NJAS

NILE JOURNAL FOR AGRICULTURAL SCIENCES

Referred Scientific Journal

Vol. 8, NO. 01, 2023
ISSN: 1585 – 5507
http://www.nilevalley.edu.sd

NILE JOURNAL FOR AGRICULTURAL SCIENCES

Published by the Faculty of Agriculture
Nile Valley University
Republic of the Sudan
In collaboration with the Unit of Scientific Research and Publication

Referred Scientific Journal

ISSN: 1585 - 5507

Nile Valley University - Faculty of Agriculture, River Nile State, Atbara, PO Box 346, Sudan

E-mail: NJAS@nilevalley.edu.sd

Preface

We present before you the first issue of the eighth volume of the Nile Journal of Agricultural Sciences. We at the University of the Nile Valley decided to foreword valued materials that cover a wide range of agricultural sciences and topics which discuss solutions for emerging problems, and this will remain from our ultimate target in editing these issues.

We extend our thanks to everyone who contribute by writing for the journal, and we hope that we will be in match to their expectations of good proofreading and rapid publication that meets everyone's aspiration

In the last four years, conditions that everyone knows, that have been imposed on our world, disturbing the well-known balance of equation between production costs and product selling prices in domestic and international markets, and our country was no exception. These conditions are worsened in our country due to the prevailing political instability, which charge farmers considerable losses in their crop revenues, due to high production costs firstly and economic stagnation secondly, in a country with limited capabilities in value addition and rational ways of crop storage.

We are in need to valuable researches to deal with issues of adding value and perfect storing of agricultural crops, in addition to the fact that the state and farmers are looking for new mechanisms and approaches for marketing agricultural production, and this will always remain a challenge facing big firms as well as small producers.

This will be an invitation for readers to enjoy some interesting writing on such issues in this and other soon proceeding issues of the journal.

Instructions to Authors

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

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

Editorial policies

Ethics

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

Peer review policy and criteria of manuscript acceptance

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

Reviewers selection is based on reputation and experience. However, the identity of reviewers is confidential and manuscripts are considered private information. The editorial board will be certain of not to allowing authors to realize reviewers identities. Similarly, author(s) identities will not be unveiled to the referees.

Reprints

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

Instructions to authors

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

Manuscripts submission:

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

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

1. Cover letter:

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

2. Manuscript:

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

Types of articles:

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

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

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

Regular scientific manuscript formatting

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

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

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

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

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

The main text: The main text should be structured into paragraphs in the following order: **Introduction** including objectives, **Materials and Methods**, **Results**, **Discussion**, **Conclusion**, **Acknowledgement** (if any) and **References**. Results and discussion could be combined in one paragraph. Each heading should be flush with the left margin and have the first letter of all main words capitalized. All major headings should be separated from the text by 1 line space above.

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

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

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 did the results compare 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. Keunings (2003) or (Keunings, 2003). If the article has two authors, their last names are used, separated by the word “and”, e.g. Gates and Dobraszczyk (2004) or (Gates and Dobraszczyk, 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 (Kent and Evers, 1994; McLeish, 2003; Morris *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 are 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:

Harris, H.; Masri, S.; Pala, M.; Raya, J. and Singh, M. (2007). Rain fed wheat based rotation under Mediterranean condition: Crop sequences, nitrogen fertilization and stubble grazing in relation to grain and straw quality. European Journal of Agronomy, 28(2):12-118.

Book:

Fitter, A.H. and Hay, R.K.M. (2002). Environmental Physiology of Plants. (2^{nd} 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. and 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

TABLE OF CONTENTS

Nile Valley University Publications
Nile Journal for Agricultural Sciences (NJAS)
(ISSN: 1585 – 5507)
Volume 08, NO. 01, 2023
http://www.nilevalley.edu.sd

Correlation and Path Analysis among Some Agro-Morphological Traits in Chickpea (*Cicer arietinum* L.) Genotypes under High and Low Temperatures of Sudan

Fatih E. A. Hamza[1], **Tahani Y. Elagib**[2], **Amani H. Eltayeb**[3] **and Atif. E. Idris**[3]

[1] *Agricultural Research Corporation, Merowe Research Station, Sudan*
[2] *Agricultural Research Corporation, Biotechnology and Biosafety Research Center, Khartoum, Sudan.*
[3] *Department of Agronomy, College of Agricultural Studies, Sudan University of Science and Technology, Shambat, Khartoum, Sudan*

Correspondent author: fafatihelalim333@gmail.com

ABSTRACT

The objectives of this study were to assess the effect of temperature on seed yield and agro-morphological traits as well as correlation and path analysis in 48 chickpea genotypes grown under normal and late sowing conditions in two locations (Merowe and Gezira) during 2018/ 19. The forty eight genotypes comprised released varieties as checks and lines from ICARDA. The study was carried out in alpha lattice design with three replications. Analysis of variance showed that differences among genotypes, sowing dates, locations and their first order interaction were highly significant ($P \leq 0.01$) for the most studied traits. Under both environments, the correlation studies revealed that seed yield was positively and highly significantly correlated with 100 – seed weight, biomass, harvest index and seed yield per plant. The path analysis confirmed that the biomass followed by harvest index, seed yield per plant, 100 - seed weight, seed yield per plant, number of seeds per pod and number of pods per plant had the maximum positive direct influence on seed yield under heat stress and non- heat stress conditions. It was concluded that biomass, harvest index, 100 – seed weight and seed yield per plant can be good selection criteria for improving seed yield in chickpea under heat stress and non - heat stress conditions in Gezira and Northern states of Sudan.

Key words: Chickpea, correlation, heat stress, late sowing, path analysis, seed yield, traits.

تحليل الارتباط ومعامل المسار لبعض الصفات الزراعية - المورفولوجية لطرز وراثية من الحمص تحت درجات الحرارة العالية والمنخفضة في ولايتي الجزيرة والشمالية

فتح العليم عوض همزة[1]، تهاني العاقب[2]، اماني الطيب[3] وعاطف ادري[3]

1هيئة البحوث الزراعية، مروي

2هيئة البحوث الزراعية، شمبات

3كلية العلوم الزراعية، جامعة السودان

ممثل المؤلفين: fafatihelalim333@gmail.com

المستخلص

الهدف من هذه الدراسة هو تقييم تأثير درجة الحرارة على محصول الحبوب والارتباط ومعامل المسار لمحصول الحبوب والصفات المورفولوجية الزراعية لعدد 48 سلاله من الحمص تحت ظروف الزراعة العادية والمتأخرة. تتألف الطرز الوراثية الثمانية والأربعون من أصناف مجازة بالإضافة الى سلالات تم استجلابها من إيكاردا. تم تقييم الطرز الوراثية تحت ظروف الزراعة العادية والمتأخرة في موقعين (مروي والجزيرة) خلال فصل الشتاء موسم 2018/ 19. نفذت الدراسة بتصميم ألفا بثلاثة مكررات. أظهر تحليل التباين (ANOVA) وجود فروق معنوية عالية بين السلالات وتواريخ الزراعه والمواقع والتداخل بينهما لمعظم الصفات المدروسة. في كلا البيئتين أوضحت دراسات الارتباط أن انتاج الحبوب كان مرتبطا موجبا ومعنويا مع وزن 100 حبة، الكتلة الحيوية، معامل الحصاد وحاصل البذور للنبات. أكد تحليل المسار أن الكتلة الحيوية متبوعة بمعامل الحصاد، وحاصل البذور للنبات، ووزن 100 حبه، وعدد الحبوب في القرن، وعدد القرون في النبات كان لها أقصى تأثير مباشر وإيجابي على انتاج الحبوب تحت ظروف الإجهاد الحراري وغير الإجهاد الحراري. لذلك يشير هذا البحث إلى أن الكتلة الحيوية ، ومعامل الحصاد، ووزن 100 حبه وحاصل البذور للنبات يمكن أن تكون معايير اختيار جيدة لتحسين انتاج الحبوب في الحمص تحت ظروف الإجهاد الحراري وغير الاجهاد الحراري في ولايتى الجزيرة والشمالية.

كلمات المفتاحية : الحمص، الإجهاد الحراري، الزراعة ألمتأخرة الارتباط، تحليل المسار ، الصفات، انتاج الحبوب.

