experiment was conducted during the two consecutive seasons 2019/20 and 2020/21 at a private field located in the west Omdurman area of Khartoum State, 36 km west of Omdurman (latitude 15° 63´ N and longitude 32° 53´ E). The area lies in the arid and semi-arid zones with low relative humidity; annual rainfall is less than 100 mm and the maximum temperature in summer 45^{0}C. The topography of the experimental site was uniform and leveled and the soil was sandy loam soil texture with more than 100 cm depth. Drip irrigation was installed in the experimental area with the main line 90mm PVC pipe, sub-main line 63mm PVC pipe, lateral length 30 m, 0.3 m distance between drippers (built in drippers), at a discharge rate of 4 L h^{-1}, 1 m between laterals.

Two irrigation systems were used: a drip irrigation system with three irrigation water regimes namely: 100% ET_c, 75% ET_c and 50 ET_c as treatments and conventional irrigation (furrow). These treatments were arranged in a split plot design with three replicates.

Meteorological data (maximum and minimum air temperature, relative humidity, sunshine duration and wind speed at 2-meter height) were taken from the Khartoum Meteorological Station and used to compute the reference evapotranspiration (ET_o) according to (Allen *et al*. 1998).

Crop evapotranspiration (ET_c) was calculated using the following formula:

$$\mathrm{ET_c} = \mathrm{ET_0} \times \mathrm{Kc} \ldots\ldots\ldots\ldots \quad (1)$$

Where:

ET_c=Crop evapotranspiration (mm/day), K_c=Crop coefficient (dimensionless)

ET_0 =reference evapotranspiration (mm/day).

The standard $K_c$of for every growth stage (initial, mid, and end) for garlic was taken from the FAO 56 (Table 1) and adjusted to local information using the following equation according to Allen et *al*. (1998):

$$\mathrm{K_{ci}} = \mathrm{K_{c\,prev}} + \left[\frac{\mathrm{i}-\Sigma(\mathrm{L_{prev}}}{\mathrm{L_{stage}}}\right](\mathrm{K_{c\,next}} - \mathrm{K_{c\,prev}}) \ldots\ldots\ldots \quad (2)$$

where:

i =day number within the growing season, $K_{c\,i}$ =crop coefficient on day I, L_{stage} =length of the stage under consideration [days] and $\sum(L_{prev})$ =sum of the lengths of all previous stages [days].

Table 1. Garlic crop coefficient.

Crop	$K_c$ini	K_c mid	K_c end
Garlic	0.70	1.00	0.70

Source: (Allen, *et al*., 1998)

The volume of water to be applied was calculated according to Bagali et *al*. (2012) using the following equation:

Quantity of water to be applied (liters) = ET_c (cm) × area (ha) × 100000 …… (3)

The irrigation water was added to each treatment in the morning and the time of irrigation was calculated using the following equation:

$$\text{Irrigation time (hr/day)} = \frac{\text{Water requirement (l/day)}}{\text{Application rate (l/hr)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Water productivity (WP) was calculated as the ratio of the crop yield to the seasonal irrigation water applied using the following formula.

$$WP\ (kg/m^3) = \frac{\text{Yield (kg /ha)}}{\text{Total water applied } (m^3/ha)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Economic water productivity (EWP) was calculated as the gross income in Sudanese Pounds (SDG) per gross water supplied in m^3 using the following equation:

$$EWP = GI/GIWR \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where:

GI is the gross income from the sale of garlic (SDG/ha) and GIWR is the gross irrigation water applied (m^3/ha).

The measured parameters in each sub-plot to determine the number of leaves, plant height and total yield (t/ha)**.**

Economic indicators such as the partial budget and benefit cost ratio were used to evaluate and compare the profitability of the tested factors as described by (CIMMYT, 1988). Total income was calculated by multiplying the crop yield (t/ha) by the crop value, (The price was set in May 2021, according to the Omdurman market, and was converted to US dollars)

The data were analyzed according to the standard statistical procedure using STATISTICS 10. The mean separation for the different parameters was computed using least significant difference (LSD) at ($p \leq 0.05$) .

Results and discussion

Effect of drip irrigation regimes and surface irrigation on plant height and number of garlic leaves

There was no significant difference in plant height, but there was a highly significant difference in the number of leaves of garlic at ($p \leq 0.05$). The taller plants and the highest number of leaves were observed under 100% ET_c with drip irrigation for both seasons compared with the other treatments (Table 1). For the interaction between irrigation and varieties, the results showed that there was a significant difference in plant height in both seasons, but the higher plants were recorded with 100% ET_c under drip irrigation (Table 1), this may be due to the fact that the crop has obtained its actual water needs. In the number of leaves, there was a significant difference in both seasons. The highest number of leaves per plant was recorded in 100% ET_c under drip irrigation, while the lowest number of leaves was recorded in 75% ET_c and surface irrigation in both seasons. This result corroborated the findings of Sankar, *et al*. (2008) who found that drip irrigation at 100% ETc recorded the highest plant height and number of leaves compared to surface and sprinkler irrigation of garlic. Moreover, Khalifa et *al*. (2022) reported that taller plants and

higher numbers of leaves of tomato were recorded under drip irrigation compared with surface irrigation.

Table 1. Effect of drip irrigation regimes and surface irrigation on the plant height and number of garlic leaves during two consecutive winter seasons, 2019/2020 and 2020/2021.

Treatments	Plant height (cm)		No. of leaves	
	2019/20	20/2021	2019/20	20/2021
Surface irrigation (D_1)	48.6	49.9	6.9	6.7
Drip irrigation with 100% of ET_c (D_2)	60.5	62.6	9.1	10.0
Drip irrigation with 75% of ET_c (D_3)	59.1	60.4	8.4	8.9
Drip irrigation with 50% of ET_c (D_4)	52.4	53.4	7.2	7.1
LSD	0.99	2.47	0.39	0.49
CV%	0.93	2.24	4.52	3.09
Baladi variety (V_1)	55.0	55.7	7.9	8.3
Egyptian variety (V_2)	55.3	55.7	7.9	8.0
LSD	1.50	2.17	0.29	0.19
D_1V_1	47.7	47.2	6.9	6.5
D_1V_2	49.5	52.6	6.9	6.9
D_2V_1	60.7	62.1	8.8	9.9
D_2V_2	60.3	63.1	9.4	10.0
D_3V_1	59.3	60.1	8.4	9.4
D_3V_2	59.0	60.0	8.1	8.2
D_4V_1	52.4	52.6	7.3	7.2
D_4V_2	52.4	52.6	7.1	7.0
LSD	2.38	3.92	0.55	0.55
CV%	3.06	4.32	4.05	2.66

Effect of drip irrigation regimes and surface irrigation on the total yield of garlic

Yield was significantly affected by irrigation, and the maximum yield of garlic was recorded with 100% ET_c under drip irrigation, while the lowest yield was recorded with 50% ET_c and surface irrigation in both seasons (Table 2). Among the interactions between irrigation methods and varieties, the highest yield was recorded with 100% ET_c under drip irrigation and the lowest yield was recorded under surface irrigation in both seasons (Table 2). This confirms the earlier findings of Khalifa et *al*. (2022), who found that the highest yield components and quality of tomato were recorded with 100% ETc under drip irrigation, while the lowest were recorded with 75% ETc and surface irrigation in both seasons. On the other hand, Sankar et *al*. (2008) reported that the highest yield of garlic was obtained with drip irrigation at 100% compared to surface irrigation.

Table 2. Effect of drip irrigation regimes and surface irrigation on the yield of garlic leaves during two consecutive winter seasons, 2019/2020 and 2020/2021.

Treatments	Yield (t/ha)	
	2019/20	20/2021
Surface irrigation (D_1)	4.6	4.5
Drip irrigation with 100% of ET_c (D_2)	7.8	7.9
Drip irrigation with 75% of ET_c (D_3)	7.1	7.1
Drip irrigation with 50% of ET_c (D_4)	5.3	5.3
LSD	0.26	0.26
CV%	2.18	2.17
Baladi variety (V_1)	6.2	6.3
Egyptian variety (V_2)	6.2	6.1
LSD	0.11	0.14
D_1V_1	4.5	4.5
D_1V_2	4.7	4.6
D_2V_1	7.9	7.9
D_2V_2	7.7	7.8
D_3V_1	7.2	7.3
D_3V_2	7.0	6.9
D_4V_1	5.5	5.4
D_4V_2	5.1	5.2
LSD	0.30	0.32
CV%	2.07	2.63

D= Drip irrigation system, V = Varity

Effect of drip irrigation regimes and surface irrigation on the total water applied of garlic

The total water applied to garlic through drip irrigation regimes were 8,620 m3/ha, 12,640 m3/ha, 6,465 m3/ha, 9,480 m3/ha, 4,310 m3/ha, and 6,320 m3/ha at 100% ETc, 75% ETc, and 50% ETc for the seasons 2019/20 and 2020/2021, respectively, while Surface irrigation were 20,230 m3/ha and 22,370 m3/ha at 100% ETc, for the seasons 2019/20 and 2020/2021, respectively. From the above results, it is noted that drip irrigation saving 50% of irrigation water at 100% ETc. Similar results of saving irrigation water by the drip irrigation system were reported by Khalifa, *et al*. (2013) who found that the micro sprinkler irrigation system saved water by about 119% and 101% for two seasons, respectively, as compared to the surface irrigation. Sankar, *et al*. (2008) indicated that the drip irrigation saved applied water by 38% compared to the surface method of irrigation on garlic.

Effect of drip irrigation regimes and surface irrigation on the water productivity of garlic

The highest values of water productivity and economic water productivity were recorded under drip irrigation with 50% ET_c while, the lowest values were recorded under surface irrigation for seasons 2019/2020 and 2020/2021, respectively (Figure 1 and 2). These results are in agreement with those reported by Abd El-Latif and Abdelshafy (2017) who reported that water use efficiency and water productivity values were higher under the drip system than the surface system in the two respective seasons of garlic.

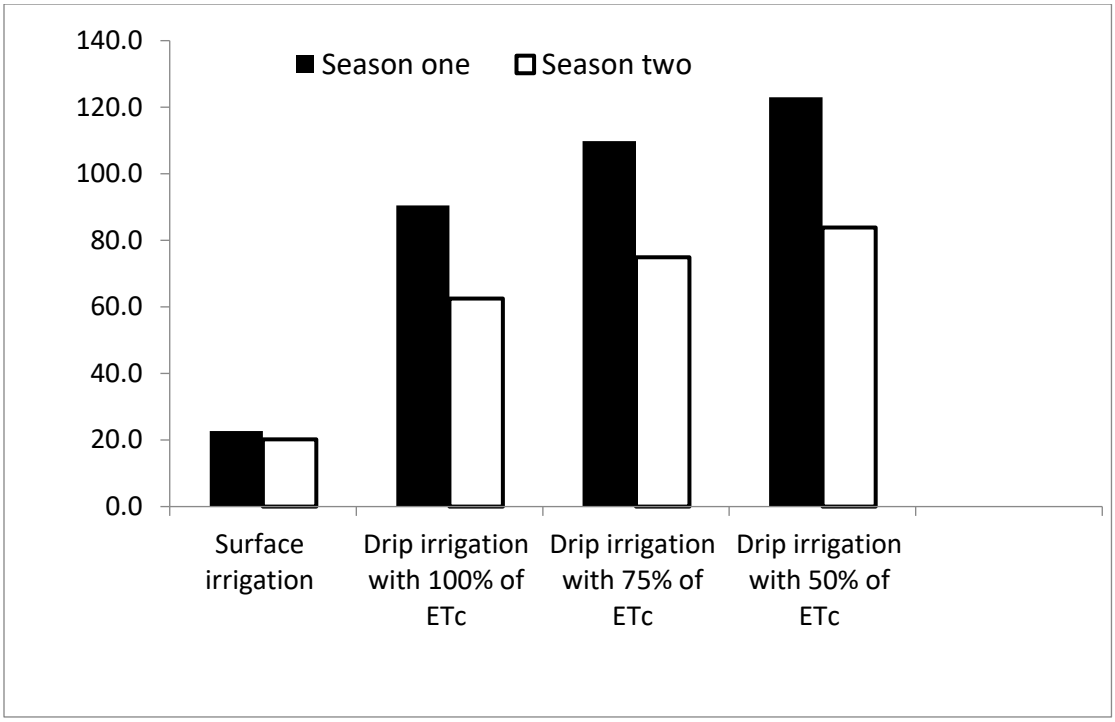

Figure 1. Effect of drip irrigation regimes and surface irrigation on the water productivity of garlic during two consecutive winter seasons, 2019/2020 and 2020/2021.

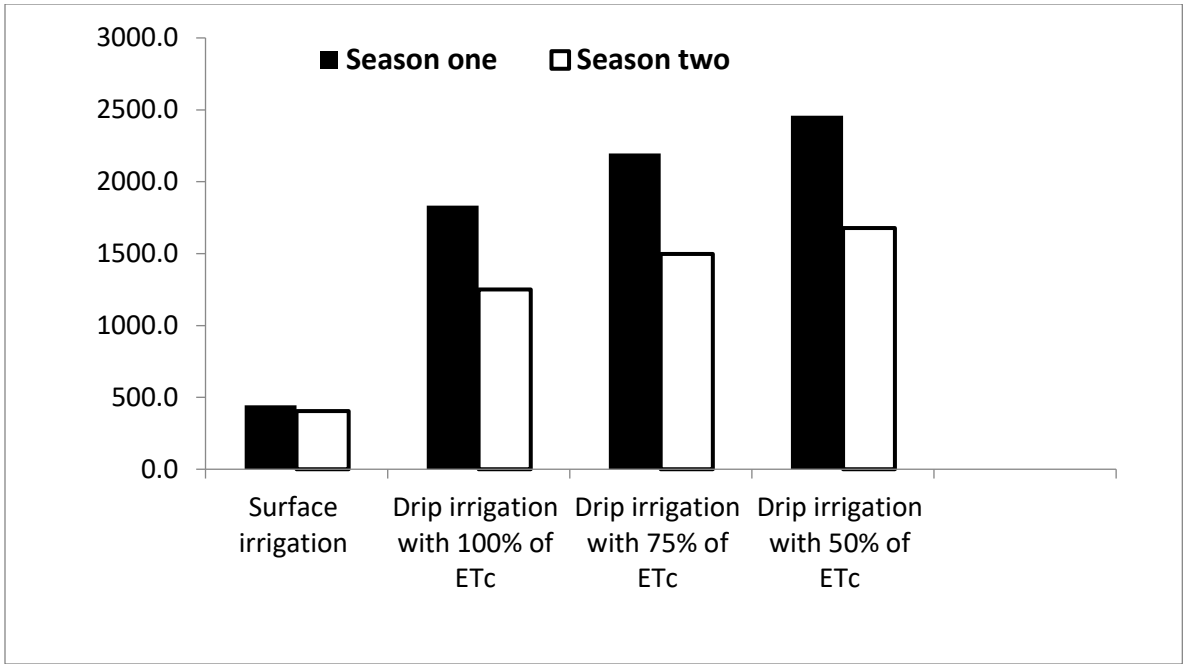

Figure 2. Effect of drip irrigation regimes and surface irrigation on the economic water productivity of garlic during two consecutive winter seasons, 2019/2020 and 2020/2021.

Effect of drip irrigation regimes and surface irrigation on the economic analysis of garlic

The variable costs of the drip irrigation regimes and surface irrigation for garlic are shown in Table 3. The benefit-cost ratio showed that drip irrigation with 100% of ET_c had a higher benefit-cost ratio compared to other treatments (Table 4). The benefit-cost ratio was higher under the drip irrigation regimes compared to surface irrigation (Table 4). These results are in agreement with those reported by Khalifa *et al*. (2014) who found that the benefit-cost ratio was obtained in drip irrigation and the lowest was obtained in surface irrigation.

Table 3. Variable cost of drip irrigation regimes and surface irrigation of garlic during two consecutive winter seasons, 2019/2020 and 2020/2021.