Introduction

Chickpea (*Cicer arietinum L.*) has been the second most important edible legume plant grown worldwide. It has an important role in meeting the protein needs of people in undeveloped countries, especially where the income imbalance is experienced (Bozoglu and Ozcelik, 2005). In Sudan, chickpea is an important cash crop which faces strong competition with the other winter legumes, mainly faba bean, in its traditional area of production in Northern Sudan. Chickpea is also grown successfully in Hawata area in eastern Sudan and Jebel Marra in western Sudan (Faki *et al.*, 1992; Sheikh Mohamed, 1991). In recent years, chickpea area has increased steadily in central Sudan, especially in the Gezira scheme and in New Halfa (Eastern Sudan). The growing season is restricted to a short period of time by the high temperatures prevailing at the beginning and at the end of the season (Amel *et al.*, 2015). The chickpea yields in Sudan vary from 0.83 to

2.8 t/ha, depending on weather conditions (Ahmed, 1996). Temperature is one of the most constraints in the main chickpea production areas in Sudan.

Chickpea productivity is constrained by several biotic and abiotic stresses (Gaur *et al.*, 2008) and temperature is one of the most important determinants of crop growth over a range of environments (Summerfield *et al.*, 1990) and may limit chickpea yield (Basu *et al.*, 2009).

Chickpea reproductive stages (flowering and podding) are vulnerable to external environmental changes and heat stress (Krishnamurthy *et al.*, 2011). Frequent decreases in the yields of chickpea seed were observed when plants were exposed to high temperatures (> 350C) at flowering and pod development stages (Wang *et al.*, 2006).

Yaqoob *et al.* (1990), studied correlation among 6 yield components in 12 genotypes of chickpea, reported that correlation between seed yield and days to maturity was negative. Eser *et al.*, (1991) recorded strong associations between seed yield per unit area and harvest index, 100 - seed weight and seed per plant in chickpea. Jahhar and Mane (1991) reported that the correlation was significant between chickpea seed yield and all yield studied parameters, except plant height.

Ciftci *et al.*, (2004) stated that positive and significant correlations were found among seed yield and plant height, number of branch, number of pods per plant, harvest index and number of seeds per plant. Ozveren *et al.* (2006) reported that, seed yield per plant was positively and significantly correlated with plant height, first pod height, total pod number, full pod number, and seed number and improving these traits may leads increase seed yield per plant.

Singh *et al.* (1990) reported that correlation and path coefficient analysis showed that biological yield and harvest index were the major direct contributors to seed yield.

To date, limited genetic resources for heat stress tolerance in chickpea have been reported (Devasirvatham *et al.*, 2013; Jha *et al.*, 2015). Heat tolerant varieties/cultivars are needed for improving chickpea yields in warm season environments and late sowing conditions especially in central Sudan (Gezira State), to expand its cultivation to new areas and improving its resilience to the impacts of climate change. The genetic variability present in the base population for desired characters plays an important role in developing improved chickpea genotypes. Less information is available on chickpea genotypes tolerant to heat stress under Sudan conditions. Hence the objectives of this study were to assess the correlation and path analysis of yield and agro-morphological traits among the chickpea genotypes under non – heat stress and heat stress conditions.

Materials and Methods

Description of the study areas

Two experiments were carried out for consecutive winter season 2018 and 2019 at two locations in Gezira Research Station Farm (GRSF) of the Agricultural Research Corporation (ARC), Wad Medani, Sudan. Gezira Research Station Farm is located in the central clay plain of the Sudan at latitude of 14° 24' N, longitude of 33° 29' E and elevation of 407 meters above sea level. The soil of the Gezira Research Farm is heavy, alkaline, cracking clay (clay 58%, pH 8.3, organic matter 0.02, nitrogen 0.25, phosphorus 0.06 and potash 3.0%). The other location at farmers' field in the Northern state of Sudan, Merowe locality (latitude: 18° 27' 0" N, longitude: 31° 49' 59" E, elevation: 258 meters).

Plant materials

Forty three chickpea genotypes were selected from advanced materials of the national chickpea breeding program. In addition, five improved released chickpea cultivars namely (Shiekh Mohamed, Merowe, Wad Hamid, Salwa and *Hwata*) were included as checks (Table 1).

Table (1). Accession No. and Origin of 48 Chickpea Genotypes Used in the Study

No	Accession No.	Origin		No	Accession No.	Origin
1	FLIP 09 – 181 C	ICARDA		**30**	22204	ICARDA
2	LIP 09 – 179 C	ICARDA		**31**	22272	ICARDA
3	FLIP 09 – 184 C	ICARDA		**32**	222389	ICARDA
4	FLIP09 – 155 C	ICARDA		**33**	222303	ICARDA
5	FLIP09 – 438 C	ICARDA		**34**	222242	ICARDA
6	FLIP09 – 261 C	ICARDA		**35**	22373	ICARDA
7	FLIP 07 – 236 C	ICARDA		**36**	22206	ICARDA
8	FLIP 09 – 259 C	ICARDA		**37**	22384	ICARDA
9	FLIP08 – 86 C	ICARDA		**38**	22341	ICARDA
10	FLIP09 – 6 C	ICARDA		39	22302	ICARDA
11	FLIP 08-59 C	ICARDA		40	22260	ICARDA
12	FLIP 09-182 C	ICARDA		41	22266	ICARDA
13	FLIP 09-187 C	ICARDA		42	22392	ICARDA
14	FLIP09 – 240 C	ICARDA		43	22261	ICARDA
15	22330	ICARDA		44	Shiekh Mohamed	Released commercial cultivar
16	22304	ICARDA		45	Merowe	Released commercial cultivar
17	22317	ICARDA		46	Wad Hamid	Released commercial cultivar
18	22233	ICARDA		47	Salwa	Released commercial cultivar
19	22278	ICARDA		48	Hwata	Released commercial cultivar
20	22267	ICARDA				
21	22232	ICARDA				
22	22223	ICARDA				

23	22235	ICARDA				
24	22366	ICARDA				
25	22293	ICARDA				
26	22380	ICARDA				
27	22362	ICARDA				
28	22254	ICARDA				
29	22335	ICARDA				

Experimental Design and Field Managements

In each location, the experiments were arranged in 12 x 4 alpha lattice design (incomplete design) with three replications. Each replicate consisted of twelve incomplete blocks and four plots in each block. The field was prepared in disc ploughed, disc harrowed, leveled then ridged (60 cm). Each genotype was sown in a separate plot which consisted of one ridge; each ridge was 4 m long. Seeds were sown in holes along the top of the ridge at a rate of two seeds per hole 0.1 m apart. Temperature stress was induced by manipulation of the sowing dates, normal and late (second week of November and first week of December, respectively) were used during both seasons. The experiments were irrigated every 12 to 14 days to avoid any water stress. The crop took a total of 11 irrigations during the growing period. A starter dose of nitrogen in the form of urea was applied at a rate of 43 kg N/ha with the third irrigation. The experiments were kept weed-free by hand weeding twice at early stages of crop cycle. Seed yield was assessed from a net area of 2.4 m2. Monthly maximum, minimum and mean temperatures during the cropping season 2018/19 for the two locations obtained from the Karima and Gezira metrological stations (Fig.1 and 2).

Measurements of growth and yield parameters

In two locations, the data of phonological and agronomical traits were collected during the growth period of the crop. In each plot, five individual plants were randomly selected for most of traits, and values for each trait were calculated as an average. The data were recorded on days to 50% flowering, days to 90% physiological maturity, plant height (cm), number of pods per plant, number of seeds per plant, number of seeds per pod, 100 - seed weight (g), seed yield per plant (g) and biomass (t ha^{-1}). The harvest index (%) was calculated as (seed yield / total shoot dry weight) x 100. Seed yield (t ha^{-1}) was determine by harvested the four meter length in each plot for yield. Weighed using electronic balance and then seed yield per plot was converted to seed yield in (t ha^{-1}).

Statistical analysis

The data were subjected to combined analysis of variance using the GenStat 12th edition statistical analysis package for windows (2009) to test the level of significance among the genotypes for different traits under study. Under normal and late sowing conditions simple correlation coefficients among all traits were calculated based on the overall means of genotypes. The correlation coefficients were estimated according to the formulae given by Al-Jibouri *et al.*, (1958). Path analysis to estimate the direct and indirect contributions of some traits to seed yield (t ha^{-1}) was also conducted using the method described by Dewey and Lu (1959).