No	Particulars	Treatments			
		Drip irrigation regimes			Surface irrigation
		100% ET_c	75% ET_c	50% f ET_c	
1	Variable cost (SDG/ha)				
	a. Irrigation system	150000	150000	150000	0
	Irrigation staff	200000	200000	200000	500000
	b. Fertilizer application	0	0	0	30000
	c. Canal maintenance	0	0	0	30000
	d. Power (SDG/ha)	21600	16200	10800	57600
	Land preparation	1500	1500	1500	3600
	Hand labor	1056	1056	1056	1800
2	Total cost (SDG/ha)	374156	368756	363356	623000

Table 4. Benefit cost ratio of drip irrigation regimes and surface irrigation of garlic during two consecutive winter seasons, 2019/2020 and 2020/2021.

Treatments	Total Cost (SDG)	Yield (t/ha)	Total income (SDG/ ha)	Net return (SDG/ha)	Benefit cost ratio
Surface irrigation	623000	4.6	920000	297000	0.48
Drip irrigation with 100% of ET_c	374156	7.9	1580000	1205844	3.22
Drip irrigation with 75% of ET_c	368756	7.1	1420000	1051244	2.85
Drip irrigation with 50% of ET_c	363356	5.3	1060000	696644	1.92

Conclusion

Drip irrigation with 100% of ET_c recorded the highest yield and benefit cost ratio of garlic compared with surface irrigation, highest values of water productivity and economic water productivity were obtained under 50% ETc.

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Physiochemical assessment of released tomato (*Solanum lycopersicum* L) varieties to Sudanese environment

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Abstract

This study aimed to perform comparative evaluation for physical, chemical, nutritional and sensory parameters with three released tomato (Lycopersicon esculentum) varieties for Sudan climate; Castle Rock, Dar-mali and Zahrat Elneel. There was some variation observed in chemical and physical characteristics between the three varieties. The three varieties were medium-size to small, round to ellipsoid, red to orange-red in colour. In terms of chemical composition, the dry matter was 6.0, 5.7 and 5.0%, total soluble solids was 5.1, 5.1 and 4.5%, ash was 5.48, 5.8 and 7.78%, fiber was 9.72, 6.43 and 14.66%, total sugars were 20.94, 20.0 and 20.3%, titratable acidity was 0.26, 0.2 and 0.3% for Dar-mali, Castle Rock and Zahrat Elneel, respectively. The level of lycopene and β-carotene were assessed in the three varieties in the levels of 12.877-15.63 and 7.92-8.87 mg/100g, respectively. The mineral composition of tested varieties was obtained and compared to their RDA. The most abundant mineral was K (299-416 mg/100g) which was more than its RDA. Appropriate amounts of Na and Mg were found. However, varieties were low in Ca. Among micro-elements, appropriate amounts of Mn, Cu, Fe and Zn were also detected. Fruits were organoleptically assessed. The three tested fruits gained high level of overall acceptability (91.1-92.71%).

Keywords: *Tomato, Released varieties, Physiochemical, Sensory evaluation*

تقييم فيزيوكيميائي لثلاث من اصناف الطماطم أجيزت للبيئة السودانية (Lycopersicon esculentum)

أماني أحمد عبد الواحد جبر، أحمد الجيلي إبراهيم، محمد سليمان مصطفى، وعبد العظيم محمد علي

كلية الزراعة، جامعة وادي النيل

المستخلص

هدفت هذه الدراسة إلى إجراء تقييم مُقارن للخصائص الفيزيائية والكيميائية والتغذوية والحسية لثلاثة أصناف من الطماطم (Lycopersicon esculentum) اجيزت تتناسب مناخ السودان هي: كاسل روك، دار مالي، وزهرة النيل. لوحظ وجود بعض التباين في الخصائص الكيميائية والفيزيائية بين الأصناف الثلاثة. تراوحت أحجام الأصناف الثلاثة بين المتوسطة والصغيرة، من دائرية إلى بيضاوية، وتراوح لونها بين الأحمر والبرتقالي المحمر. من حيث التركيب الكيميائي، بلغت نسبة المادة الجافة 6.0%، و5.7%، و5.0%، وإجمالي المواد الصلبة الذائبة 5.1%، و5.1%، و4.5%، والرماد 5.48%، و5.8%، و7.78%، والألياف 9.72%، و6.43%، و14.66%، والسكريات الكلية 20.94%، و20.0%، و20.3%، والحموضة القابلة للمعايرة 0.26%، و0.2%، و0.3% في أصناف دار مالي، وكاسل روك، وزهرة النيل، على التوالي. قُيِّم مستوى الليكوبين وبيتا كاروتين في الأصناف الثلاثة بمستويات تراوحت بين 12.877 و15.63 ملغم/100 غرام، و7.92 و8.87 ملغم/100 غرام، على التوالي. وتم الحصول على محتوي العناصر للأصناف المختبرة ومقارنته بالكمية الغذائية الموصى بها. كان البوتاسيوم (299-416 ملغ/100 غرام) أكثر المعادن وفرةً، وهو ما يفوق الكمية اليومية الموصى بها. وُجدت كميات مناسبة من الصوديوم والمغنيسيوم. ومع ذلك، كانت الأصناف منخفضة في الكالسيوم. ومن بين العناصر الدقيقة، وُجدت أيضًا كميات مناسبة من المنغنيز والنحاس والحديد والزنك. قُيّمت الثمار حسيًا. وقد حظيت الثمار الثلاث المختبرة بقبول عام مرتفع (91.1- 92.71 %).

الكلمات المفتاحية: *طماطم، أصناف مُصدرة، كيميائي حيوي، تقييم حسي*

Introduction

Tomato (*Solanum lycopersicum* L.), which is indigenous to South America, is now grown worldwide for its edible fruits and considered as one of the most popular vegetable fruits in the world. It is an economically important crop grown in tropical and sub-tropical parts of the world. Tomato is a good source of fiber and believed to be health promoter and supplementary sources of minerals and vitamins as well as disease fighting phyto chemicals especially lycopene within human diets (Charanjeet *et al.* 2004). It is consumed either fresh or processed in products such as tomato juice, soup, paste, puree, ketchup, sauce and salsa (Helyes *et al.*, 2009; Ray *et al.*, 2011).

China, India, Turkey, United States and Eygypt are the leading tomato growing countries (FAOSTAT, 2025). In Sudan, tomatoes constitutes one of the most important vegetables were it is used for fresh consumption, cooked, paste or dried. Tomato is the second important vegetable crop in the Sudan after onion with an estimated production of 633000 metric tons during 2022.

At present, there are a large number of tomato varieties with a wide range of morphological and quality characteristics which determine their use (Fernandez-Ruiz *et al.*, 2011; Pinela *et al.*, 2012). In Sudan, releasing new varieties is progressing for different uses and to fit mainly climatic conditions of the country. Therefore, it is becoming increasingly important to assess their nutritional value in terms of content.

The main objective of the present study is to evaluate three released tomato fruit varieties, “Castle Roke”, 'Dar-malli" and "Zhrat Elneel" for their physicochemical and nutritional properties.

Materials and Methods

Materials:

Fresh, fully ripped tomato fruits from three varieties; Castle Rock, Dar-mali and Zahrat Elneel, were collected from El-Hudaiba Research Station Farm, River Nile State, season 2014-2015. Hundred fruits selected randomly from each cultivar. Five fruit selected for the physical analysis.

Physical characteristics:

Fruit colour:

The fruit color was determined using a Hue Chart (Fig. 1) as described by Glynn (2005).

Fruit shape:

The fruit shape for the three varieties was assessed according to Visa *et al*. (2014) who classified tomato fruit shapes into 9 categories (classes) as: Class1 round; class2 rectangular; class3 ellipsoid; class4 flat; class5 heart; class6 obovoid; class7 oxheart; class8 long rectangular; class9 long) (Fig.2).

Fruit weight:

Five fruits taken randomly in three lots from ripe fresh fruits were weighted on a top pan balance and average weight of fruit was calculated (in 0.00 grams).

Fruit volume

Fruit volume was estimated by water displacement method described by Jahromi *et al*. (2007) and Ibrahim (2009). Individual fruits were lowered in a measuring cylinder containing distilled water and the water displaced recorded.

Fruit density

The average whole tomato fruit density (g/cm^3) was estimated as the average fruit weight/ average fruit volume.

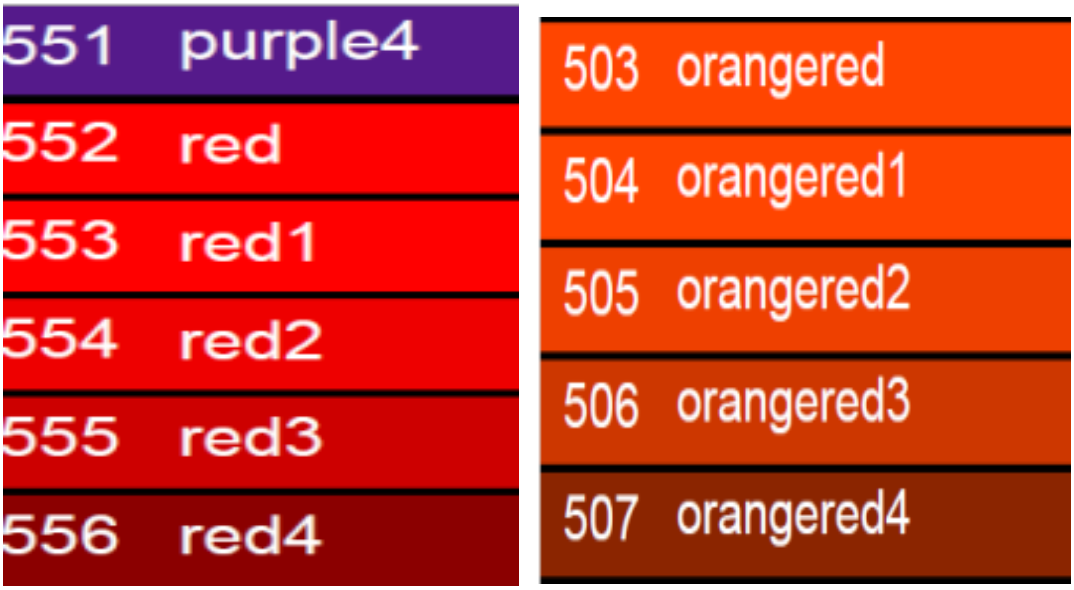

Fig.1: Hue chart for tomato fruits

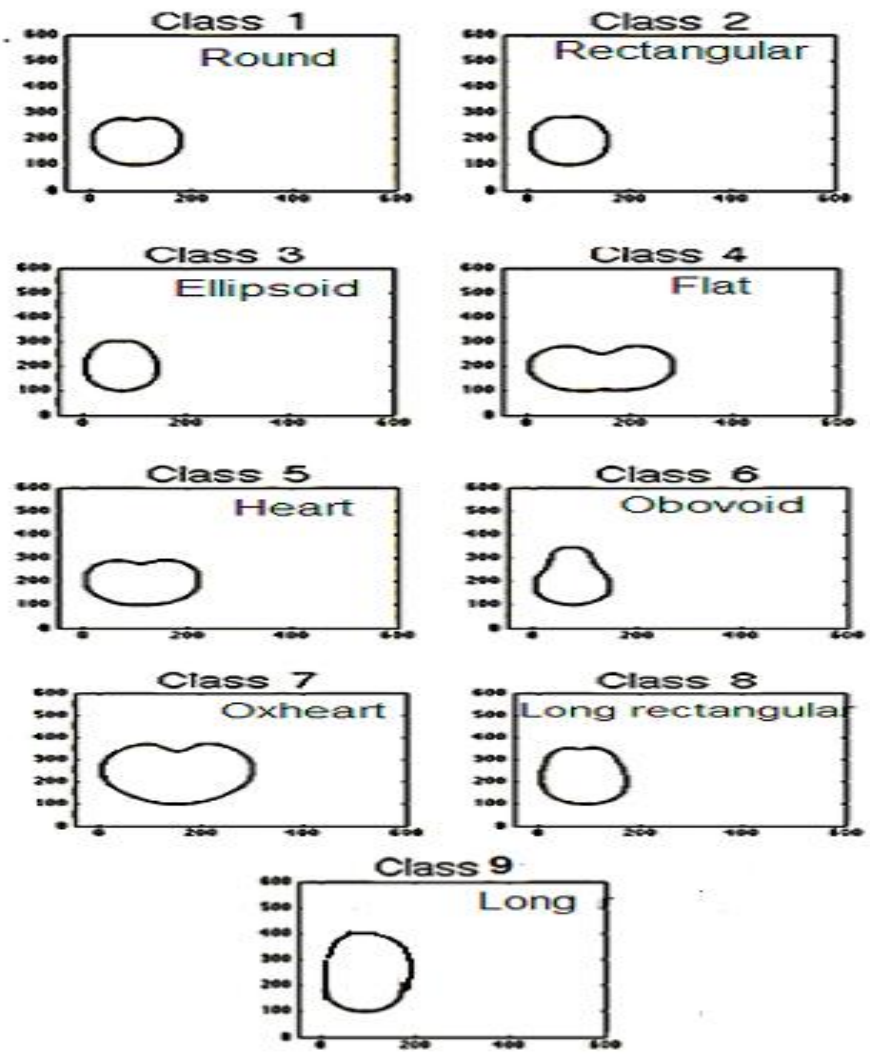

Fig.2. Tomato fruit shape classes

Fruit dimensions:

Fruit length and width

Fruit dimensions (length, width) for the individual fruits were measured by a vernier caliper (0.00cm).

Geometric mean diameter, surface area and sphericity

Geometric mean diameter (Dg), fruit mean surface area (S) and sphericity (φ) values were found using the following formulae (Jahrome *et al.*, 2007 and Ibrahim, 2009):

Geometric mean diameter (Dg) = $(LW^2)^{0.33}$

Fruit surface area S = πDg^2

Fruit sphericity (φ) = $(LW^2)^{0.33}$ /L

Where:

L= mean fruit length (cm),

W= mean fruit width (cm)

Circumference

The fruits circumference for the three varieties was assessed in cm using a cotton thread.

Fruit pulp and skin thickness

The thickness of pulp and skin was measured by a vernier caliper (0.00cm).

Fruit cavities

Fruit cavities (locules) were counted in each fruit sample. The mean of five fruits was deduced.

Number of fruits per kilogram

The mean number of fruits per kg for each tomato cultivar was obtained.

Seed weight

The weight of seeds for a single fruit was obtained using a digital balance (0.00g). The seeds% for each fruit was obtained as follows:

$$\text{Seed \%} = \frac{\text{Weight of seed in fruit} \times 100}{\text{Weight of fruit}}$$

Taste index

Taste index is estimated by using Brix and acidity (Suarez *et al.*, 2008):

$$\text{Taste index} = \frac{\text{Brix degree + Acidity}}{20 \times \text{acidity}}$$

Fruit shelf life

Fruit shelf-life was determined in terms of fruit firmness, curliness, weight loss% and decay according to the methods applied by Jan *et al.* (2012) and Parker and Maalekuu (2013) with some modifications. Fruits of three tomato varieties (castle rock, Darmally and Zahrat-Elneel) stored at room temperature (about 27^0C) and in refrigerator (10-12^0C) for 1-15 days. Quality parameters; fruit weight loss, fruit firmness, curliness and decay were evaluated.

Fruit firmness

Fruit firmness was determined by feeling how hard or soft the fruit was. The fruits were rated on a scale of 1-5 with; 5-4= very firm, 4-3= firm, 3-2= soft, 2-0 = very soft

Fruit weight loss%

Five fruits in each variety were separated for weight loss test. The initial weight of each fruit was noted daily with the help of electronic balance. The average loss of weight was calculated at day's intervals. The weight loss (%) was calculated as:

$$\text{Weight loss \%} = \frac{\text{Weight of fresh fruits} - \text{Weight after interval} \times 100}{\text{Weight of fresh fruit}}$$

Fruit curliness

Fruit curliness was determined visually. The fruits were rated on a scale of 1-4;

1-2= non, 2-3= very little, 3-4= little, 4 to above= much

Decay or rotting

Fruit decay was determined by the visual observation. Development of spots on the fruit's skin and softening and rotting of fruits were rated on a scale of 1-4;

1-2= non, 2-3= very little, 3-4= little, 4 to above = much

Chemical analysis of the fruit

Moisture content

Moisture content of each sample was determined by drying method according to AOAC (2000):

$$\text{Moisture Content \%} = [W_1\text{-}W_2)\backslash(W_1)] \times 100$$

Where

W_1 = Original weight of sample

W_2 = Weight of sample after drying.