Results and Discussion

Combined analysis of variance

The combined analysis of variance for studied traits under normal sown (non- heat stress) and late sown (heat stress) were presented in Table 2. Combined analysis of variance showed highly significant difference ($P \leq 0.001$) among genotypes, locations, and sowing dates and their interactions for the most studied traits. This variation can be exploited for selection of heat tolerant chickpea genotypes. These results were similar to Jeena *et al.* (2005) who reported high amount of genetic variation for number of pods per plant, 100-seed weight and seed yield. The interaction between the genotypes and locations were not significant for days to 50% flowering indicating that the performance of the genotypes with respect to this trait was consistent across locations.

Seed yield performance

The mean seed yield of early sowing (non – heat stress) was about two times greater than that of late sowing (heat stress). Under non – heat stress, entry no. 1 (FLIP 09 – 181 C) out - yielded all genotypes, in particular, the four checks cultivars (Wad Hamid, Shiekh Mohamed, Salwa and Hwata) by about 34.3, 23.1, 10.6 and 10.1%, respectively (Table 3). The results also, showed that under heat stress, entry no. 11 out - yielded the five chickpea commercial cultivars Merowe, Shiekh Mohamed, Hwata, Wad Hamid and Salwa by 30.1, 17.4, 9.5, 6.7 and 4.7%, respectively. Based on seed yield under the heat stress the entries no. 11, 4, 30, 34 and 43 were relatively more adapted to heat and exceeded cultivar Merowe in seed yield (Table 3). Seed yield was reduced at the late sowing date (heat stress) which may be reasonably explained by the relatively high temperatures prevailing during fertilization and pod setting stage.

Correlation coefficient analysis

Normal sowing (non- heat stress)

Under non – heat stress conditions, simple correlation coefficients were calculated based on means averaged over the two locations (Table 4). The character 100 - seed weight recorded positive and highly significant correlation with seed yield (r = 0.4119**). This result is in agreement with that of Shara (2019). The highest positive relationship was observed between seed yield and harvest index (r = 0.4214**). This result was in agreement with those of Erman *et al.*, (1997) and Ciftci *et al.*, (2004). Seed yield showed highly positive significant correlation with plant height (r = 0.3107*) and biomass yield (r = 0.3565*), while days to 50% flowering (-0.4127**) and days to 90% maturity (-0.3401*) demonstrated highly negative significant correlation with seed yield. These results agreed with those of many workers (i.e. Amare *et al.*, 2020; Fatih and Amel, 2018).

Highly significantly positive association was consistently observed between days to 50 % flowering and days to 90% maturity indicating that early flowering may lead to early maturity. These results are in agreement with those of Dasgupta *et al.* (1992).

Plant height exhibited positive and highly significant correlation with the 100 – seed weight, seed yield per plant, but it was correlated negatively and significantly with days to 50% flowering, number of seeds per plant and number of seeds per pod (Table 4).

The number of seeds per pod recorded positi ve and highly significant correlation with days to 50% flowering, number of seeds per plant and harvest index but it was correlated negatively with plant height, number of seeds per plant and 100 - seed weight.

The biomass showed significantly positive correlation with the seed yield t ha1, seed yield per plant and negative correlation with other characters. The number of pods per plant has positive and non-significant correlation with days to 50% flowering, days to 90% maturity, number of seeds per pod, biomass and seed yield t ha-1, but it has negative and highly significant correlation with 100 – seed weight (Table 4).

The seed yield per plant was positively and significantly correlated with plant height, number of pods per plant, 100 – seed weight and seed yield t ha1, but it has significant negative correlation with days to 90% maturity. These results agreed with the findings reported by Muhammd *et al.*, (2002).

Harvest index has positive and significant correlation with number of seeds per pod, 100 – seed weight, seed yield per plant and seed yield t ha1. On the other hand, it has negative but non-significant correlation with number of pods per plant, number of seeds per plant and biomass (Table 4).

100 -seed weight had a highly significant negative correlation with the number of pod per plant, number of seeds per pod and number of seeds per plant. This negative correlation indicates a compensatory relationship between them. These results are in close conformity to the findings of Banik *et al.* (2017) and Shafique *et al.* (2016).

Seed yield per plant exhibited significant and positive correlation with biomass, number of pods per plant, harvest index and 100 -seed weight. These results were in conformity with those of Vaghela *et al.* (2009).

Late sowing (heat stress)

Under late sowing (heat stress conditions), the simple correlation coefficients were determined between characters investigated based on mean values averaged over of the two locations (Table 5). Such, correlations help breeders to identify the characters that could be used as selection criteria in breeding program. The results indicate that seed yield t ha^{1} is positively and highly significantly correlated with biomass, seed yield per plant, harvest index, number of pods per plant and 100 – seed weight (r = 0.7498***, r = 0.7021***, r = 0.6793***, r = 0.6729*** and r = 0.2856*, respectively). The high positive correlation coefficient indicates that selection based on biomass, seed yield per plant, number of pods per plant, harvest index and 100 – seed weigh have an equal contribution towards increasing the seed yield in chickpea under heat stress condition. These results are in close agreement with those reported by Tesfamichael *et al.* (2015).

The 100 – seed weight was positively and significantly correlated with seed yield t ha^{1}. This result was comparable to that obtained by Khan *et al.* (1989). On the other hand, there was negative and significant correlation between seed yield t ha^{1} and days to 50% flowering (Table 5). This result is in agreement with the results of Singh *et al.* (2001) and Singh *et al.* (2017) who reported significant negative association between seed yield and days to 50% flowering.

Number of pods per plant has positive highly significant correlation with number of seeds per plant (r = 0.9396***), seed yield per plant (r = 0.7703***), harvest index (r = 0.5463***) and biomass (r = 0.3753**). Days to 50% flowering showed considerable negative and significant correlation with all the traits studied except days to 90% maturity. Number of seeds per plant had positive and significant correlation with number of pods per plant, seed yield per plant, harvest index and biomass, while it was negatively correlated with days to 50% flowering, days to 90% maturity and plant height. There was a negative correlation observed between harvest index and days to 50% flowering, days to 90% maturity, plant height and number of seeds per pod. There was a positive and significant correlation observed between seed yield per plant and number of pods per plant, number of seeds per plant and 100 – seed weight (Table 5). 100 –seed weight was negatively correlated with all traits except plant height and seed yield per plant. Biomass had a positive correlation with days to 90% maturity, plant height, number of pods per plant, number of seeds per pod, harvest index and 100 – seed weight.

Plant height showed positive and highly significant correlation with 100 - seed weight and seed yield per plant, while it was negatively correlated with number of pods per plant. Similar findings have been reported by Tejashwini *et al.* (2018).

Path coefficient analysis

Normal sowing (non- heat stress*)*

Table 6 shows path coefficient analysis under non– heat stress for eleven characters in chickpea based on data combined over two locations. Path coefficient analysis using seed yield as dependent variable and days to 50% flowering, days to 90% maturity, plant height, number of pods per plant, number of seeds per plant, number of seeds per pod, 100 - seed weight, seed yield per plant, biomass and harvest index as independent variables. Path coefficient analysis showed that among the ten traits; 100 – seed weight (p.c = 0.7902) followed by number of pods per plant (p.c= 0.5150), number of seeds per pod (p.c = 0.4652), harvest index (p.c = 0.2906) and biomass (p.c = 0.21359) had high positive direct influence on seed yield. This result was comparable to that obtained by Usman *et al.* (2012) and Jivani *et al.* (2013). 100 – seed weight had the greatest direct effect on seed yield (p.c= 0.7902), its indirect effect on seed yield was more positive through number of pods per plant but negative and low through days to 50% flowering, days to 90% maturity and number of seeds per pod.

The path coefficient analysis revealed that number of seeds per plant (p.c = -0.9080) had maximum negative direct effect on seed yield. The indirect effects of days to 50% flowering due to, days to 90% maturity, number of pods per plant, number of seeds per plant and number of seeds per pod were positive, but due to other characters were negative (Table 6).

The results of correlation and path analysis indicated that 100 – seed weight, harvest index, seed yield per plant and biomass were the major yield contributing characters as they showed positively and highly significant correlation with seed yield and also had highly positive direct effects. Thus these four characters could be considered as the most important for selection in order to improve the seed yield in chickpea under non – heat stress conditions. In addition number of seeds per plant also affected seed yield indirectly through number of pods per plant.

Late sowing (heat stress)

The direct and indirect effects of different characters on seed yield under heat stress condition are presented in Table 7. Path coefficients were computed to estimate the contribution of individual characters to seed yield. According to the path coefficient analysis the harvest index (0.5183), biomass (0.4545), number of seeds per plant (0.1478), seed yield per plant (0.1285), days to 90% maturity (0.0964), plant height (0.0673), number of pods per plant (0.0560), number of seeds per pod (0.0410) and 100 – seed weight (0.0343) had positive direct influence on seed yield (Table 7). The harvest index recorded highest positive direct effects on seed yield. The main reason for significant effect of harvest index was due to the close positive correlation of this character with seed yield (0.6793***). These results indicated that selection for this character may be effective in the improvement of chickpea seed yield under heat stress condition. The earlier studies for direct effect on seed yield for harvest index and biological yield were reported by Kuldeep *et al.* (2014) and Tadesse *et al.* (2016). Also these results confirmed those of Agrawal *et al.* (2018). Other trait such as days to 50% flowering (-0.1271) had negative direct effect on seed yield. This is in agreement with the findings of Vartika *et al*. (2017) and Fatih and Amel (2018).

The indirect effects of plant height due to, 100 – seed weight, seed yield per plant and biomass were positive, but those due to days to 50% flowering, days to 90% maturity, number of pods per plant, number of seeds per plant, number of seeds per pod and harvest index were negative. Also the indirect effects of 100 – seed weight due to all traits were positive except those due to days to 50% flowering, days to 90% maturity and number of seeds per pod which were negative (Table 7). In addition number of pods per plant also affected seed yield indirectly through harvest index. The estimated residual effect of path analysis was very low (0.07592), indicating that about 99% of the variability in seed yield was contributed by the traits studied.

Conclusion

The study revealed the existence of significant genetic variability among the tested genotypes for the different traits. The presence of significant genetic variability among genotypes suggests the possibility of improving traits through direct and indirect selection.

The genotypes no. 1, 40. 3, 6, 39 and 43 recorded the best average seed yield under non- heat stress and out-yielded the check, Salwa by 10.6, 10.6, 7.1. 3.5, 2.2 and 1.9%, respectively. On the other hand, under heat stress, the genotype no. 11 gave the highest seed yield outperforming the five checks Merowe, Shiekh Mohamed, Hwata, Wad Hamid and Salwa by 30.1%, 17.4%, 9.5%, 6.7% and 4.7%, respectively.

Under heat stress and non – heat stress conditions the negative correlations of the characters days to 50% flowing and days to 90% maturing with seed yield, indicate that the late maturing genotypes generally performed better than early maturing genotypes.

Seed yield (t ha-1) was positively and highly significantly correlated with seed yield per plant, harvest index, 100 – seed weight and biomass (t ha-1). These four traits could be used as potential selection criteria in breeding programs for developing high yielding chickpea genotypes under heat stress and non – heat stress conditions.

Path coefficient analysis showed that among the ten causal (independent) traits; the harvest index, biomass (t ha-1), number of seeds per plant and seed yield per plant had highly positive direct effects on seed yield. Thus, these traits can be used as criteria in selection for the improvement of seed yield in chickpea under late sown (heat stress) condition.

Table (2). Mean squares of seed yield (t ha-1), vegetative traits and some yield components of 48 chickpea genotypes grown under normal sown (non- heat stress) and late sown (heat stress) and two locations (Gezira and Merowe) during winter season 2018/ 19.

Traits	Genotype (d.f = 47)	Sowing date (d.f = 1)	Location (d.f = 1)	Geno. x Sowing date (d.f = 47)	Geno. x Location (d.f = 47)	Geno. x Sowing date x Location (d.f = 47)
Days to flowering	28453.47***	205.44*	552.25***	2596.72**	2006.25n.s	2294.25*
Days to maturity	9020.57***	4505.77***	30990.67***	2114.65n.s	6947.41***	2023.11n.s
Plant height (cm)	10046.56***	9702.25***	12904.96***	2344.96*	2634.07**	1797.08n.s
No. of pods / plant	104719.0***	192512.5***	237806.6***	56051.6***	78148.5***	59265.7***
No. of seeds / plant	189515.9***	221754.7***	436623.6***	91055.7***	114613.4***	77633.1***
No. of seeds / pod	9.84340***	0.70350***	3.65606***	1.75131n.s	1.95541*	0.86995n.s
100-seed weight (g)	23581.26***	592.11***	2525.06***	593.51n.s	1349.02***	845.32n.s
Seed yield / plant (g)	14797.99***	16838.31***	56792.85***	4999.95***	9292.77***	5853.38***
Harvest index (%)	6390.01***	8406.60***	6789.07***	3674.45***	5358.85***	3707.94***
Biomass (t ha^{-1})	646292537***	777473307***	492209298***	181320100*	442390185***	280082879***
seed yield (t ha^{-1})	101288763***	299575518***	40955733***	37786491n.s	47252430*	31099675n.s

* , ** and *** Significant at the P = 0.05, p = 0.01 and P = 0.001, respectively.
n.s = non - significant.

Table (3). Seed yield (t ha-1) of 48 chickpea genotypes grown under normal sown (non- heat stress) and late sown (heat stress), averaged over two locations.

No.	Normal	Late	No.	Normal	Late	No.	Normal	Late
1	3.93	1.52	**18**	3.00	1.50	**35**	2.74	1.44
2	2.61	1.36	**19**	3.45	1.70	**36**	2.20	1.61
3	3.78	1.32	**20**	2.18	1.12	**37**	2.03	0.89
4	3.45	2.12	**21**	3.16	1.42	**38**	3.26	1.16
5	3.21	1.75	**22**	2.55	1.47	**39**	3.59	1.56
6	3.64	1.30	**23**	3.04	1.12	**40**	3.93	1.31
7	2.74	1.37	**24**	2.88	1.14	**41**	1.84	0.93
8	2.72	1.05	**25**	2.90	1.44	**42**	1.91	1.07
9	2.82	1.05	**26**	2.73	1.86	**43**	3.58	1.99
10	3.45	1.42	**27**	3.40	1.69	**44**	3.02	2.08
11	3.29	2.52	**28**	2.09	0.83	**45**	3.91	1.76
12	2.58	1.74	**29**	2.94	1.50	**46**	2.58	2.35
13	3.20	1.77	**30**	3.14	1.91	**47**	3.51	2.40
14	3.51	1.61	**31**	2.40	1.51	**48**	3.53	2.28
15	2.83	1.29	**32**	2.87	1.10	**Mean**	2963	1521
16	2.84	1.63	**33**	1.86	0.98	**S.E ±**	1009	490.7
17	2.20	1.09	**34**	3.22	1.94	**C.V (%)**	34.0	32.3

Table (4). Simple correlation coefficient among seed yield, yield components and some vegetative traits of chickpea genotypes grown under normal sown (non- heat stress) conditions based on means averaged over two locations.

Traits	DF	DM	PH	NPP	NSPL	NSP	100-S.W	SYP	HI (%)	BIO
DM	0.7978***									
PH	-0.3159*	-0.1950n.s								
NPP	0.0683n.s	0.1496n.s	-0.1634n.s							
NSPL	0.1701n.s	0.1895n.s	-0.2813*	0.8535***						
NSP	0.2894*	0.1888n.s	-0.3610*	0.2103n.s	0.6194***					
100-S.W	-0.4506**	-0.4116**	0.5583***	-0.5275***	-0.7153***	-0.6040***				
SYP	-0.4710***	-0.3924**	0.2792*	0.3889**	0.2146n.s	-0.1719n.s	0.3714**			
HI (%)	-0.4053**	-0.2879*	0.0504n.s	-0.0390n.s	-0.1967n.s	0.2767*	0.3162*	0.2836*		
BIO	-0.2182n.s	-0.1981n.s	0.2412n.s	0.2595n.s	0.1680n.s	-0.0749n.s	0.1233n.s	0.3150*	-0.2259n.s	
SY (t ha^{-1})	-0.4127**	-0.3401*	0.3107*	0.2457n.s	0.0494n.s	-0.1652n.s	0.4119**	0.8100***	0.4214**	0.3565*

DF: Days to 50 % flowering, DM: Days to 90 % maturity, PH: Plant height (cm), NPP Number of pods per plant, NSPL: Number of seeds per plant, NSP: Number of seeds per pod, 100-S.W: Hundred seed weight (g), SYP: seed yield per plant (g), HI: Harvest index (%), BIO: Biomass (t ha-1) and SY: Seed yield (t ha-1).

Table (5). Simple correlation coefficient among seed yield, yield components and some vegetative traits of chickpea genotypes grown under late sown (heat stress) conditions based on means averaged over two locations.