Fruit juice pH

The pH of the fruit juice was determined by a pH-meter (in 5 fruits juice) in triplicate.

Total soluble solids (^{0}Brix)

The amount of total soluble solids (TSS) of samples was determined by a hand refractometer.

Total ash

Crude ash was determined as described by AOAC (2000). Incineration is accomplished with a muffle furnace at 550 0C using porcelain crucibles.

$$\text{Total ash\%} = \frac{(Wt_1 - Wt_2)}{\text{Weight of sample}} \times 100$$

Where:

Wt=Weight of crucible with ash.

Wt_2= Weight of empty crucible.

Sugars content

The diluted extract of the tested sample was firstly clarified by adding lead acetate to precipitate non sugars, then excess lead acetate precipitated by adding potassium oxalate and filtration followed to remove all non-sugars.

Reducing sugars

The reducing sugars (fructose and glucose) were assessed by titrating the clarified, de-leaded sample extract with mixed Fehling A and B solutions using Lane and Eynon volumetric method (AOAC, 2000 official method). The reducing sugars content was calculated according to the following equation:

$$\text{Reducing sugar \%} = \frac{\text{factor for Fehling's solution} \times \text{Dilution} \times 100}{\text{Titration} \times \text{Sample weight}}$$

Total sugars

Twenty five ml of the clarified solution was inverted by HCL (50%) at 70^{0}C for 24hrs. The solution was neutralized by NaOH (40%) and assayed for total sugars using Lane and Eynon method (AOAC 2000 official method).

Non reducing sugars

Non-reducing sugars were estimated as:

$$\text{Non-reducing sugars \%} = [\text{Total sugar-Reducing sugar}] \times 0.95$$

Crude fiber

Crude fibre was analyzed according to the AOAC (2000) as the residual of sequential extraction of a defatted sample with 1.25% H_2SO_4 and 1.25% NaOH. The insoluble residue is collected by filtration, dried, weighed and ashed to correct for mineral contamination of fiber residue.

$$\text{Crude fiber \%} = [(W_1-W_2)/S] \times 100$$

Where

W_1 = Weight of sample before ignition

W_2 = Weight of sample after ignition

S = Original Weight of sample.

Titratable acidity

Titratable acidity was measured by the titrimetric method (AOAC, 2000). The filtered tomato fruit extract (juice) was titrated with 0.1N sodium hydroxide in the presence of phenolphthalein as indicator. Titratable acidity of tomato was expressed as % citric acid:

$$\frac{\text{Titre} \times \text{Normality of alkali} \times 64 \times \text{Volume made up} \times 10}{\text{Ml of filtrate taken for titration} \times \text{wt of sample} \times 100}$$

Carotenoids and lycopene

Carotenoids and lycopene in tomato ethanol/acetone fresh pulp extract were determined following the procedure described by Nagata and Yamashita (1992) and Barros *et al.* (2010), measuring the absorbance at 453, 505, 645, and 663 nm. Contents were calculated according to the following equation:

Lycopene (mg /100ml) = A663 + A645+ A505- A453.

β- Carotene (mg/100ml) = A663- A645- A505+ A453.

(A663, A645, A505 and A453 are absorbance reading at 663, 645, 505 and 453nm)

Minerals

Eight minerals namely; potassium, sodium, calcium, manganese, zinc, copper, magnesium and iron in tomato fruit were determined using atomic absorption method. The ash was dissolved in a 5ml HCl (20%), filtered and the volume of the solution was completed to 50ml. Samples were transferred to atomic absorption to determine the minerals:

$$\text{The element in } \mu g/g = \frac{R \times V}{Wt}$$

Where:

R= reading in mg/g

V= volume of dilution

Wt = weight of sample

Tannins content

Tannins in tomato juice were estimated using Lowenthal-Procter method as applied by Tafti and Fooladi (2006) and Ibrahim (2009). Tomato fruit diluted extract was titrated vs 0.1N $KMNO_4$ with the presence of indigo Carmine indicator. A blank sample (free of tannins) which was prepared by

treating fruit diluted extract with gelatin/charcoal was also titrated versus 0.1N $KMNO_4$ to correct for the actual tannin content.

Sensory evaluation of fruits

The sensory evaluation for the parameters of shape, taste, odor, color, firmness and overall acceptability was carried by a panel of 10 judges according to the ranking test method as described by Ibrahim *et al*. (2014). The fruit for the three varieties under the study were evaluated by the panelists for the described parameters by giving a score. The data were tabulated and statistically analyzed to compare the means.

Statistical analysis

Analysis of variance was used to test the significance of treatment effects. LSD Test was used to compare treatment means using the computer program .The data were analyzed by Two-way ANOVA. Significance levels were portrayed (Statistics version 8.0 Software Inc., 1986).

Results and discussion

Tomato fruits physical properties:

Fruit dimensions:

Fruit length and width

The three investigated varieties were significantly different in terms of their fruit length (Fig.3). Castle Rock has the longest fruit (6.46cm), followed by Dar-mali (5.8cm) and Zhrat Elneel (5.36 cm), respectively. While in terms of fruit width, the three varieties were not significantly different. According to USDA (1991) tomato fruits classification (Table 1), Dar-mali and Zhrat Elneel could be classified as medium size fruits, while Castle Rock could be classified as small size fruit.

Geometrical mean diameter:

No significant difference (P≥0.05) in fruit geometrical diameter between the three varieties as illustrated in Fig.4. Among the three varieties, however, Dar-mali possessed the larger geometrical diameter (5.91cm).

Fruit circumference (cm):

As illustrated in Fig.5. The fruit circumference of the three varieties (Dar-mali, Zhrat Elneel and Castle Rock) ranged between 19.18 and 20cm, with no significant difference between them (P≥0.05).

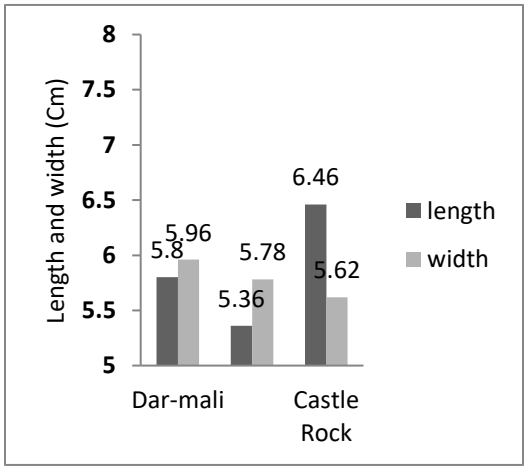

Fig.3. Tomato fruits length and width (cm)

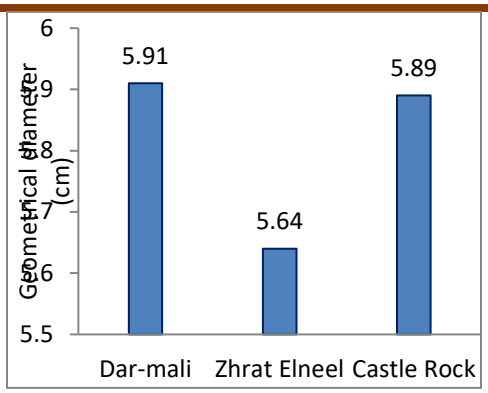

Fig.4. Tomato fruit geometrical diameter (cm)

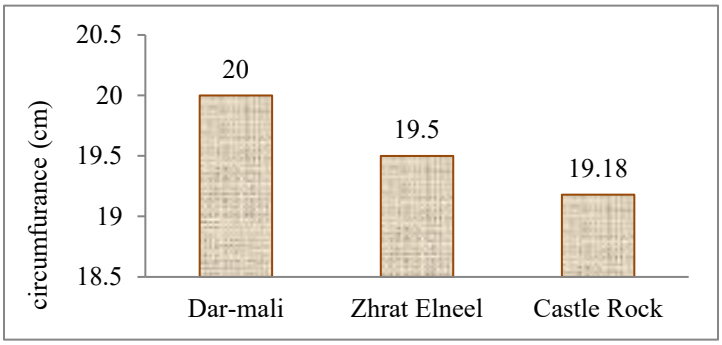

Fig.5. Tomato fruits circumference

Fruit shape and sphericity

Fruit sphericity is an important quality criterion for both consumer and food processers. Sphericity of the three tested tomato varieties was graphically depicted in Fig.6. Among the three varieties, Zhrat Elneel and Dar-mali were rather spherical (1.05 and 1.02, respectively), while Castle Rock was less spherical (0.91). According to Visa *et al.* (2014) shape classification (Fig.3) Dar-mali could be classified as round with little flatness, Zhrat Elneel nearly round, while Castle Rock was ellipsoid (Plate 1).

Fruit surface area

Measuring fruit surface area aid in the estimation of drying, cooling, coating and packing media and machine design (Ibrahim, 2009)**.** It is evident from Fig.7 that Dar-mali has the biggest surface area (109.73cm^2) followed by Castle Rock (108.99cm^2) and Zhrat Elneel (99.93 cm^2), respectively.

Fruit color:

In reference to Hue chart (Fig.1), it could be established that the skin color of Dar-mali fruit was red (552), Zhrat Elneel red1 (553) and Castle Rock was orange-red (503). The red color is good maturity index for harvesting and processing, and as a major factor in the consumer preference for fresh tomatoes.

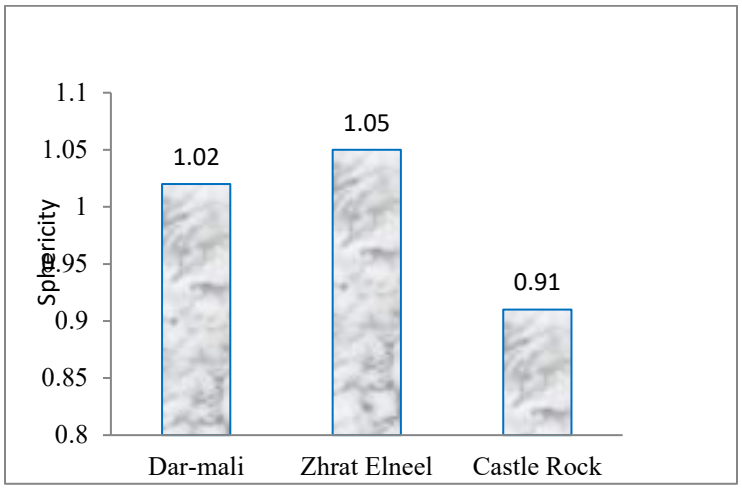

Fig.6. Tomato fruits sphericity

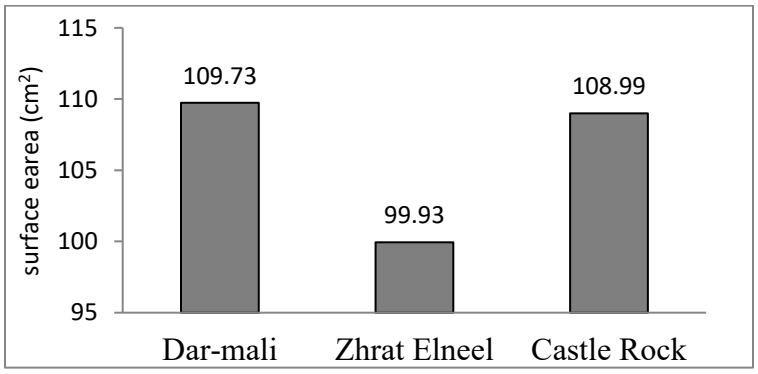

Fig.7. Tomato fruit surface area (cm^2)

Plate 1: Tomato fruit profile

Fruit weight and fruit number per kg

The fruit number/Kg and fruit weight were illustrated in Fig.8. and Fig.9. Among the three varieties, Dar-mali variety recorded heavier fruit weight and least fruit number/Kg, followed by Castle- Rock, while Zhrat Elneel showed the lowest value. There was no significant difference between the 3 varieties in fruit weight and fruit number/Kg. These results are in accordance with

those obtained by Suarez *et al.* (2008) in 5 tomato varieties with weight ranged between 61.5 and 195 g. Ben Aoun *et al*. (2013) recorded far different values (324.25-15.5g).

Fruit volume

The fruit volume of the three tested tomato varieties ranged between 144.4 and 123.2cm^3 (Fig.10). However, Castle Rock had the largest volume, followed by Dar-mali and Zhrat Elneel, respectively. Hawever, differences were not significant (P≥0.05. These results were higher than the findings of Sulieman *et al*. (2011) regarding Sudanese tomato genotypes with fruit volume ranging between 86.3 and 72.8 cm^3. This could be attributed to the inherited properties, climate and cultural practices.

Fruit density

Results in Fig. 11 revealed that the fruit density of the three tested varieties ranged between 0.9-0.98gm/cm^3. Zahrat Elneel fruit was the densest (0.98 g/cm^3), followed by Dar-mali (0.97g/cm^3) and Castle Rock (0.9g/cm^3), respectively.

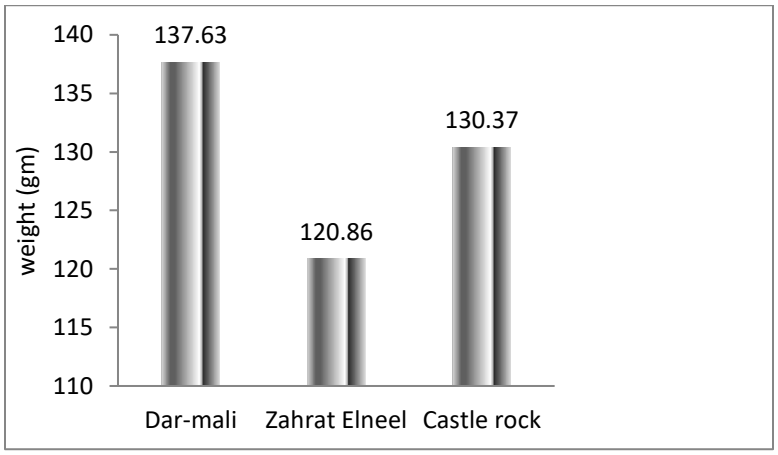

Fig.8. Fruit weight (gm)

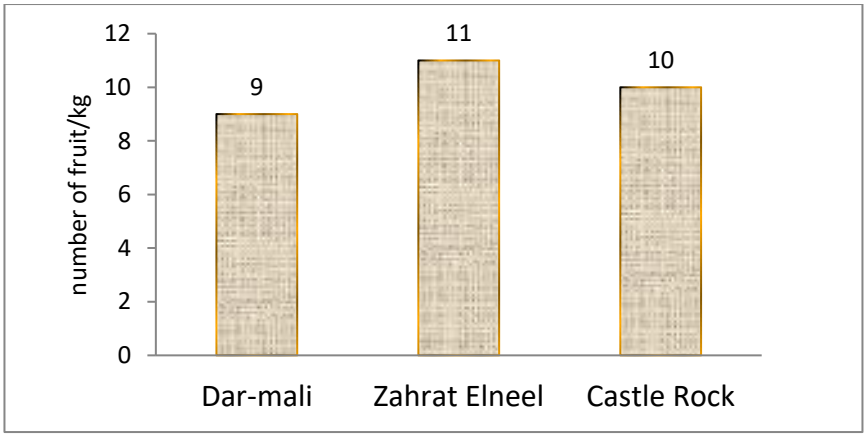

Fig.9. Number of fruit per kg

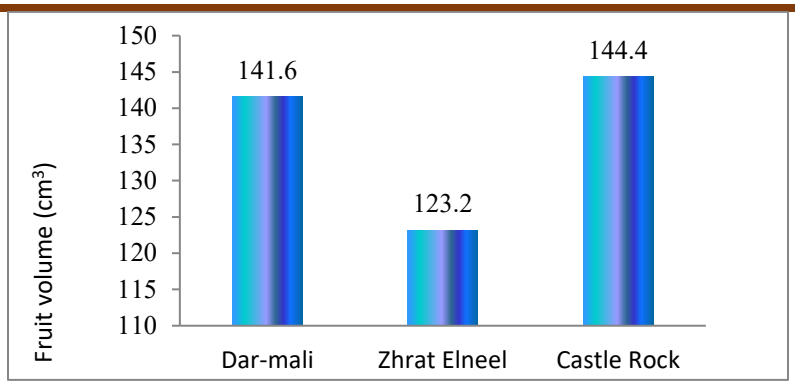

Fig.10. Tomato fruit volume (cm^3)

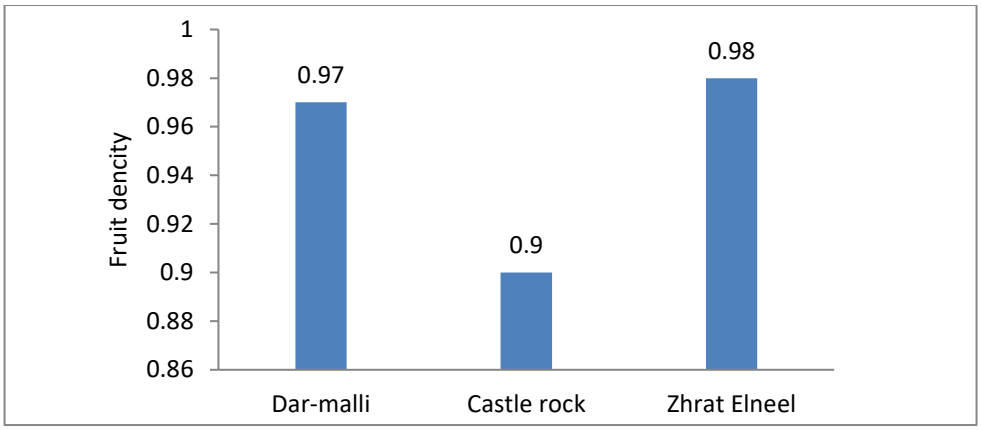

Fig.11. Whole tomato fruit density (g/cm^3)

Seed weight

The average seeds weight/fruit of the tested varieties ranged between 0.1 and 0.4g. Dar-mali variety had significantly heavier seeds, than Zhrat Elneel and castle Rock (Fig.12). However, the less seed weight of the cultivar, the higher will be the product yield for processing tomatoes.

Number of cavities (locules)/fruit

Number of fruit cavities of the three varieties was significantly different ($P<0.05$). Zhrat Elneel had the highest mean number of cavities per fruit (4.4), followed by Dar-mali (3.4) and Castle Rock (2.8), respectively (Fig.13). Ho and Hewitt (1986) classified tomato fruits according to their locules number. They described fruits with 2 locules as cherry and plum or pear types (processing tomatoes), fruits with four-six locules as commercial varieties for fresh marketing and more than six were large beefsteak type for garden or greenhouse production. Accordingly, varieties under this study could be classified as followed:

1- Dar-mali as fresh market and processing tomatoes
2- Zhrat Eneel as fresh market variety
3- Castle Rock as processing tomatoes

Pulp thickness (cm)

The flesh thickness of Dar-mali, Castle Rock and Zhrat Elneel varieties was 0.42, 0.34 and 0.42cm, respectively with no significant deference (P>0.05). Fleshy fruits are considered as processing varieties (Fig. 14).

Skin thickness (cm)

As shown in Fig. 15, the fruit skin thickness of the three tomato varieties was similar (0.034cm). However, the thicker fruit skin needs more technical effort in milling and filtration operations. The skin also produces more processing waste.

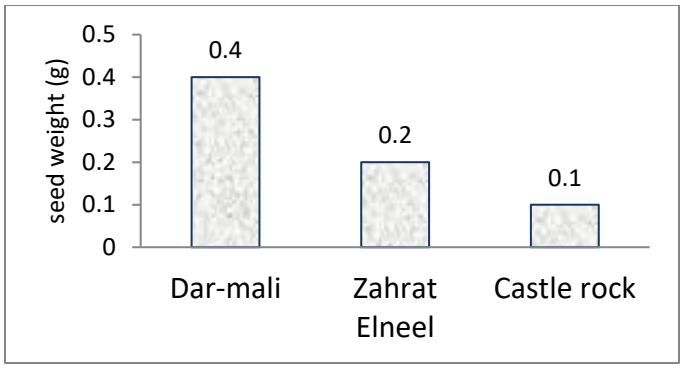

Fig.12. Seed weight (g)/fruit

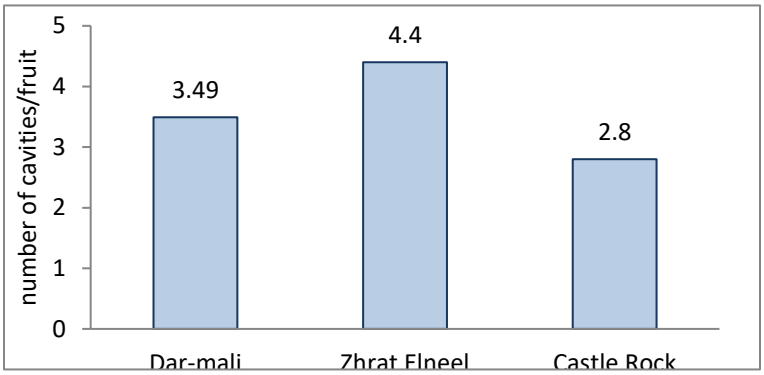

Fig.13. Number of cavities per fruit

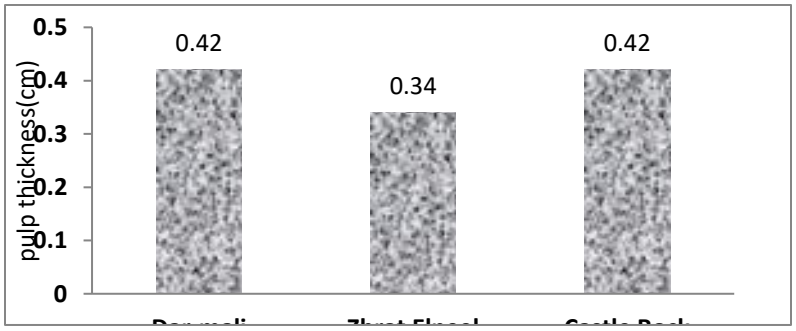

Fig.14. Pulp thickness (cm)

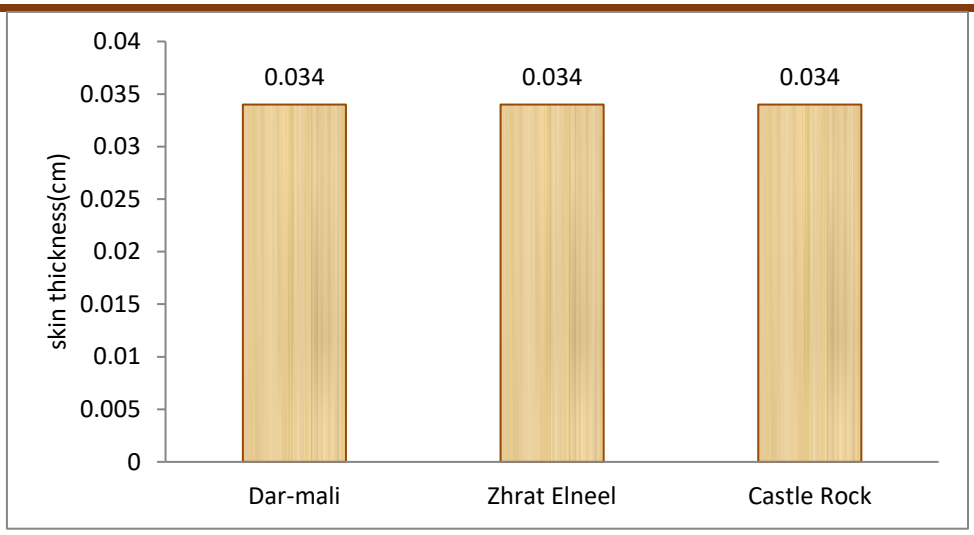

Fig.15. Skin thickness (cm)

Chemical characteristics

The chemical composition of tomato fruit depends on genetics, environment, varieties, plant growth regulators, ripening stage at harvest, training and irrigation system, and on post-harvest conditions (Borguini and Da Silva, 2009; Marsic *et al.*, 2011; Vinkovic *et al.*, 2011).

Moisture content

The fruit moisture content of the three varieties apparently ranged from 94 to 95% (Fig.16). These results were nearly in agreement with the findings of Sulieman *et al*. (2011). He found that the moisture content of 4 Sudanese tomato genotypes ranged between 92-94%. Also Gupta *et al*. (2011) found that the moisture content of tow tomato varieties was 94.45 and 92.27%.

Ash content

As shown in Fig.17., Zhrat Elneel possessed higher ash level (7.7%) than Castle Rock (5.8%) and Dar-mali (5.48%). These results are within the range of the findings of Suarez *et al.* (2008), Gupta *et al.* (2011) and Abdullahi *et al.* (2016).

Fiber content

Dietary fibers in tomato and other fruits had high physiological value as they can reduce constipation and fight many diseases. It is evident from results that the three tested varieties possessed appropriate quantities of fibers (Fig.18.). Among the three varieties, Zhrat Elneel possessed significantly higher fiber level (14.67%) than Dar-mali (9.72%) and Castle Rock (6.43%). Gupta *et al*. (2011) found that the crude fiber content in 2 tomato genotypes was 7.58 and 8.69 %.

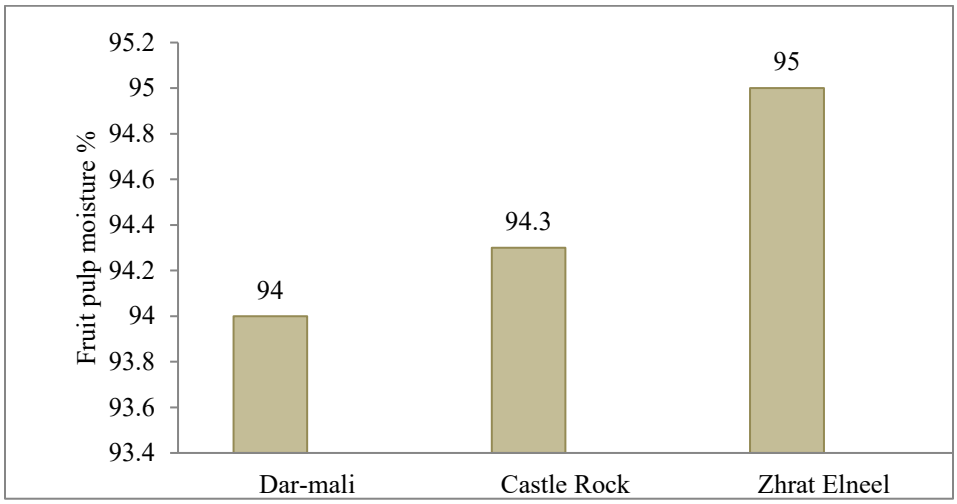

Fig.16. Moisture content%

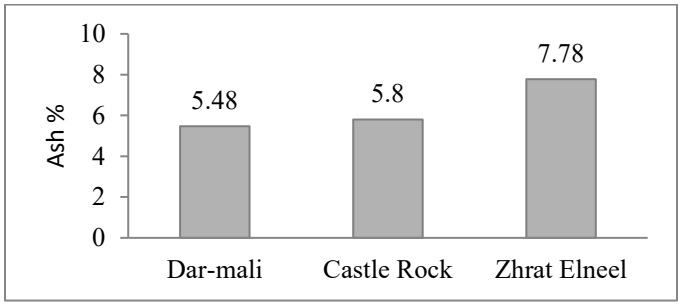

Fig.17. Tomato fruits ash content

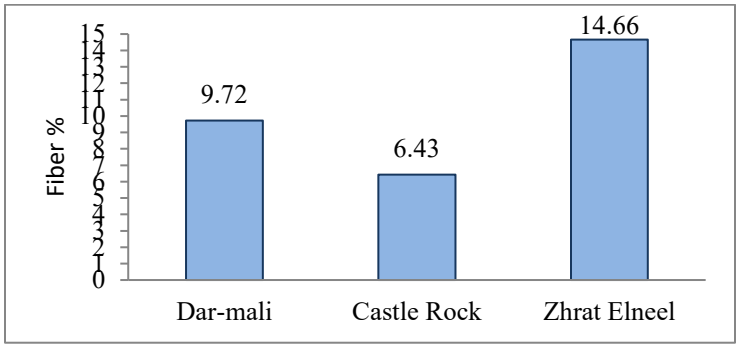

Fig.18. Tomato fruits fiber content (%)

Total soluble solids

Soluble solids (TSS) are a key parameter in tomato products such tomato paste and Ketchup. As illustrated in Fig.19, the mean total soluble solids in the fruit of Dar-mali, Castle Rock and Zhrat Elneel were 5.1, 5.1 and 4.5%, respectively. However, Difference (P<0.05) were not significant. These results are lower than Caliman *et al.* (2010) findings, but nearly agreed with the findings of Gupta *et al*. (2011) and lies within the range of Violeta *et al*. (2013) and slightly higher than the values obtained by Ilic *et al*. (2013) in conventional system tomatoes.

Fruit Juice pH

Results revealed that the pH of Dar-mali, Castle Rock and Zhrat Elneel fruits was 5.04, 5 and 4.5, respectively (Fig. 20). These are slightly higher than Ben Aoun *et al*. (2013) findings in 13 traditional tomato varieties (4. 21-4.49).

Titratable acidity

Acidity tends to decrease with fruits maturation while the sugar content increases (Raffo *et al.*, 2002). Fig.21. showed that the mean of the titratable acidity (as citric acid) were 0.26, 0.2 and 0.3 in Dar-mali, Castle Rock and Zhrat Elneel, respectively. These results are lower than the findings of Gupta *et al*. (2011) (0.54 and 0.50). The differences in fruits acidity could be attributed to variety dependent and soil characteristics.

Taste index

Among the three varieties, Castle Rock had the highest value of taste index (1.48) followed by Dar-mali (1.24) and Zhrat Elneel (1.05), respectively (fig.22). Felföldi *et al*. (2022) grade each trait on a hedonic scale, with grades from 1 ("Extremely Dislike") to 9 ("Extremely pleasant"). the tomato is considered as having little taste (not tasty) if taster judged it not tasty. Accordingly, the tested tomato fruits (with taste index higher than 0.85) could be considered as "tasty". These results are higher than the findings of Ilic *et al*. (2013).