Traits	DF	DM	PH	NPP	NSPL	NSP	100-S.W	SYP	HI (%)	BIO
DM	0.7116***									
PH	-0.2143n.s	-0.1029n.s								
NPP	-0.3832**	-0.4919***	-0.0758n.s							
NSPL	-0.2841*	-0.3651*	-0.2255n.s	0.9396***						
NSP	0.2190n.s	0.2667n.s	-0.3759**	-0.0022n.s	0.3081*					
100-S.W	-0.3770**	-0.3168*	0.4379**	-0.0027n.s	-0.2582n.s	-0.7124***				
SYP	-0.6089***	-0.5793***	0.2116n.s	0.7703***	0.6154***	-0.3063*	0.5091***			
HI (%)	-0.5000***	-0.4116**	-0.0834n.s	0.5463***	0.4909***	-0.0882n.s	0.1928n.s	0.4997***		
BIO	-0.3222*	-0.2278n.s	0.3753**	0.3753**	0.2966*	-0.0749n.s	0.1341n.s	0.4031**	0.1585n.s	
SY (t ha^{-1})	-0.6099***	-0.4547**	0.2309n.s	0.6729***	0.5745***	-0.1346	0.2856*	0.7021***	0.6793***	0.7498***

DF: Days to 50 % flowering, DM: Days to 90 % maturity, PH: Plant height (cm), NPP Number of pods per plant, NSPL: Number of seeds per plant, NSP: Number of seeds per pod, 100-S.W: Hundred seed weight (g), SYP: seed yield per plant (g), HI: Harvest index (%), BIO: Biomass (t ha-1) and SY: Seed yield (t ha-1).

Table (6). Path coefficient analysis showing direct and indirect effects of different traits on seed yield (t ha-1) of 48 chickpea genotypes grown under normal sown (non- heat stress) conditions based on means averaged over two locations.

Traits	Indirect effect										Direct effect
	DF	DM	PH	NPP	NSPL	NSP	100-S.W	SYP	HI (%)	BIO	Seed yield (t ha^{-1})
DF	___	-0.0041	-0.0295	0.0391	-0.1564	0.1317	-0.3633	0.0516	-0.1118	-0.0534	0.0824
DM	0.0653	___	-0.0175	0.0702	-0.1662	0.0927	-0.3009	0.0455	-0.0828	-0.0469	0.0051
PH	-0.0257	0.0010	___	-0.0892	0.2601	-0.1461	0.2020	-0.0608	0.0097	0.0556	0.0946
NPP	0.0063	-0.0007	-0.0164	___	-0.7756	0.0905	0.3128	0.0599	-0.0073	0.0608	0.5150
NSPL	0.0142	-0.0009	-0.0271	0.4399	___	0.2852	0.1800	0.0809	-0.0534	0.0398	-0.9080
NSP	0.0233	-0.0010	-0.0297	0.1002	-0.9080	___	-0.1490	0.0667	-0.0863	-0.0170	0.4652
100-S.W	-0.0379	0.0020	0.0223	0.1328	-0.2068	-0.0877	___	-0.0401	0.0816	0.0731	0.7902
SYP	-0.0379	0.0021	0.0512	0.1002	-0.5567	-0.2763	0.2821	___	0.0875	0.0286	0.1123
HI (%)	-0.0317	0.0015	0.0032	-0.0130	0.1669	-0.1381	0.2220	-0.0338	___	-0.0500	0.2906
BIO	-0.0187	0.0010	0.0223	0.1328	0.6545	-0.0335	0.2450	-0.0136	-0.0616	___	0.2359

DF: Days to 50 % flowering, DM: Days to 90 % maturity, PH: Plant height (cm), NPP Number of pods per plant, NSPL: Number of seeds per plant, NSP: Number of seeds per pod, 100-S.W: Hundred seed weight (g), SYP: seed yield per plant (g), HI: Harvest index (%), BIO: Biomass (t ha-1).

Table (7). Path coefficient matrix showing direct and indirect effects among seed yield (t ha-1) and related traits of 48 chickpea genotypes grown under late sown (heat stress) conditions based on means averaged over two locations.

Traits	Indirect effect										Direct effect
	DF	DM	PH	NPP	NSPL	NSP	100-S.W	SYP	HI (%)	BIO	Seed yield (t ha^{-1})
DF	___	0.0678	-0.0143	-0.0210	-0.0409	0.0084	-0.0209	-0.0483	-0.2648	-0.1432	-0.1271
DM	-0.0894	___	-0.0069	-0.0272	-0.0534	0.0095	-0.0197	-0.0401	-0.2230	-0.1020	0.0964
PH	0.0270	-0.0099	___	-0.0045	-0.0348	-0.0153	0.0072	0.0558	-0.0481	0.1796	0.0673
NPP	0.0478	-0.0469	-0.0054	___	0.1391	0.0014	0.0263	-0.0008	0.2858	0.1702	0.0560
NSPL	0.0352	-0.0348	-0.0158	0.0526	___	0.0136	0.0210	-0.0331	0.2558	0.1328	0.1478
NSP	-0.0260	0.0224	-0.0251	0.0019	0.0493	___	-0.0098	-0.0938	-0.0595	-0.0358	0.0410
100-S.W	0.0778	-0.0554	0.0141	0.0429	0.0908	-0.0117	___	0.0649	0.2634	0.1812	0.0343
SYP	0.0478	-0.0301	0.0292	-0.0003	-0.0381	-0.0299	0.0173	___	0.0951	0.0569	0.1285
HI (%)	0.0649	-0.0414	-0.0062	0.0308	0.0729	-0.0047	0.0174	0.0235	___	0.0781	0.5183
BIO	0.0400	-0.0216	0.0265	0.0209	0.0432	-0.0032	0.0136	0.0161	0.0890	___	0.4545

DF: Days to 50 % flowering, DM: Days to 90 % maturity, PH: Plant height (cm), NPP Number of pods per plant, NSPL: Number of seeds per plant, NSP: Number of seeds per pod, 100-S.W: Hundred seed weight (g), SYP: seed yield per plant (g), HI: Harvest index (%), BIO: Biomass (t ha-1).

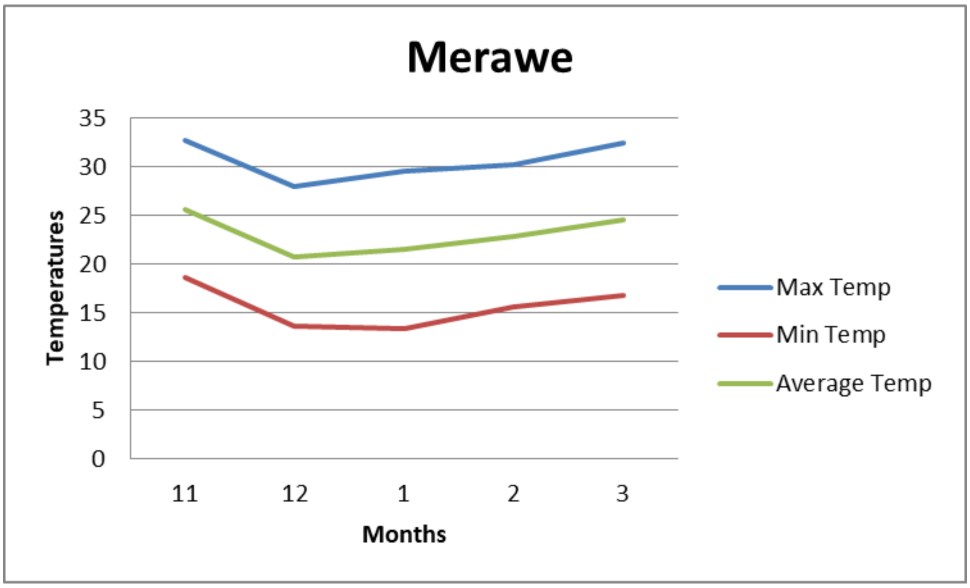

Fig.(1): Metrological data for minimum, maximum and mean air temperature (°C) Merawe location during winter season 2018/ 19. (Source: Karima Metrological Station.**)**

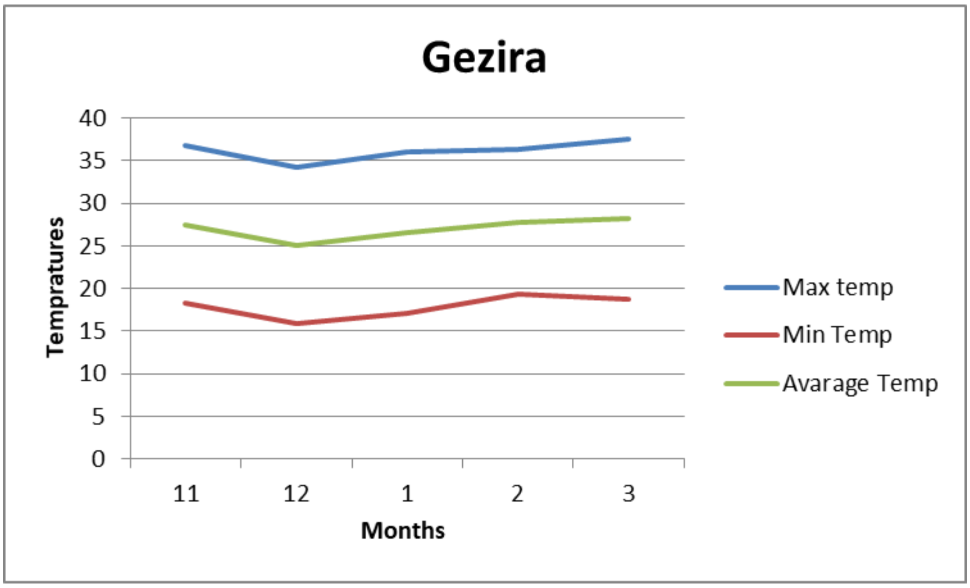

Fig.(2): Metrological data for minimum, maximum and mean air temperature (°C) Gezira location during winter season 2018/ 19. (Source: Gezira Metrological Station.**)**

References:

Ahmed, A.T. (1996). Food Legumes Production Situation. In: Salih, S.H., Ageeb, O.A., Saxena, M.C. and Solh, M.B., Eds., Production and Improvement of Cool-Season Food Legumes in the Sudan, Proceedings of the National Research Review Workshop, 27-30 August, 1995, Wad Medani; ICARDA/Agricultural Research Corporation, Aleppo, 7-14.

Agrawal, T.; Kumar, A.; Kumar, S.; Kumar, A.; Kumar, R.R. (2018). Correlation and path coefficient analysis for grain yield and yield components in chickpea (*Cicer arietinum L.*) under normal and late sown conditions of Bihar, India. Int J Curr Microbiol App Sci 7: 1633-1642.

Al-Jibouri, H.A; Miller, P.A.; Robinson, H. F. (1958). Genotypic and environmental variances and covariances in an upland cotton cross of inter specific origin. Agron. J. 50: 633-636.

Amare, T.; Asnake, F.; Muluken, B. (2020). Genetic variability and association analysis of Desi-type chickpea *(Cicer arietinum L.*) advanced lines under potential environment in North Gondar, Ethiopia, Cogent Food and Agriculture, 6:1, 1806668.

Amel, A. Mohamed.; Izzat, S.A. Tahir; Ashraf, M.A. Elhashimi (2015). Assessment of Genetic Variability and Yield Stability in Chickpea *(Cicer arietinum L.)* Cultivars in River Nile State, Sudan. Journal of Plant Breeding and Crop Sciences, 7(7): 219-224.

Banik, M.; Deore, G.N.; Mandal, A.K.; Shah, P. (2017). Selection of yield contributing traits in chickpea genotypes by correlation and path analysis studies. J Pharm Innov 6: 402-405.

Basu, P.S.; Ali, M.; Chaturvedi, S.K. (2009). Terminal heat stress adversely affects chickpea productivity in northern India- Strategies to improve thermo tolerance in the crop under climate change on Agriculture, 23-25 February, New Delhi, India, Pp. 189-193.

Bozoglu, H.; Ozcelik, H. (2005). A Study on determination of genotype x environmental interactions and stabilities of some genotypes in chickpea (*Cicer arietinum L.*). GAP Fourth Agricultural Congress. Uni. Har. Fac. Agr.,Sanliurfa,1: 834-839.

Ciftci, V.; Togay, N.; Togay, Y.; Dogan, Y. (2004). Determining Relationships among Yield and Some Yield Components Using Path Coefficient Analysis in Chickpea (*Cicer arietinum L.*). Asian Journal of Plant Sciences, 5: 632-635.

Dasgupta, T.; Islam, M.O.; Gayen, A. (1992). Genetic variability and analysis of yield components in chickpea (*Cicer arietinum L.).* Annals Agric. Res., 13:157-160.

Devasirvatham, V.; Gaur, P.; Mallikarjuna, N.; Raju, T.N.; Trethowan, R.M.; Tan, D.K.Y. (2013). Reproductive biology of chickpea response to heat stress in the field is associated with the performance in controlled environments. Field Crops Research 142: 9–19.

Dewey, D.R.; Lu, K.H. (1959). A Correlation and path coefficient analysis of component of crested wheat grass seed production. Agronomy Journal 51:515-518.

Erman, M.; Ciffci,V.; Ciffci, H.H. (1997). A research on relations among the characters and path coefficient analysis in chickpea (*Cicer arietinum L*.). J Agric. Sci.; 3:43-46.

Eser, D.; Gecit, H.H.; Emeklier, H.Y. (1991). Evaluation of germplasm in chickpea (Cicer arietinum L.) landraces in Turkey. International Chickpea News alphabet No. 22-23 [PI. Br. Abst. 63(2): 1677; 1993].

Faki, H.H.; Sheick Mohamed, A.I.; Ali, M.E.K. (1992). Adaptation of chickpea in Sudan. In proceedings of the International Workshop on Adaptation of Chickpea in the WANA Region, 9-12 November 1992. ICARDA, Aleppo, Syria.

Fatih, E. A. Hamza; Amel, A. Mohamed (2018). Agronomic Performance, Genetic Variability, heritability and Interrelationship for Yield and Some Quantitative Traits of Some Chickpea (*Cicer arietinum L*.) Genotypes Grown in the Northern Sudan. Sudanese journal of Agricultural Sciences, 4 (1): 36 – 49.

Gaur, P.M; Kumar, J.; Gowda, C.L.L.; Pande, S.; Siddique, K.H.M.; Khan, T.N.; Warkentin, T.D.; Chaturvedi, S.K.; Than, A.M.; Ketema, D. (2008). Breeding chickpea for early phenology: perspectives, progress and prospects. In: Kharkwal MC (ed) Food Legumes for Nutritional Security and Sustainable Agriculture, Vol. 2, New Delhi, India: Indian Society of genetics and Plant Breeding, pp. 39-48.

GenStat for Windows (2009).12th Edition.VSN International Ltd., Hemel Hempstead, UK.

Jahhar, A.S.; Mane, B.N. (1991). Correlation and path-coefficient analysis in gram (*Cicer arietinum* L.). J. Mahars. Agri. Uni. 16: 204- 206.

Jeena, A.S.; Arora, P.P.; Ojha, O.P. (2005). Variability and correlation studies for yield and its components in chickpea. Legume Research 28:146-148.

Jha, U.C.; Basu, P.S.; Singh, D.K. (2015). Genetic variation and diversity analysis of chickpea genotypes based on quantitative traits under high temperature stress. International Journal of Bio-resource Stress Management 6: 700–706.

Jivani, J. V.; Mehta, D. R.; Vaddoria, M. A.; Raval, L. (2013). Correlation and path coefficient analysis in chickpea (*Cicer arietinum* L.). Electronic Journal of Plant Breeding, 4(2): 1167-1170.

Khan, I.A.; Bashir, M.; Malik, B.A. (1989). Character association and their implication in chickpea breeding. Pak. J. Agri. Sci., 26(2): 214-220.

Krishnamurthy, L.; Gaur, P.M.; Basu, P.S.; Chaturvedi, S.K.; Tripathi, S.; Vadez, V.; Rathore, A. (2011). Large genetic variation for heat tolerance in the reference collection of chickpea (*Cicer arietinum* L.) germplasm. Plant Genetics Research, 9(1): 59–69.

Kuldeep, R.K.; Pandey, S.; Babbar, A.; Mishra, D.K. (2014). Genetic variability, character association and path coefficient analysis in chickpea grown under heat stress condition. Electronic Journal of Plant Breeding 5(4):812-819.

Muhammd, S.; Hammad, M. N. T.; Rehmat, K.; Muhammad, J. A. K. S. (2002). Interrelationships and path analysis of yield attributes in chickpea (*Cicer arietinum* L.), Int. J. Agri. Biol., 4 (3): 404-406.