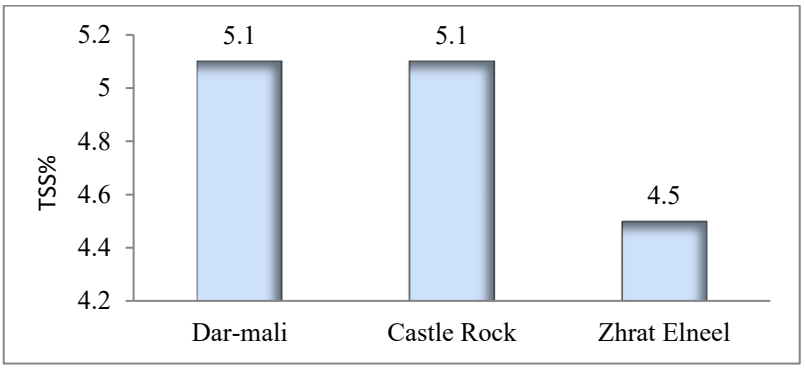

Fig.19. Total soluble solids (TSS%)

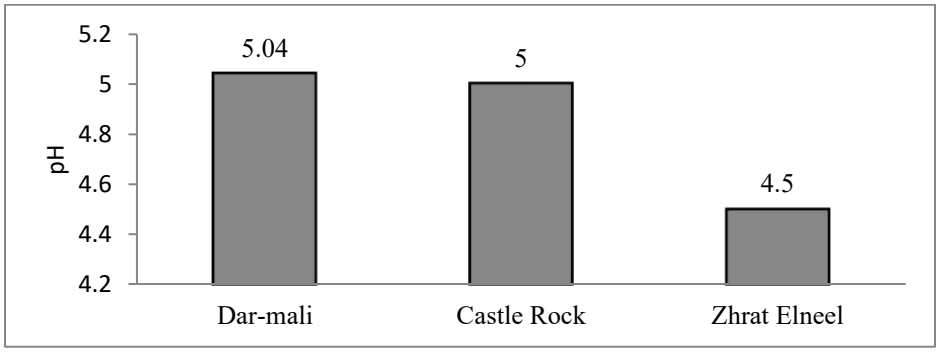

Fig.20. The pH values of tomato fruit pulps

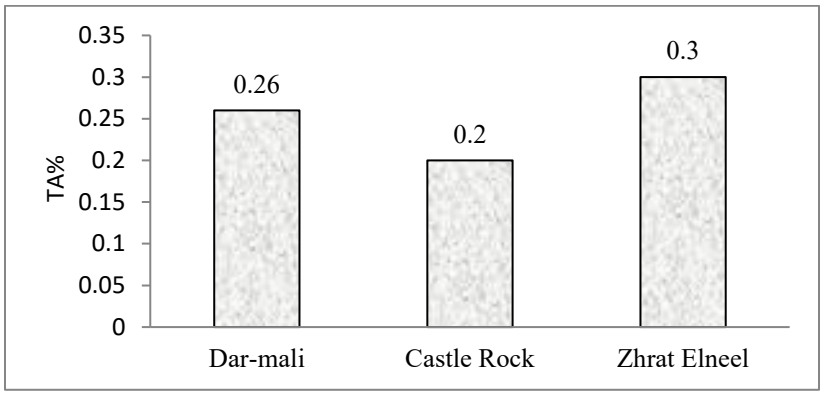

Fig.21. Titratable acidity (TA) %

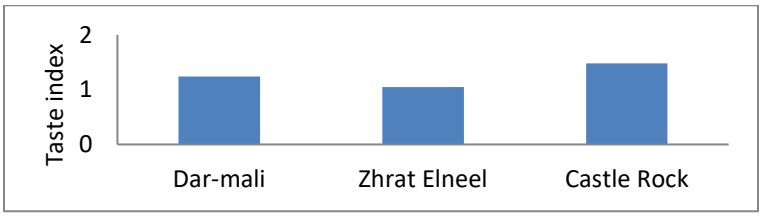

Fig. 22 Tomato fruits taste index

Sugars content

Dar-mali varieties contained the highest percentage of total sugars (20.83) followed by Zhrat Elneel (20.3) and Castle Rock (20.0), respectively (Fig. 23). Most sugars in tested verities are of reducing type. Reducing sugars were 20.1, 20.06 and 19.3% in Dar-mali, Zhrat Elneel and Castle Rock, respectively. The non-reducing sugar highest level was found in Zhrat Elneel (0.74%). The three varieties are significantly different in their sugars content, except in reducing sugars. Results obtained were lower than those obtained by Gupta *et al*. (2011). However, Suarez *et al.* (2008) stated that the mean content (wet basis) of glucose in 5 tomato varieties was 0.93% and fructose 1.02%.

Lycopene and β - carotene

The level of lycopene and β-carotene in the three tested tomato varieties was assessed spectrophotometrically and portrayed in Fig.24.

The lycopene content of the three varieties was significantly different. The highest level of lycopene (mg/100g, wet basis) was found in Zhrat Elneel (15.63), followed by Dar-mali (13.353) and Castle rock (12.877). These results were higher than the findings of Nguyen and Schwartz (1999), Alda *et al*. (2009), Violeta *et al*. (2013) and Suwanaruang (2016).

Level of β-carotene was 8.87, 7.92 and 8.07mg/100g in Dar-mali, Castle Rock and Zhrat Elneel varieties, respectively with high significant difference between them. However, these results were higher than the results obtained by Gupta *et al*. (2011).

Tannin content

The polyphenols (tannins) present in tomato is the principal constituent responsible for providing the typical astringent taste, odour and colours. As shown in Fig.25 the level of tannins in studied fruit samples ranged between 0.7 and 0.9%. Among the three varieties, Castle Rock contains higher level of tannins compared to other varieties with significant deference ($p< 0.05$).

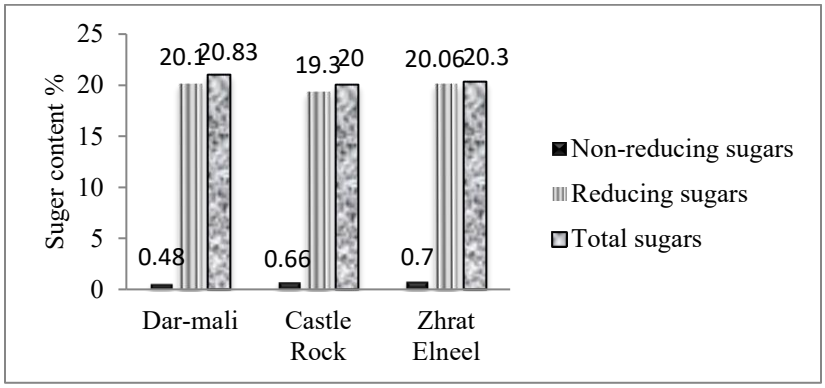

Fig.23. Tomato fruits sugar content %

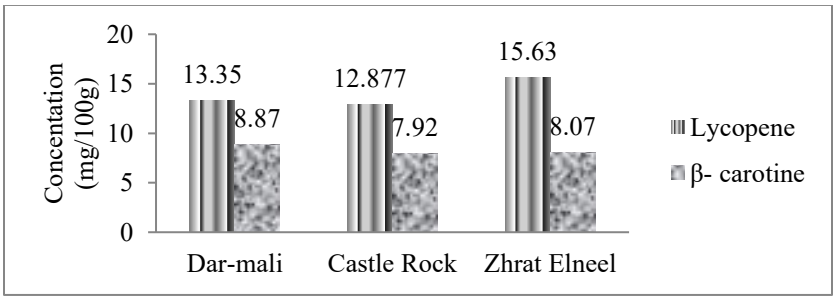

Fig.24. Lycopene and β carotene

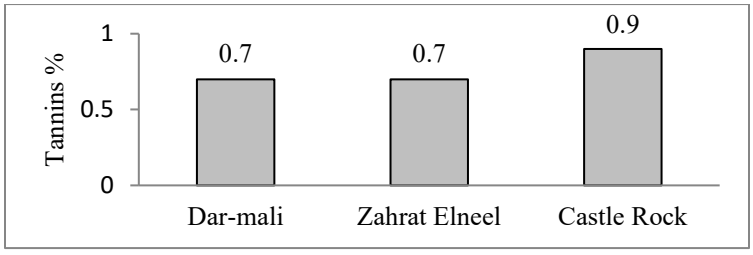

Fig.25. Tannin concentration %

Fruit mineral composition

The mineral content of tomato fruits was obtained and compared to the recommended daily allowances (RDA) set for each mineral by the American Society for Nutritional Sciences (ASNS, 2004) and the Joint FAO/WHO Expert Committee (FAO/WHO, 1989) (Fig28). Further, the %cover and the quantity (g) of tomato fruit which is expected to cover the recommended dietary allowances of individual minerals were also calculated (Table 3).

Macro-elements

Potassium (K)

Potassium is the most abundant mineral element in tomato fruits under this investigation. Its level is 399, 299, 416 mg/100g in Dar-mali, Castle Rock and Zhrat Elneel, respectively. These values were higher than the data reported by USDA (2010) (292 mg/100g), Daniela *et al*.(2013), within the range of Violeta *et al*. (2013) and far higher than Ilic (2013).

Further, the concentration of this element in each of the three varieties exceeds the recommended dietary intake (RDA= 100mg/100g) (Fig. 28) by 299-416%. However, eating 24-33g of a tomato fruit will be satisfactory to meet the RDAs of this element.

Sodium (Na)

Results (Fig.28) showed that sodium concentration was 66.6, 62.2 and 53.3mg/100g in Dar-mali, Castle Rock and Zhrat Elneel, respectively. These values are close or within the values obtained for local tomato varieties by Sulieman *et al*. (2011) and higher than those obtained by Abdullahi *et al*. (2016) and Violeta *et al*. (2013).

It is evident from results that sodium content of the three varieties was lower than its RDA (120-500mg/100g) (Fig.28). Further, the level of sodium in 100g of Dar-mali, Castle Rock and Zhrat Elneel tomato fruits will cover 13.32- 55.5, 12-52 and 11-44% of the upper and lower limits of sodium RDA, respectively. Furthermore, it is expected that by eating 180-751, 193-804 and 225-938g fruit from Dar-mali, Castle Rock and Zhrat Elneel, respectively, the recommended lower and upper limits of sodium metal will be reached.

Magnesium (Mg)

The magnesium concentration in the three varieties ranged between 18.7 and 24.1mg/100g (Fig.28). The largest amount of this element is being present in Dar-mali and the lowest in Castle Rock fruits. These results are higher than those obtained by Ordonez *et al*. (2013) and Violeta *et al*. (2013). Further, 100g of Dar-mali, Castle Rock and Zhrat Elneel will supply 5.7-7.5, 4.6-5.8 and 5.7-7.4% of the lower and upper limits of magnesium RDA, respectively. However, consuming 133-172, 171-225 and 134-176 of Dar-mali, Castle Rock and Zhrat Elneel, respectively will supply the RDA of magnesium.

Calcium (Ca)

The studied varieties contained between 25.17-29.15 mg/100g (Fig.28). The calcium value obtained for Castle Rock is the highest and that obtained for Dar-mali is the lowest. These results are higher than the findings of Ordonez *et al*. (2011) and Violeta (2013), but lower than those by Gupta *et al*. (2011). Furthermore, the three varieties contain calcium in amounts far lower than its RDA (Fig. 28). The amount of calcium provided by 100g of Dar-mali, Castle Rock and Zhat Elneel fruits will cover only 1.94-2.52, 2.24-2.92 and 2.09-2.72% of upper and lower limits of its RDA, respectively. However, consuming 397-516, 343-446 and 368-479g of Dar-mali, Castle Rock and Zhrat Elneel fruits could afford the lower and the upper limits of calcium RDA, respectively.

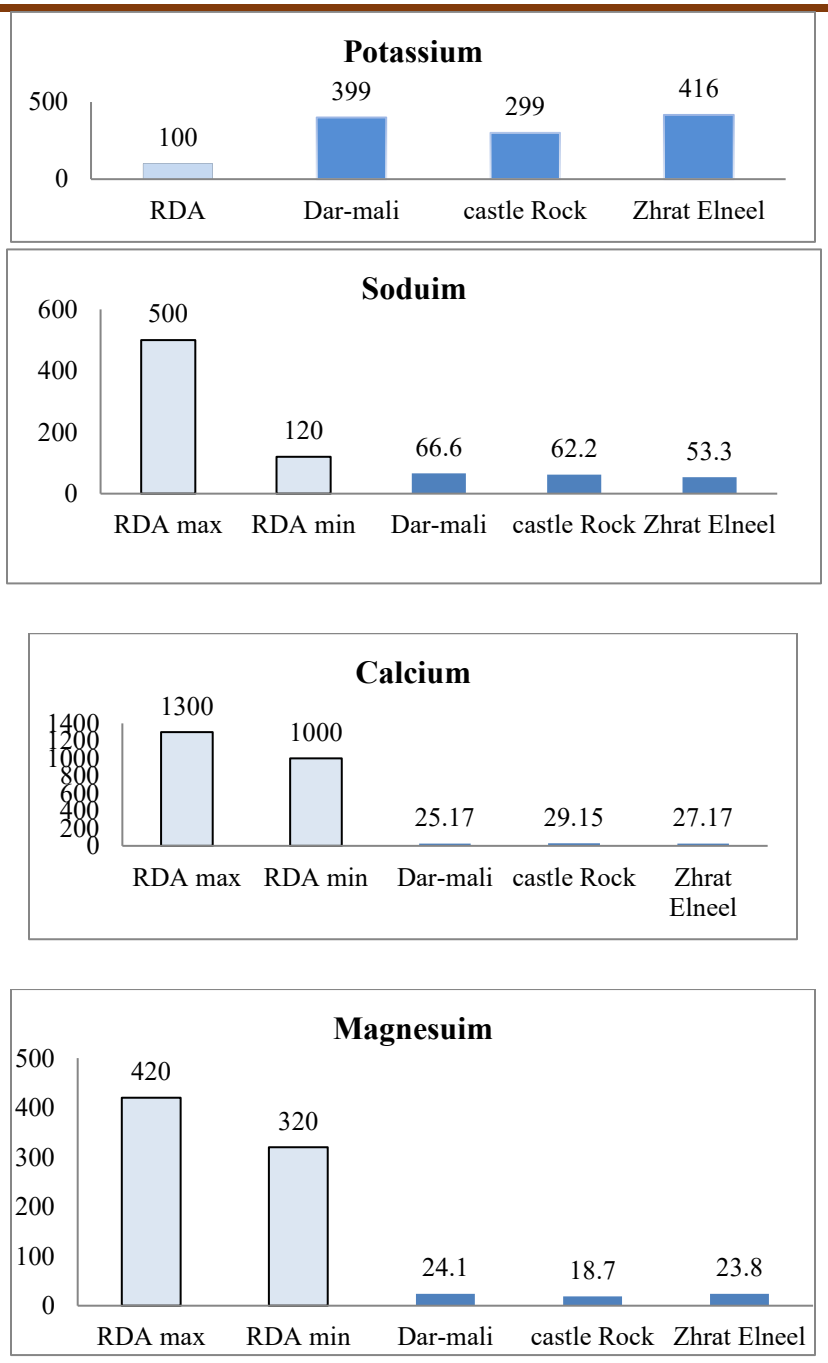

Fig.26. Macro-element concentration (mg/100g) compared to recommended daily allowance (RDA).

Micro-elements

Manganese (Mn)

Castle Rock contains the highest amount of manganese (0.47mg/100g) followed by Zhrat Elneel (0.4mg/100g) and Dar-mali (0.36mg/100g), respectively (Fig.27.). These results are higher than those obtained by Violeta *et al*. (2013).

The concentration of manganese in the three tomato varieties was far lower than the higher limits, but close to the lower limit of the RDA of Mg (Fig.27). In addition, 100g of the Dar-mali, Castle rock and Zhrat Elneel fruits could supply 15.7-60, 20-78 and 17.4-66.7% of the lower and upper limits of Mn RDA, respectively. Consequently, consuming 167-639, 127.7-489 and 150-575g of Dar-mali, Castle rock and Zhrat Elneel fruits, respectively, will supply the lower and upper limits of the RDA of manganese, respectively.

Cupper (Cu)

Cupper level in the three tomato varieties ranged from 0.31 to 0.37mg/100g which was below its RDA limits (Fig.27). Dar-mali contains the highest amount of cupper, followed by Zhrat Elneel and Castle Rock, respectively. These results were higher than the findings of Violeta (2013) and Ordonez - Santos *et al.* (2011). Consuming 100g from Dar-mali, Castle Rock and Zhrat Elneel should provide 24.7-12, 20.7-10.3 and 21.3-10.7% of the lower and the upper limits of cupper RDA, respectively. Accordingly, eating 405-811, 483.9-968 and 469-938 of Dar-mali, Castle Rock and Zhrat Elneel, respectively, could supply the body with the lower and upper limits of cupper RDA.