Ozveren Yucel, D.; Anlarsal, A. E.; Yucel, C. (2006). Genetic Variability, Correlation and Path Analysis of Yield and Yield Components in Chickpea (*Cicer arietinum* L.). Turk. J. Agric. For., 30: 183-188.

Shafique, M.S.; Muhammad, A.; Zafar, M.; Muhammad, A.; Awais, S. (2016). Genetic variability and interrelationship of various agronomic traits using correlation and path analysis in chickpea (*Cicer arietinum* L.). Acad J Agric Res 4: 82-85.

Shara, J. Hama. (2019). Correlation and Path Coefficient Analysis for Seed Yield and Yield Components in Chickpea under Rainfed Condition. Journal of Kerbala for Agricultural Sciences Vol.(6), No.(1): 26-35.

Sheikh Mohamed, A. I. (1991). Current status and future prospects of chickpea production in Sudan. International Chickpea Newsletter 24: 10-11.

Singh, K.B.; Bejiga, G.; Malhotra, R.S. (1990). Associations of some characters with seed yield in chickpea collections. Euphytica 49: 83-88.

Singh, N. P.; Ram, K.; Kumar, R. (2001). An assay of effects of different traits on chickpea grain yield. Annals. Agri. Res., 22(4): 564-569.

Singh, V.; Vimal, S.C.; Shrivastav, S.P.; Maurya, V.; Singh, N. (2017). Character association and path analysis of yield contributing traits and quality parameter in chickpea (*Cicer arietinum* L.). Journal of Pharmacognosy and Phytochemistry. 6 (5): 1488-1492.

Summerfield, R.J.; Virmani, S.M.; Roberts, E.H.; Ellis, R.H. (1990). Adaption of chickpea to agro climatic constraints. In: Van Rheenen, H.A., Saxena, M.C.(Eds.), Chickpea in the

Nineties, Proceeding of the second International workshop on chickpea Improvement, 4-8th December 1989. ICRISAT Publishing, India pp. 50-61.

Tadesse, M.; Fikre, A.; Eshete, M.; Girman, N.; Korbun, L.; Mohamed, R.; Bekele, D.; Funga, A. ; Ojiewo, C.O. (2016). Correlation and path coefficient analysis for various quantitative traits in desi chickpea genotypes under rainfed conditions in Ethiopia. J. of Agri Sci, 8(12):112.

Tejashwini, A.; Anand, K.; Sanjay, K.; Anil, K.; Ravi, R.K.; Sanjeev, K.; Singh, P.K. (2018). Correlation and path coefficient analysis for grain yield and yield components in chickpea (*Cicer arietinum* L.) under normal and late sown Conditions of Bihar, India. Int. J. of Current Microbiology and Applied Sciences. 7(2): 1633-1642.

Tesfamichael, S. M.; Githiri, S. M.; Nyende, A. B.; Rao, N. V. P. R. G. (2015). Variation for Agro-Morphological Traits among Kabuli Chickpea (*Cicer arietinum* L.) Genotypes. Journal of Agricultural Science; 7(7): 75-92.

Usman, S.; Qurban, A.; Naveed, M. T.; Saleem, M. (2012). Correlation analysis of seed yield and its components in chickpea (*Cicer arietinum* L.) genotypes. International Journal for Agro Veterinary and Medical Sciences, 6(4): 269-276.

Vaghela, M.D.; Poshiya, V.K.; Savaliya, J.J.; Davada, B.K.; Mungra, K.D. (2009). Studies on character association and path analysis for seed yield and its components in chickpea (*cicer arietinum* L.). Legume Res., 32(4): 245-249.

Vartika, S.; SC, V.; Shiv, P.S.; Virendra, M..; Nidhi, S. (2017). Character association and path analysis of yield contributing traits and quality parameter in chickpea (*Cicer arietinum L.)*. Journal of Pharmacognosy and Phytochemistry, 6(5): 1488-1492.

Wang, J.; Gan, Y.T.; Clarke, F.; McDonald, C.L. (2006). Response of chickpea yield to high temperature stress during reproductive development. Crop Science, 46: 2171-2178.

Yaqoob, M.; Ahmad, M.B.; Jan, H. (1990). Interrelationship between grain yield and other important characters in chickpea (*Cicer arietinum* L.). Sarhad J. Agric. 6: 159-164 [PI. Br. Absts. 61(10): 9673; 1991].

Nile Valley University Publications
Nile Journal for Agricultural Sciences (NJAS)
(ISSN: 1585 – 5507)
Volume 08, No. 01, 2023
http://www.nilevalley.edu.sd

Effects of Nitrogen Fertilization, Datura and Jatropha Aqueous Extracts on *Striga hermonthica* Incidence on Wheat *(Triticum eastivum L.)*

Mukhtar Abdel Aziz Mohamed Osman

Faculty of Agricultural Science, El Selaim, University of Dongola, Sudan
Correspondent author: mukhtarazizm@gmail.com 0122843150 & 0911162653

Abstract

Pots experiment was conducted during the two consecutive winter seasons 2019/20 and 2020/21 at the demonstration farm, Collage of Agricultural studies (CAS), Shambat, University of Science and Technology, Khartoum Bahri, Khartoum state, Sudan (Latitude15° 40` N and Longitude 32° 23` E,) to evaluate the efficacy of nitrogen fertilization and two botanical water extracts (Datura and Jatropha) and Nitrogen, each one alone on Striga hermonthica incidence and growth and yield of wheat. All treatments significantly reduced number of Striga emergence, Striga shoot fresh and dry weights (g). Striga infestation significantly reduced wheat grain yield by 63.14%. Nitrogen in the form of urea at 80 lb/fed., significantly increased wheat grain yield (kg/fed.,) by 196.15 %. Among all treatments Nitrogen at 80 lb/fed., was the best treatment which achieved highest wheat grain yield (kg/fed,) and gave comparable grain yield (kg/fed,) to that obtained by Striga free control.

Keywords: Combination, incidence, grain, and reduced

تأثيرات التسميد النيتروجيني والمستخلصات المائية للداتورة والجاتروفا علي البودا في القمح

مختارعبد العزيز محمد عثمان

Correspondent author: mukhtarazizm@gmail.com

المستخلص

أجريت التجربة خلال موسمين شتويين متعاقبين للعامين 2019/ 20م 21/2020م بالمزرعة التجريبية، كلية الدراساتالزراعية، شمبات، جامعة السودان للعلوم والتكنولوجيا، الخرطوم بحري، ولاية الخرطوم، السودان (خطي عرض 15 و °40وخطي طول 23 و °40 لتقييم كفاءة المستخلصات المائية لنباتي (الداتورة والجاتروفا)، والنيتروجين، كل منهامنفرداً علي نمو طفيل البودا وتأثيره علي نمو وانتاجية القمح. كل المعاملات قللت معنوياً أعداد البودا المنبثقة، الوزن الرطب والوزن الجاف (جم) للمجموع الخضري للبودا. اصابة القمح بالبودا قللت معنوياً انتاجية الحبوب بنسبة63.14%. النيتروجين في صورة يوريا بمعدل 80 رطل للفدان زاد معنوياً انتاجية حبوب القمح (كجم/فدان) بنسبة 196.15%. من بين المعاملات كلها النيتروجين بمعدل 80 رطل للفدان كان أحسن معاملة وحقق أعلي إنتاجية حبوب للقمح (كجم/فدان) وأعطي إنتاجية حبوب مشابهة لتلك التي تم الحصول عليها في الشاهد الخالي من البودا.

***كلمات مفتاحية*: دمج، اصابة، حبة، وقللل**

Introduction

Wheat (*Triticum aestivm* L.) belongs to the Family Poaceae. It is the most important cereal crop in the world. At present it is cultivation extends word wide. It is considered as the third most-produced cereal after maize and rice (FAO, 1992). Its grains are a major source of energy, protein, and dietary fiber in human nutrition. Wheat supplies much of the world's food supply and dietary protein (FAO, 1992). It has become the most important source of carbohydrate in the majority of countries in the temperate zone. Its straw is used as feed for livestock in underdeveloped countries (FAO, 2003 and FAO, 1992).