Iron (Fe)

The concentration of iron in three tomato varieties ranged between 2.76 and 3.11 mg/100g (Fig.27.). Zhrat Elneel contains the highest amount of this mineral followed by Dar-mali and Castle Rock, respectively. Results obtained were higher than the values obtained by Ordozen *et al*. (2011). A weight of 100g from Dar-mali, Castle rock and Zhrat Elneel could supply 19.6-29.4, 20-78 and 18.4-27.6% of the lower and upper limits of iron RDA, respectively. Consequently, consuming 350-510, 362-543 and 322-482gm of Dar-mali, Castle Rock and Zhrat Elneel, respectively will supply the lower and upper limits of the RDA of iron.

Zinc (Zn)

The concentration of zinc was 1.18, 1.11 and 1.21 mg/100g in Dar-mali, Castle Rock and Zhrat Elneel varieties, respectively (Fig. 27). These results nearly agreed with the findings of Ordonez *et al*. (2011) and Ilic (2013). Results of Zn obtained in the three varieties were lower than the limits of its RDA (Fig.27). Further, 100g from Dar-mali, Castle rock and Zhrat Elneel fruits could supply the body with 24.1-16.9, 22.7-15.9 and 24.7-17.3% of the lower and upper limits of zinc RDA, respectively. Consequently, consuming 415-593, 441-630 and 404-578g of Dar-mali, Castle Rock and Zhrat Elneel, respectively will supply the lower and upper limits of zinc RDA.

Sensory evaluation

The quality characters assessed organoleptically were appearance, shape, taste, colour, odour, firmness and overall acceptability. In terms of overall acceptability, tomato fruits from the three varieties obtained high level of acceptance (91.1-92.71%) (Fig.28). However, Dar-mali was the most acceptable, followed by Castle Rock and Zhrat Elneel, respectively. There was no significant difference in the overall acceptability between Dar-mali and Castle Rock varieties.

The mean ratings for sensory attributes are depicted in Fig.29. Statistically, the taste score given to Dar-mali variety was just slightly ($P<0.05$) higher than the Castle Rock, but significantly ($P<0.05$) higher than Zhrat Elneel variety, also the firmness score showed that there was no significant deference between Dar-mali and Castle Rock but, they were significantly higher than Zhrat Elneel. In addition, Zhrat Elneel had the best score of colour.

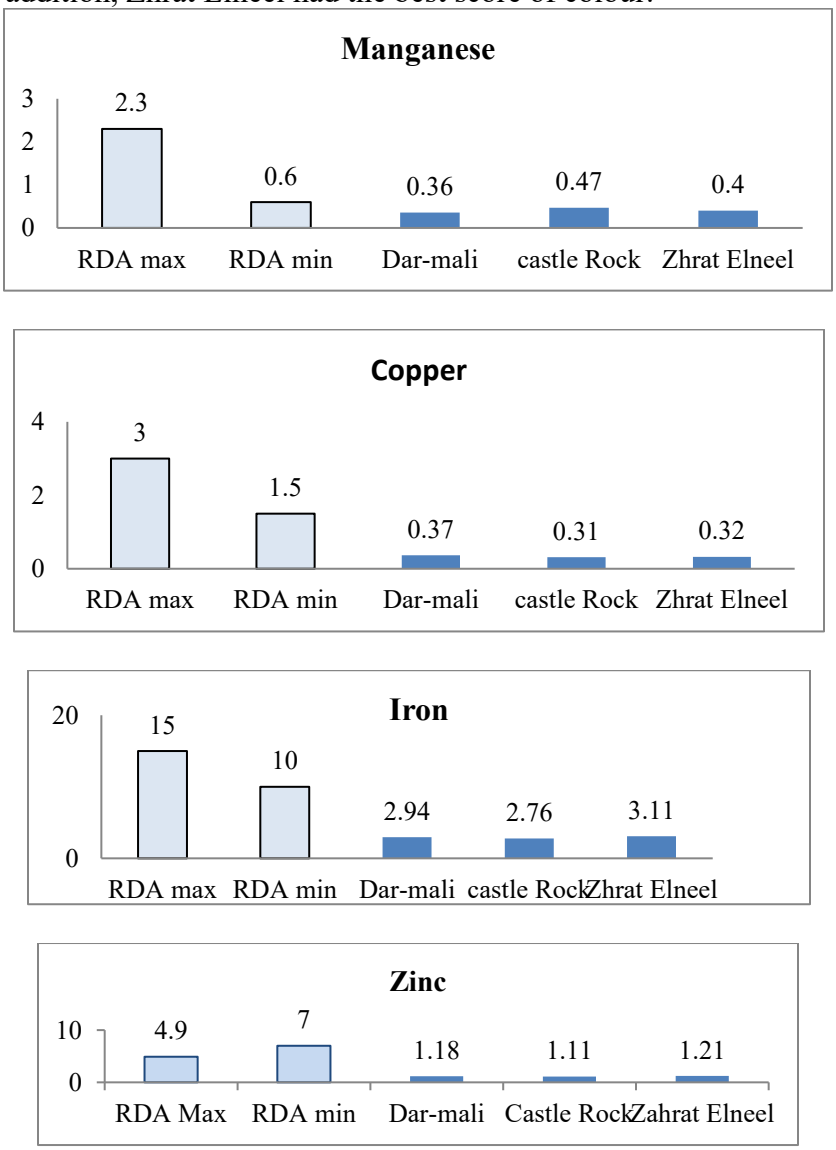

Fig. 27: Micro-element concentration (mg/100g) of tomato fruits compared to RDA

Table (3): The % cover and the quantity (g) expected to cover the recommended dietary allowances (RDA) of individual minerals (ASNS, 2004).

Minerals	Tomato varieties			RDA mg/100g
	Dar- mali	Castle Rock	Zhrat Elneel	
Potassium				100
Mg/100g	399	299	416	
Cover%	399	299	416	
expected (g)	25	33	24	
Sodium				120-500
Mg/100g	66.6	62.2	53.3	
Cover %	55.5-13.32	52-12	44-11	
expected (g)	180 – 751	193-804	225-938	
Magnesium				320-420
Mg/100g	24.1	18.7	23.8	
Cover%	7.5-5.7	5.8-4.6	7.4-5.7	
Expected (g)	1327-1742	1711-2246	1344-1764	
Calcium				1000-1300
Mg/100g	25.17	29.15	27.17	
Cover%	2.52-1.94	2.92-2.24	2.72 - 2.09	
Expected (g)	3972 - 5.164	3431- 4459	3680 - 4785	
Manganese				0.6-2.3
Mg/100g	0.36	0.47	0.4	
Cover%	60 -15.7	78 – 20	66,7 – 17.4	
Expected (g)	167 – 639	127.7 – 489	150 – 575	
Cupper				1.5-3
Mg/100g	0.37	0.31	0.32	
Cover%	24.7 – 12	20.7 – 10.3	21.3 – 10.7	
Expected(g)	405 – 811	483.9 – 968	469 – 938	
Iron				10-15
Mg/100g	2.94	2.76	3.11	
Cover%	29.4 – 19.6	27.6 – 18.4	31 – 20.7	
Expected (g)	340 – 510	362 – 543	322 - 482	
Zinc				4.9-7
Mg/100g	1.18	1.11	1.21	
Cover%	24.1-16.9	22.7-15.9	24.7-17.3	
Expected (g)	415- 593	441-630	404 - 578	

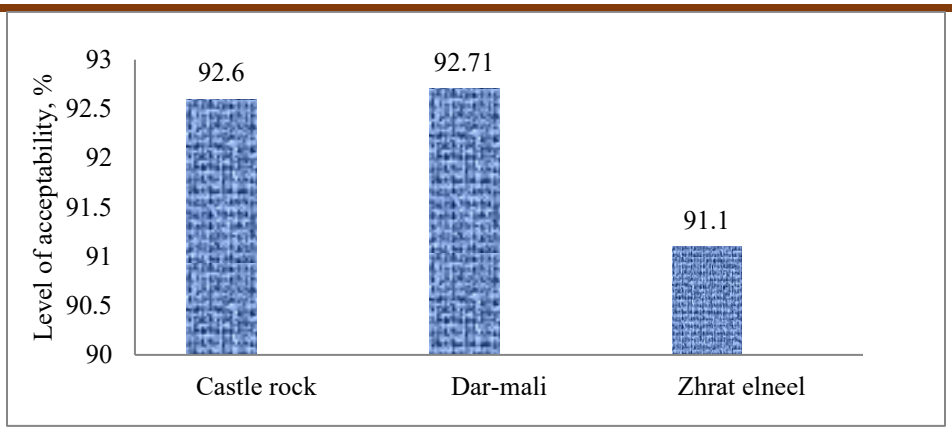

Fig.28. Tomato fruits overall acceptability

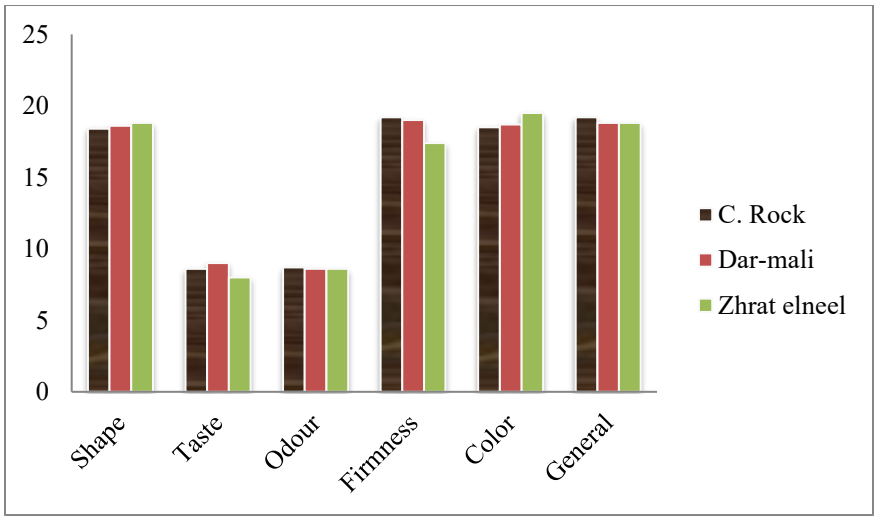

Fig.29. Tomato fruits sensory attributes

Conclusion and Recommendations

Three tomato fruit varieties; Castle Rock, Dar-mali and Zahrat Elneel were physically, chemically as well as organoleptically evaluated.

The three varieties were different in their physical characteristics and chemical composition. In terms of fruits colour, Dar-mali and Zhrat Elneel are red, while Castle Rock was orange-red. Dar-mali variety could be classified as round with little flatness, Zhrat Elneel nearly round, while Castle Rock was ellipsoid. Dar-mali and Zhrat Elneel could be classified as medium size fruits, while Castle Rock could be classified as small size fruit. Further, the three tomato varieties had a mean value of 2.22-4.4 fruit locules (cavities). The fruit geometric mean diameter was 5.91, 5.64 and 5.89cm, sphericity was 1.02, 1.05 and 0.91, surface area was 109.73, 99.93 and 108.99cm^2, volume was 141.6, 123.2 and 144.4cm^3 and weight was 137.63, 120.86 and 130.37gm for Dar-mali, Zahrat Elneel and Castle Rock, respectively.

In terms of chemical composition (dry basis), the dry matter was 6.0, 5.7 and 5.0%, total soluble solids was 5.1, 5.1 and 4.5%, ash was 5.48, 5.8 and 7.78%, fiber was 9.72, 6.43 and 14.66%, total sugars (mostly reducing sugars) were 20.94, 20.0 and 20.3%, titratable acidity was 0.26, 0.2 and 0.3% for Dar-mali, Castle Rock and Zhrat Elneel, respectively.

The level of lycopene and β-carotene were assessed in the three tested varieties in the levels of 12.877-15.63 and 7.92-8.87 mg/100g, respectively. The mineral composition of tested varieties was obtained and compared to their RDA. The most abundant mineral was K which was more than its RDA. Other minerals detected included Na, Mg, Ca, Mn, Cu, Fe and Zn.

In terms of level of acceptability, the three tested fruits gained high level of overall acceptability (91.1-92.71%).

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Response of Roselle (Hibiscus sabdariffa L.) and Soybean (Glycine max L. Merr.) grown as intercropping and sole crop to inter-row spacing under rain-fed conditions in the Blue Nile Region, Sudan

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Abstract

The experiment was conducted at Damazin Research Station Farm during the autumn seasons of 2019 and 2020, to evaluate the effect of inter-row spacing on Roselle and Soybean grown as intercropping and a sole under rain-fed conditions. A 2x2 factorial experiment arrangement in a randomized complete block design (RCBD) was used. The two factors were two inter-row spacing (60 and 80 cm) and planting methods (intercropping and sole cropping). Data collected included growth parameters (plant height and number of branches and yield components. Yield parameters at harvest included Roselle calyces yield, Roselle seed yield and soybean seed yield, all measured in tons per hectare (t ha -1). The Land Equivalent Ratio (LER) was calculated to assess the yield advantage of intercropping. Data were subjected to analysis of variance (ANOVA) using the GenStat computer statistical package. Intercropping resulted in a yield reduction of less than 50% for Roselle calyces, Roselle seed yield and soybean seed yield. The LER values consistently exceeded 1.0, indicating that intercropping was more efficient than sole cropping in resources utilization.

Keywords*: Roselle, Soybean, inter-row spacing, intercropping, sole, Calyces.*

استجابة الكركدي(*Hibiscus sabdariffa* L.) وفول الصويا (*Glycine max* L. Merr.)للزراعة البينية وكمحصول مفرد اووحيد للتباعد بين الصفوف تحت ظروف الامطار في اقليم النيل الازرق بالسودان

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المستخلص

اجريت التجربة في مزرعة محطة بحوث الدمازين خلال موسمي خريف 2019 و 2020 لتقيم تأثير التباعد بين الصفوف علي الكركديه وفول الصويا المزروع كزراعة بينية (مختلطة) ومحصول منفرد تحت ظروف الامطار في اقليم النيل الازرق , السودان. التجربة عامليه من عاملين بتصميم القطاعات العشوائية الكاملة (المسافات بين الصفوف (60 و 80 سم) وطريقتين للزراعة (الزراعة البينية و محصول وحيد). تضمنت البيانات التي تم جمعها معايير النمو والغلة للكركديه وغلة فول الصويا. تضمنت معايير النمو طول النبات وعدد الفروع. تم تسجيل الغلة للكركديه عند الحصاد بما في ذلك الكؤوس وغلة البذور (طن للهكتار $^{-1}$) كما تم تسجيل محصول بذور فول الصويا (طن للهكتار $^{-1}$) تم تقيم ميزة الغلة للكركديه وفول الصويا المزروع كزراعة بينية عن طريق حساب نسبة كفاءة استخدام الارض. خضعت البيانات التي تم جمعها من التجربة لتحليل التباين باستخدام برنامج الكمبيوتر GenStat. كانت نسبة انخفاض الغلة الناتجة من الزراعة البينية في ترتيبي الزراعة البينية بنسبة اقل من 50 % في كؤوس الكركديه وفي انتاج البذور وفي انتاج بذور فول الصويا , وكانت قيم كفاءة استخدام الارض اعلي من 1.0 مما يعني ان الزراعة البينية كانت اكثر كفاءة من الزراعة الوحيدة في استغلال الموارد.

الكلمات المفتاحية : *الكركدي ،فول الصويا ، المسافة بين الصفوف ، الزراعة المختلطة ، زراعة المحصول المفرد ، ماتحت الكاس .*

Introduction

Roselle (*Hibiscus sabdariffa* L.) is an important annual medicinal plant that belongs to the family Malvaceae and is locally known as *"Karkade"*. Roselle is an important cash crop in Western Sudan, particularly in Northern *Kordofan* State, especially in *Elrahad* and *Um-Rawaba* areas (El Naim *et al.,* 2012). The calyces are widely used to prepare herbal drink, cold and warm beverages, and for making jams and jellies (Tsai *et al.,* 2002).The seeds are somewhat bitter but are grounded to a meal for human food in Africa and are roasted as a substitute for coffee (Seiyaboh *et al.,* 2013).

Soybean is a dominant oilseed crop of the United States, accounting for about 90% of the U.S. oilseed production. Soybean is widely used for food, oil, animal feed, industrial uses, and biodiesel in the U.S. The U.S. is the leading producer and the second-largest exporter of soybean globally. In 2020, soybean was planted on 33.4 million ha and had an average yield of 3.78 t ha with production totaling over 112 Mmt (USDA-NRCS, 2022).

Due to the environmental problems of current agricultural systems as well as reduction of the agricultural land, application of new methods in order to minimize these negative effects and to increase the efficiency of land use are often considered in agricultural development programs. One of the most proper management methods in crop production that leads to improvement of efficiency in resource use is the intercropping system (Mahapatra, 2011). This cropping system might provide insurance against crop failure by reducing disease (Fininsa and Yuen 2000) and insect incidence (Girma, *et al.,* 2000) or against unstable market prices by planting two or more crops under intercropping, and thus reducing the risk of unexpected changeable prices. It was shown by many researchers that intercropping of different crops provided important advantages as well as higher profitability than crops grown as sole (Nursima, 2009). However, yield production of crops grown under intercropping depends on the component of the crops selected as well as row arrangements (Lewis *et al.,* 2003). More work of this nature is needed and calling for more research due to the conflicting results obtained by different researchers. Therefore, the objective of this study was to determine best inter-row spacing for Roselle and soybean under intercropping fashion that result a greatest yield and provide better land use efficiency, which could be useful to small farmer's scale under rain-fed conditions in the Blue Nile Region.

Materials and method

The experiment was conducted at Damazin Research Farm during the seasons of 2019 and 2020, to evaluate the effect of different inter-row spacing on Roselle and Soybean grown as intercropping and a sole under rain-fed conditions. The treatments comprised (2x3 factorial in randomized complete block design) of two inter-row spacing's (60 and 80 cm) and two planting methods (intercropping and a sole). These treatments were arranged in randomized complete block design, replicated three times. The land was disc harrowed two times before planting. Each experimental unit included five rows of Roselle 60 or 80 cm between them 4 m long with a net area of 12 or12.8 m^2. Sowing dates was 21th and 27 th July in 2019 and 2020 seasons respectively. Three or four seeds were planted at 30 cm intra-row spacing and then thinned to two plants hole $^{-1}$, two weeks after sowing. Soybean was grown between each two rows of Roselle and then thinned to 5 cm plant spacing. Chemical spraying (Folimate) was applied to control insects populations. Rainfall records were obtained from the Ministry of Agriculture and Natural Resources, of the Blue Nile Region. The data collected included growth and yield parameters for both Roselle and soybean. Five plants of each crop were randomly selected to measure growth parameters, at 50% flowering and again at the end of the season. At harvest, yield was recorded which included calyces and seed yield for Roselle and seed yield for soybean, with all yields reported in tons per hectare t ha $^{-1}$. The yield

advantage of the intercropping system was determined by calculating the Land Equivalent Ratio (LER), a method described by (Mead and Willey, 1980 as cited by Bantie (2014).

$$\text{LER} = \frac{yield\ intercropped\ (main\ crop)}{Yield\ of\ \text{sole}\ cropped\ (main\ crop)} + \frac{yield\ of\ intercropped\ (intercrop)}{yield\ of\ monocropped\ (intercrop)}$$

When LER measures was
LER=1: No advantage of intercropping.
LER <1: Intercropping reduced total yield.
LER>1: Intercropping increases total yield.

All collected data were subjected to an analysis of variance (ANOVA) using the GenStat statistical package, following the procedure outlined by Buysse *et al.,* (2004). A homogeneity test was also performed to compare the data between two growing seasons.

Results

Table 2 showed meteorological data of rainfall (mm) in both seasons at Damazin Research Station. Main rainfall data recorded in season 2019 was higher than that of 2020. Homogeneity test between two seasons was done showed that no significant difference between two seasons, and combined analysis was done.

(Table 3) showed that planting methods and inter-row spacing significantly affected Roselle plant height during both seasons and combined. The heights increase was recorded in the first season compared to the second season. A narrow inter-row spacing and grow Roselle as intercropping with soybean were gave the tallest plants (cm) in both seasons.

Table 4 showed that planting methods and inter-row spacing significantly affected on Roselle number of branches plan $^{-1}$ and combined_in both seasons and combined_except that of planting methods in season one. Wide inter-row spacing and grow hibiscus as a sole cropping were gave the highest number of branches plan $^{-1}$.

Table (5) showed that planting methods was significantly affected on Roselle Calyces yield (ton's ha $^{-1}$) in both seasons and combined analysis except planting methods in season one, while inter-row spacing and interaction were not affected Calyces yield (ton's ha $^{-1}$). Growing Roselle as a sole cropping was gave the highest Calyces yield (ton's ha $^{-1}$)**.**

Table 6 showed that planting methods and inter-row spacing were significantly affected on Roselle seed yield ton's ha $^{-1}$ in both seasons and combined except inter-row spacing in the second season, while interaction was effected only in the second season. Wide inter-row spacing and grow Roselle as a sol cropping were gave the highest seed yield ton's ha $^{-1}$.

Table 7 showed that planting methods was significantly affected on soybean number of branches plan $^{-1}$ just in second season and combined, while inter-row spacing and interaction were not significantly affected on soybean number of branches plan $^{-1}$ except inter-row spacing in second season. Wide inter-row spacing and sowing soybean as a sole cropping gave the highest number of branches plan $^{-1}$.

Table (8) showed that planting methods, inter-row spacing and interaction effect were significant on soybean seed yield (ton's ha $^{-1}$,) except planting methods in the second season and inter row spacing in first season. Close inter-row spacing and sowing soybean as a sole cropping were gave the highest seed yield (ton's ha $^{-1}$).

Table (9) showed that the combined (total) land equivalent ratio (LER %) of Roselle and Soybean intercropping were not significantly influenced by the interaction compare with inter-row spacing. LER measures were greater than 1.0 that means an intercropping is more advantageous than sole cropping in utilizing resources. A combined analysis of data from both seasons revealed that the close inter-row spacing resulted in a significant increase in the land equivalent ratio (LER) [The highest land equivalent ratio (LER %) and combined

analysis of Roselle and Soybean intercropping during both seasons and combined analysis were obtained by 60 cm inter-row spacing].

Discussion

Narrow inter-row spacing and intercropping of Roselle with soybean gave the highest plants height (cm) in the two seasons and combined. This could be due to high competition of plants to light. Supporting evidences were reported by Ramos *et al.* (2011) on Roselle and Mushayabasa *et al.* (2014) on Okra who stated that an increase in planting population markedly would increase plant height. The tallest plants produced by the most densely populated plants might be attributed to the competition for light and other growth resources among the plants that were crowded at the closer plant spacing (Mauryaet *al.,* 2013). Contrasting result obtained by ElNaim *et al.* (2012) who showed that crop density had no significant effect on plant height of Roselle. Yield of Roselle and soybean in two intercropping row spacing was significantly less than Roselle and soybean yield as sole crops, that might be due to the competition between these two crops for the available resources. Similar results were obtained by Akintoye *et al.* (2011) in their work on okra / pumpkin intercropping. From the result of this study, soybean can be intercropped with Roselle, since LER in two inter-row spacing, this was in agreement with the reports of (Olowe and Adebimpe, 2009) who observed, soybean can be intercropped with sunflower, since LER in most plant spacing testing.

In intercropping treatments, the increase in inter-row spacing from 60 cm to 80 cm increase yield of Roselle and Soybean. This increase can be attributed to increased competition in narrow arrangement. As Roselle and Soybean inter-row arrangement decreased from 80 cm to 60 cm, there was an increasing trend in total LER from 1.3, 2.1 and 1.7 to 1.4, 2.7 and 2.1 on season two and combine analysis respectively. This was in agreement with the reports of (Pushpa *et al.,* 2017) who observed increment in total LER as common bean planting density increased from 25% to 100%. Based on the values of total LER, advantage of intercropping Roselle with pigeon pea.

Conclusions

- This study showed that that wide inter-row spacing (80 cm) and grow Roselle as a sole cropping gave the highest number of branches per plan and seed yield ton ha $^{-1}$.
- Growing Roselle as a sole cropping gave the highest Calyces yield in ton ha $^{-1}$.
- Narrow inter-row spacing (60 cm) and grow Soybean as a sole cropping gave the highest seed yield in ton ha $^{-1}$.
- Yield decrease percentage as effected by intercropping in two intercropping arrangements were less than 50% on Roselle Calyces, seed yield and soybean seed yield in ton ha $^{-1}$.
- LER measures were greater than 1.0, that means an intercropping is more advantageous than sole cropping in utilizing resources.

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Table. 1 Theoretical plant populations hectare $^{-1}$ of the two inter-row spacing's

inter-row (cm)	Roselle ha^{-1}	Soybean ha $^{-1}$	Plants ha $^{-1}$ (total)
80	83,333	250,000	333,333
60	111,111	333,333	444,444

Table 2. Metrological data of rainfall (mm) at two seasons 2019 and 2020

Months	2019	2020
May	78.1	32.6
June	128.3	82.6
July	220.5	175.0
August	242.4	196.9
September	119.6	74.1
October	81.0	35.5
Mean	869.9	596.7

Table 3. Effect of intercropping and inter-row spacing on Roselle plant height (cm)

Planting Methods	Inter-row spacing (cm)								
	Season 2019			Season 2020			Combine		
	60	80	Means	60	80	Means	60	80	Means
Sol	94.8	81.2	88.0	77.7	83.0	80.3	86.3	82.1	84.2
In. C.	98.3	91.2	94.8	85.3	88.7	87.0	81.8	89.9	90.9
Means	96.6	86.2		81.5	85.8		89	86	
Statistics									
	Sig.	SE ±	CV%	Sig.	SE ±	CV%	Sig.	SE ±	CV%
Methods	*	1.54	2.5	*	0.83	1.4	*	0.36	9.4
Spacing	*	1.29		*	0.69		*	0.47	
Interaction	NS	4.6		NS	4.5		NS	5.9	

Table 4. Effect of intercropping and inter-row spacing on Roselle number of branches plan $^{-1}$

Planting Methods	Inter-row spacing (cm)								
	Season 2019			Season 2020			Combine		
	60	80	Mean	60	80	Mean	60	80	Mean
Sol	10.2	13.7	11.9	10.2	12.0	11.1	10.2	12.8	11.5
In. C.	7.0	10.2	8.6	6.9	7.8	7.3	6.9	9.0	7.9
Mean	8.6	11.9		8.6	9.9		8.5	10.9	
Statistics									
	Sig.	SE ±	CV%	Sig.	SE ±	CV%	Sig.	SE ±	CV%
Methods	NS	1.1	14.6	*	0.73	3	*	0.56	14.8
Spacing	*	0.86		*	0.16		*	0.47	
Interaction	NS	4.7		*	0.75		NS	4.7	

Table 5. Effect of intercropping and inter-row spacing on Roselle Calyces yield ton's ha $^{-1}$

Planting Methods	Inter-row spacing (cm)								
	Season 2019			Season 2020			Combine		
	60	80	Mean	60	80	Mean	60	80	Mean
Sol	0.23	0.25	0.24	0.25	0.29	0.27	0.24	0.27	0.25
In. C.	0.18	0.19	0.19	0.21	0.24	0.23	0.19	0.23	0.21
Mean	0.20	0.22			0.26		0.22	0.24	
Statistics									
	Sig.	SE ±	CV%	Sig.	SE ±	CV%	Sig.	SE ±	CV%
Methods	*	0.008	10.4	*	0.002	12.8	*	0.004	6.9
Spacing	NS	0.01		NS	0.01		NS	0.01	
Interaction	NS	5.9		NS	4.7		NS	4.4	

yield decrease percentage as effected by intercropping were 20, 15 and 16 % at two seasons and combine analyses respectively

Table 6. Effect of intercropping and inter-row spacing on Roselle seed yield ton's ha $^{-1}$

Planting Methods	Inter-row spacing (cm)								
	Season 2019			Season 2020			Combine		
	60	80	Mean	60	80	Mean	60	80	Mean
Sol	0.43	**0.57**	0.50	0.24	**0.31**	0.28	0.37	**0.41**	0.39
In. C.	0.23	0.33	0.28	0.16	0.20	0.18	0.20	027	0.23
Mean	0.33	0.45		0.20	0.26		0.28	0.34	
Statistics									
	Sig.	SE ±	CV%	Sig.	SE ±	CV%	Sig.	SE ±	CV%
Methods	**	0.04	7.4	***	0.001	7.4	*	0.02	17.6
Spacing	**	0.02		NS	0.01		*	0.01	
Interaction	NS	0.1		*	0.009		NS	3.3	

yield decrease percentage as effected by intercropping were 40, 35 and 31% at two seasons and combine analyses respectively.

Table 7. Effect of intercropping and inter-row spacing on soybean number of branches plan $^{-1}$

Planting Methods	Inter-row spacing (cm)								
	Season 2019			Season 2020			Combine		
	60	80	Mean	60	80	Mean	60	80	Mean
Sol	11.8	12.8	12.3	14.3	17.2	15.8	13.1	15	14
In. C.	8.1	8.4	8.3	7.4	8.3	7.9	7.8	8.4	8.1
Mean	9.9	10.6		10.9	12.8		10.4	11.7	
Statistics									
	Sig.	SE ±	CV%	Sig.	SE ±	CV%	Sig.	SE ±	CV%
Methods	NS	3.9	11.5	*	0.3	9.3	*	0.8	21.5
Spacing	NS	4.1		*	0.6		NS	0.6	
Interaction	NS	3.9		NS	5.5		NS	1.6	

Table 8. Effect of intercropping and inter-row spacing on soybean seed yield ton's ha $^{-1}$

Planting Methods	Inter-row spacing (cm)								
	Season 2019			Season 2020			Combine		
	60	80	Mean	60	80	Mean	60	80	Mean
Sol	1.4	1.0	1.2	1.3	0.6	0.9	1.3	0.8	1.1
In. C.	0.6	0.7	0.7	0.5	0.7	0.6	0.6	0.6	0.6
Mean	**1.0**	**0.9**		0.9	0.6		1.0	0.8	
Statistics									
	Sig.	SE ±	CV%	Sig.	SE ±	CV%	Sig.	SE ±	CV%
Methods	*	0.08	10.8	NS	0.1	11.1	*	0.09	19.8
Spacing	NS	0.1		*	0.03		**	0.02	
Interaction	*	0.1		**	0.08		***	0.09	

yield decrease percentage as effected by intercropping were 41, 40 and 45% at two seasons and combine analyses respectively.

Table 9. land Equivalent Ratio (LER%) of Roselle and Soybean intercropping

intercropping	Season 2019		Season 2020		Combine	
	60	80	60	80	60	80
1	1.4		2.7		2.1	
2		1.3		2.1		1.7
Statistics						
Sig.	NS		NS		*	
SE ±	0.09		0.2		0.06	
CV%	9.`		11		12.6	

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Training Needs of Agricultural Extension Workers, Ministry of Production and Economic Resources, Sinnar State, Sudan

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Abstract

This study assessed the competency and training needs of agricultural extension workers in Sinnar State, aiming to enhance their performance in delivering timely extension work and expert-recommended messages. The entire population of extension workers in the Ministry of Production and Economic Resources was surveyed (N=48). Data were analyzed using the Statistical Package for Social Sciences (SPSS), calculating frequencies, percentages, and weighted means to identify specific training requirements. Key findings revealed that while 72.1% of the workers held a bachelor's degree, significant skill gaps existed in communication and administrative tasks. Only 62.5% of extension workers demonstrated proficiency in executing agricultural programs and writing reports. Furthermore, a minority were skilled in media preparation, with only 35.4% capable of preparing agricultural radio programs and 33.3% able to write newspaper articles. Based on these results, it is recommended that the agricultural extension directorate implement targeted training programs in coordination with experts and media directorates. Training should focus on improving skills in formal meetings, using instructional aids, writing detailed reports, and preparing content suitable for various mass media channels, including pamphlets, magazines, radio, and television programs.

Keywords: *Agricultural Extension Workers, Training Needs, Performance Enhancement*

احتياجات العاملين بالارشاد الزراعي التدريبية بوزارة الانتاج والموارد الاقتصادية بولاية سنار، السودان

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المستخلص

قيّمت هذه الدراسة كفاءة واحتياجات التدريب للعاملين في الإرشاد الزراعي بولاية سنار، بهدف تحسين أدائهم في تقديم أعمال الإرشاد في الوقت المناسب وإيصال الرسائل التي يوصي بها الخبراء. استُطلعت آراء جميع العاملين في الإرشاد الزراعي بوزارة الإنتاج والموارد الاقتصادية (عددهم 48). وحُلّلت البيانات باستخدام الحزمة الإحصائية للعلوم الاجتماعية (SPSS)، مع حساب التكرارات والنسب المئوية والمتوسطات المرجحة لتحديد متطلبات التدريب المحددة. أظهرت النتائج الرئيسية أنه على الرغم من حصول 72.1% من العاملين على درجة البكالوريوس، إلا أن هناك فجوات كبيرة في مهارات التواصل والمهام الإدارية. أظهر 62.5% فقط من العاملين في الإرشاد الزراعي كفاءة في تنفيذ البرامج الزراعية وكتابة التقارير. علاوة على ذلك، كانت أقلية منهم ماهرة في إعداد المواد الإعلامية، حيث بلغت نسبة القادرين على إعداد البرامج الإذاعية الزراعية 35.4% فقط، بينما بلغت نسبة القادرين على كتابة المقالات الصحفية 33.3%. وبناءً على هذه النتائج، يُوصى بأن تنفذ مديرية الإرشاد الزراعي برامج تدريبية مُستهدفة بالتنسيق مع الخبراء ومديريات الإعلام. ويجب أن يركز التدريب على تحسين المهارات في الاجتماعات الرسمية، واستخدام الوسائل التعليمية، وكتابة التقارير التفصيلية، وإعداد المحتوى المناسب لقنوات الإعلام المختلفة، بما في ذلك الكتيبات والمجلات والبرامج الإذاعية والتلفزيونية.

الكلمات المفتاحية: *العاملين بالارشاد الزراعي، احتياجات التدريب، تحسين الاداء*

Introduction

Agricultural extension training is one of the major undertaking which a government, non-agricultural Groups, as well as other stakeholders with in the agricultural sector to educate worker, disseminates information, provide logistical inputs and organized training programs and workshops. Such aims will enhance and support the livelihoods of farmers. Extension teaches farmers about improved technologies so that they can increase agricultural production and productivity, thereby improving their living standard (Abibatu and T.Kromah 2016).

Agricultural extension aims to help rural people acquire new ideas, sound practices, and desirable attitudes to use their available resources wisely to raise their production, raise their economic level, and hence improve their living standards, (Elfaki, 2000; Swanson *et al*., 1997). To achieve this aim, extension workers use many agricultural approaches and utilize many educational means to make farmers aware of the new technologies and farm management systems. A good linkage between research centres and extension department keep extension workers up-to-date with discoveries and problem-solving procedures. The extension agents in the field should also reflect on the farmers' needs and problems associated with the agricultural research station and government bodies. Eltayeb (2005) stated that no one is perfectly fit at the time of hiring. Training is necessary to bridge the gap between what he is and what the job demands. In the absence of a systematic and planned training, employees learn their job by the trial-and-error method or observation, (Flippo, 2001). These methods consume more time and energy, thereby increasing the cost of training. Even then, there is no guarantee that the employee will learn the best method of doing the job. To have effective training at a reduced cost, planned training is a must. For any extension organization to improve its performance, continuous and systematic training of its staff is necessary. Training is not a luxury but a necessity; it is a kind of investment. Training has been recognized as an important input for improving the professional competence of extension personnel for effective transfer of technology to the farming community, so every organization seeks to raise the level of performance of their employees to do a better job through in-service training, (McDermott, 2003). The goal of this work is to assess the training needs of the agricultural extension workers in Sinnar State.

Material and methods:

This study is conducted in Sinnar state during 2021 which is represent the heart of Sudan and one of the 18 states of Sudan. It has an area of 37,844 km² and an estimated population of approximately 1,402,265 Persons. Sinnar state is composed of (7) seven localities, Sinnar, Sinja, Abuhugar, Aldinder, East Sinnar, Alsuki and Aldali Mazmom, People in Sinnar state is a mix of Arab and African tribes and some tribes of western Sudan. The people of Sinnar State depends mainly on agriculture and pastorals and trade in crops in their livelihood. Sinja is the capital and largest city in the state. The main economic activity is agriculture. All extension workers in the study area are 48, representing the total number of extension working in the Ministry of Agriculture Animal Wealth and Natural Resources is considered as the study population. The data for this study was collected through an interview using a structured Questionnaire, which contains questions about the assessment of agricultural extension worker's training needs in Sinnar State. While the secondary data were collected from theses, reports, scientific papers, books related to studies, and references. The data were coded and

emptied, and a code plan was made accordingly. The extracted data were analyzed using SPSS program. Descriptive analysis was used for calculating frequencies and percentages and weighted mean according to the Likert scale to reveal the actual training needs that extension workers in the study area lack on each issue regarding their daily activities.

Result and Discussion:

Table (1) shows that more than half of the agricultural extension workers (58.4%) are in the age group ranging from 30 to 40 years old, this means that about half the extension workers are young which encourages the administration to train them to better their jobs.

Table (2) reveals that most agricultural extension workers (72.9%) have a bachelor's degree, and 27.1% have a master's degree. This reflected in their high ability to acquire new technical knowledge.

Table (1) Frequency distribution of extension workers by age (N = 48).

Age	Frequency	Percent
30 years	7	14.6
31-40 years	21	43.8
41-50 years	16	33.3
51-60 years	4	8.3
Total	**48**	**100**

Table (2) Frequency Distribution of extension workers by educational level (N = 48).

Educational level	Frequency	Percent
B.Sc	35	72.9
Master	13	27.1
Total	**48**	**100**

Table (3) reflects that only 47.9% half of the agricultural extension workers are specialized in agricultural extension education. Therefor that is a need to train those how haven't agricultural degree in agricultural extension methods. Table (4) reveals that only 52.1% more than half of the agricultural extension workers attended training courses five times, 16.7% of them engaged in training courses once times, 12.5% of them attended never and three times, 4.2% of them attended only four times, 2.1% of them attend only times. This result shows that the agricultural extension workers do not received enough training as it is ought to be.

Table (5) denotes that only 62.5% of the agricultural extension workers received enough training on how at a weighted mean of (2.6) to write reports, which shows there is a need a train extension workers to write reports It is the role of the agricultural extension worker to write reports on the real extension of farmers. Reports about the problems that farmers face at the end of every season in specific areas, and urges the authorities to find solutions to these problems. Paul, (1998) and Laonard, (1997) stated that one of the specific objectives of agricultural extension is to relay the problems and needs of farmers back to the government agencies for research, study, and solution. Without being well skilled at writing reports, this objective cannot be accomplished.

Table (3) Frequency Distribution of Extension Workers by Academic Specialization (N = 48).

Academic specialization	Frequency	Percent
Agric. Extension	23	47.9
Agric. economic	9	18.8
Crop production	2	4.2
Agric. engineer	14	29.2
Total	**48**	**100**

Table (4) Frequency Distribution of extension workers by training duration (N = 48).

Attending Training courses	Frequency	Percent
Never	6	12.5
Once	8	16.7
Twice	1	2.1
Three times	6	12.5
Four times	2	4.2
Five times	25	52.1
Total	**48**	**100**

Table (6) reveals that 56.2% more than half of the agricultural extension workers are skilled at conducting formal meetings. The result shows there a need to train extension workers on conduct formal meetings at a weighted mean of (3.8). Through conducting formal meetings extension workers can reach more persons at one time.

Table (7) reflects that only 70.9% of the agricultural extension workers are skilled at using instructional audio aids, Result shows there is a need to train extension workers on instructional audio aids at a weighted mean of (3.8). Instructional audio aids are anything used in an instructional situation to help the learner reach the instructional objectives through the involvement of the sense of hearing. Dubay (2008) argued that audio aids are easy to use and have the advantage of making teaching more stimulating and dynamic, and they can be adapted to various topics and each type of audience.

Table (5) Frequency Distribution of extension workers by training in extension writing report (N = 48).

Writing report skills	Frequency	Percent	Weighted mean
Skilled enough	30	62.5	2.6
To some extent	18	37.5	
Not skilled at all	00	00	
Total	**48**	**100**	

*Weighted mean=3 no training need
*Weighted means less than 3 there is a training need

Table (8) shows that only 58.3% more than half of the agricultural extension workers

Table (6) Frequency distribution of extension workers by training in formal meeting (N = 48).

Formal meeting	Frequency	Percent	Weighted mean
Very skilled	17	35.4	3.8
Skilled	10	20.8	
Moderate	16	33.3	
Weak	5	10.4	
Not skilled at all	00	00	
Total	**48**	**100**	

*Weighted mean ≥ 4 no training need.
*Weighted mean= 3-3.9 there is a training need.
*Weighted mean= less than 3 there is an urgent training need.

are skilled at using instructional visual aids; The result shows there is a need to train extension workers on instructional visual aids at a weighted mean of (2.8). Instructional visual aids are anything used in an instructional situation to help the learners reach the instructional objectives through the involvement of both the sense of sight. Hawkings, (1999) stated that visual aids help step-by-step presentations and preset complicated facts in a simple manner.

Table (7) Frequency distribution of extension workers by training in audio aids(N= 48).			
Instructional audio aids	**Frequency**	**Percent**	**weighted mean**
Very skilled	13	27.1	3.8
Skilled	21	43.8	
Moderate	8	16.7	
Weak	5	10.4	
Not skilled at all	1	2.1	
Total	**48**	**100**	
*Weighted mean ≥ 4 no training need *Weighted mean= 3-3.9 there is a training need *Weighted mean= less than 3 there is an urgent training need			

Table (8) Frequency distribution of extension workers by training in Instructional visual aids (N = 48).			
Instructional visual aids	**Frequency**	**Percent**	**weighted mean**
Very skilled	12	25.0	2.8
Skilled	16	33.3	
Moderate	10	20.8	
Weak	6	12.5	
Not skilled at all	4	8.3	
Total	**48**	**100**	
*Weighted mean ≥ 4 no training need *Weighted mean= 3-3.9 there is a training need *Weighted mean= less than 3 there is an urgent training need			

Table (9) shows that only 45.8% half of the agricultural extension workers are skilled at using instructional audio-visual aids; The result shows there a need to train extension workers on use instructional audio-visual aids at a weighted mean of (3.0). Audiovisual aids are anything used in an instructional situation to help the learners to reach the instructional objectives through the involvement of both the sense of sight and the sense of hearing. Hawkings in (1999) argued that one of the main advantages of audio-visual aids over others is that they can show motion. On the other hand color, motion, and sound add realism and hold the learner's interest.

Table (9) Frequency distribution of extension workers by training in audio visual aids (N = 48).			
Instructional audio-visual aids	**Frequency**	**Percent**	**weighted mean**
Very skilled	6	12.5	3.0
Skilled	16	33.3	
Moderate	9	18.8	
Weak	6	12.5	
Not skilled at all	11	22.9	
Total	**48**	**100**	
*Weighted mean ≥ 4 no training need *Weighted mean= 3-3.9 there is a training need *Weighted mean= less than 3 there is an urgent training need			

Table (10) Frequency distribution by experience in writing extension pamphlets (N = 48).			
Preparing Pamphlets	**Frequency**	**Percent**	**weight mean**
Very skilled	14	29.2	3.7
Skilled	17	35.4	
Moderate	12	25.0	
Weak	3	6.3	
Not skilled at all	2	4.2	
Total	**48**	**100**	
*Weighted mean ≥ 4 no training need *Weighted mean= 3-3.9 there is a training need *Weighted mean= less than 3 there is an urgent training need			

Table (10) denotes that only 64.6% of the agricultural extension workers are skilled at preparing pamphlets; The result shows there is a need to train extension workers to prepare pamphlets at a weight mean of (3.7). Pamphlets are printed material often supported by appropriate illustrations, they give accurate or specific information on a particular topic in simple language. Sanders (1997) stated that pamphlets provide reliable scientific information, and can reach a large section of literate people simultaneously. Also, can be preserved and used by the readers for reference purposes.

Table (11) illustrates that only 56.2% more than half of the agricultural extension workers are adept at writing agricultural newspaper articles; The result shows there is a need to train extension workers to write agricultural newspaper articles at a weighted mean of (3.4). The newspaper article is an accurate, unbiased account of the main facts of a current event that is of interest to the readers of a newspaper. Hodgson (1996); Maaloouf, and Contado, (2005) reported that newspaper article gives information to many people quickly which would be of service to the leaders and people and highlight the important activities of individuals and groups.

Table (11) Frequency distribution by experience in writing journal articles (N = 48).			
Writing newspaper article	**Frequency**	**Percent**	**weighted mean**
Very skilled	11	22.9	3.4
Skilled	16	33.3	
Moderate	10	20.8	
Weak	5	10.4	
Not skilled at all	6	12.5	
Total	**48**	**100**	
*Weighted mean ≥ 4 no training need *Weighted mean= 3-3.9 there is a training need *Weighted mean= less than 3 there is an urgent training need			

Table (12) shows that only 52.1% more than half of the agricultural extension workers rely on agricultural radio programs to gain new information; The result shows there is a need to train extension radio programs as a source of information a weighted mean of (3.6). In Sudan, many radio stations compete to broadcast the most modern and useful information. They broadcast so many programs that can increase extension workers' awareness in many areas to make them cope with new advances in agriculture, (Omer, 2005). Klapper, (1990) and Hilland, (2000) reported that radio programs represent one of the most important information sources for farmers. Radio messages reach people instantly as the broadcaster speaks, the listeners hear him on their radio sets. Thus, urgent information can reach all parts of the country without delay.

Table No. (13) reflects that only 33.4% half of the agricultural extension workers rely on agriculture, the result shows there is a need to train to TV. program as a source of information with a weighted mean of (3.5). As is the case in radio programs, there are many TV. channels in Sudan that contribute to disseminating innovations and technology tailored to farming. Klapper (1990) stated that TV. the program has the advantage of displaying objects, pictures, and movies. It can represent a good source of information for extension workers.

Table (12) Frequency distribution by following radio program as a source of information:			
Radio Program as a Source of Information	**Frequency**	**Percent**	**Weighted Mean**
Always	10	20.8	3.6
Often	15	31.3	
Sometime	21	43.8	
Rarely	1	2.1	
Never	1	2.1	
Total	**48**	**100**	
*Weighted mean ≥ 4 no training need *Weighted mean= 3-3.9 there is a training need *Weighted mean= less than 3 there is an urgent training need			

Table (13) Frequency distribution by following T.V program as a source of information (N = 48).			
T.V program as a source of information	**Frequency**	**Percent**	**weighted mean**
Always	9	18.8	3.5
Often	7	14.6	
Sometime	26	54.2	
Rarely	4	8.3	
Never	2	4.2	
Total	**48**	**100**	
*Weighted mean ≥ 4 no training need *Weighted mean= 3-3.9 there is a training need *Weighted mean= less than 3 there is an urgent training need			

Conclusion:

It can be concluded that agricultural extension workers are in need to be trained in writing reports, instructional audio-visual aids, writing newspaper articles, preparing T.V programs, journals as a source of information, T.V programs as a source of information and Scientific books as a source of information.

Recommendations:

To Agricultural Extension Workers Directorate:

- To design training course according to training need for agricultural extension staff.
- More training course should be prepared to fulfill the trainee gap.

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