In Sudan, wheat is becoming the staple food of both urban and rural populations. It considered the second food grain in the Sudan after sorghum. It is an important strategic crop in terms of food security. Wheat is planted in the fertile alluvial soils of the Nile in the Northern and River Nile States where winter is relatively longer and cooler (Mukhtar *et al*., 2013). Since 1960, wheat production has moved south wards and the crop is now cultivated in the Geziera, White Nile, Gedarif, Kassala and Darfur states (FAO, 2003). The recent construction of the Merowe Dam expand areas under wheat cultivation in the two Northern States.

Parasitic weeds are a major threat today in agriculture and provide an intriguing case of pathogenesis between species. Almost all crops species are potential hosts for parasitic weeds, but severe infestation and outbreak are usually restricted to certain host-pathogen combinations (Ejeta 2007; Ejeta *et al*., 1992). *Striga hermonthica* parasitic weed belongs to the Orobanchaceae Family infects economically important cereals crops, such as Sorghum, wheat, maize, pearl millet, and rice, causes huge damage to world agriculture, especially in sub-saharan Africa (Ejeta, 2007). Research in Africa on the control of *Striga* has been going on for 70 years (Ahmed *et al*., 2001). *Striga spp* are obligate hemi-parasitic weeds attach to the root of their host to obtain water, nutrients and carbohydrate (Fasil, 2002). The seed of *S. hermonthica* is small dust like (Parker and Riches, 1993). *Striga* is completely dependent on the host for its survival, and its life cycle is closely linked with that of the host plant (Haussmann *et al*., 2000). They have an after-ripening requirement and cannot germinate in the season in which they are produced (Fasil, 2002). Many potential control methods were developed against the parasite problem such as physical, cultural, chemical, and biological (Joel, 2002).

Botanical extracts of some plants will be a promising source of pest control compounds such as *Jatropha curcas* (Osman, 2019). The current study design to explore new environmental friendly pesticide to control weeds that can replace the highly toxic chemicals. The plant *Datura stramonium* L. belongs to Family Solanaceae, it is used in traditional medicine worldwide, practically in African countries such as Sudan and Libya (Shayoub *et al*., 2013; Ahmed, 2007; Elkamali and Khalid, 1996). *Jatropha curcas* L. belongs to Family Euphorbiaceae, that is native to the American tropics, most likely Mexico and Central America (Osman, 2019). It is cultivated in tropical and subtropical regions around the world (Yonli *et al*. (2010). In Sudan can be found in many regions like the Blue Nile, South Kordufan, Kassala, South Darfur States and other Stats (Adam, 2016).

Generally there is lack information on effects of nitrogen fertilizer and medicinal botanical extracts on *striga*, thus, this research was designed to investigate the effects of nitrogen fertilizer and two medicinal botanical aqueous extracts (Datura and Jatropha) on *Striga hermonthica* incidence on wheat. We have been following this approach to exploit of the effectiveness of the interaction of these control methods in a sound manner to fulfill the following objectives:

1- To determine the effect of different concentrations of aqueous extracts of Datura, Jatropha on *Striga hermonthica* and growth and yield of wheat.
2- To determine effects of different doses of Nitrogen on *Striga* and growth and yield of wheat.

Materials and Methods

A pot experiment was conducted during the two consecutive winter seasons 2019/20and 2020/21 at the demonstration farm, Collage of Agricultural Studies, Shambat, Sudan University of Science and Technology, Khartoum Bahri Locality, Khartoum State, Sudan, Latitude15° 40` N and Longitude 32° 23` E (Babiker *et al*., 2013) to evaluate the efficacy of water extracts of Datura leaves, Jatropha seeds and Nitrogen fertilizer In the form of urea, on *striga hermonthica* incidence and wheat growth and yield.

Datura leaves were collected from Shambat, Khartoum Bahri and Jatropha seeds were collected from National Tree Seeds Center. The plants materials were washed and dried at room temperature and were separately ground into fine powder (<1mm) and stored until use.

Plant aqueous extracts at 10% concentrations were obtained by soaking at room temperature. Ten grams of powdered part of plant material were placed in a 250 ml glass beaker with 100 ml of sterile distill water for 24 hours and each suspension was then filtered through two tools, the first (nylon cloth) served to move big debris and the second (filter paper) to set an homogeneous solution. Other concentrations (5% and 2.5%) were obtained by dilution 10% concentration as described by Yonli *et al.* (2010).

Wheat cultivar (Asareca-w2) grains were obtained from Elobied Research Station, Agricultural Research Corporation. The wheat grains were placed in six beakers contained Datura and Jatropha water extracts each at 2.5%, 5% and 10%. beakers were placed at room temperature for eight hours before planting. The seeds of controls were placed in beaker containing sterile distilled water.

The inoculated soil with *Striga* seeds at 20mg was added to the pots except *Striga* free control and thoroughly mixed by hand.

The wheat grains which were treated by *Datura* and *Jatropha* aqueous extracts were sown on 23th December in 2 cm soil depth, five /hole, later thinned to two plants per hole three weeks after sowing (WAC). Nitrogen fertilizer in the form of urea was applied at 40, 80 and 120 Ibs/fed. They applied as two equal split doses, one at thinning and the second at when plant at knee high. *Striga* Infested and *Striga* free controls were included for comparison. The treatments arranged in a randomized complete block design (RCBD).

The effects of the treatments were assessed by counting number of *Striga* shoots at 6, 10 and 14 WAS. At harvest *Striga* plants collected from each treatment were weighted to determine fresh weight, and then air-dried for dry weight. At flowering, two plants of wheat were taken to determine growth parameters including plant height (cm), shoot fresh weight/plant (g), shoot dry weight/plant (g), number of leaves/plant and days to 50% flowering. At harvest 1000 grain weight (g) and grain yield (kg/fed.) were recorded.

Data collected and measured in this experiment were subjected to analysis of variance (ANOVA) for each season separately and then combined as described by Gomez and Gomez (1984). The analysis carried out using the statistical analysis system (SAS) computer package for SAS Institute Inc., 1990, to detect significant effects among the treatments and populations compared.

Results and Discussion

Striga count made at 6, 10 and 14 (WAS) showed that, the number of *Striga* emergence increased with increasing of the number of weeks (Table 1). Statistical analysis showed significant differences among all treatments. At 6, 10 and 16 WAS, all treatments significantly reduced number of *Striga* emergence as compared to Striga infested control treatment (Table 1). Similar results were found by Osman (2019).The treatments which achieved lowest number of *Striga* were the highest (120 lb/fed.), and medium (80 lb/fed) of nitrogen and they gave comparable number of *Striga* shoots to Striga free control. Possible reason for this might be the presence of allele pathic effects of concentrations, and that might be attributed to the hormone –like properties of allelo-chemicals of plants extracts such as choline and flavonoids (Osman, 2019).

All treatments significantly reduced *Striga* shoot fresh and dry weights (g) compared to the Striga infested control treatment (Table 2). The highest rates of Datura and Jatropha, and the medium rate of nitrogen gave highest *Striga* shoot fresh and dry weights (g) comparable to that obtained by control treatments (Table 2). Possible reason for this could be due to *Striga* seeds cannot germinate in the absence of a chemical stimulant, because nitrogen decreases stimulant production by the host plant Osman, 2019). This result is in agreement with that obtained by Lagoke and Isah (2010) who reported that, Nitrogen reduced the severity of *S. hermonthica*.

All treatments significantly increased wheat shoot fresh (g)/plant and shoot dry weight (g)/ plant as compared to the *Striga* infested control treatment (Table 3). The high concentration of Datura (10%) and the medium rate of Nitrogen (40 lb/fed.) were the best treatments which achieved highest shoot fresh (g)/plant and shoot dry weight (g)/ plant and were comparable to that obtained by *Striga* free control treatment. Similar findings were obtained by Asifullah *et al*. (2017).

All treatments significantly increased number of tillers/plant as compared to the *Striga* infested control treatment. The highest concentration of Datura (10%) and the medium rate of nitrogen (40 lb/fed.) were the best treatments which achieved highest number of tillers/plant. The attained number of tillers per plant were comparable to that obtained by *Striga* free control treatment.

The high rate of Datura (10%), medium (5%) and high rates (10%) of Jatropha and the low and medium rates of nitrogen (40 and 80 lb/fed.) significantly increased plant height (cm) as compared to the Striga infested control treatment (Table 3). The highest concentration of Jatropha (10%) and the medium rate of nitrogen (80 lb/fed.) resulted in highest plant height (cm) and were comparable to that obtained by *Striga* free control treatment(Table 3).

All treatments did not significantly increased 1000 grain weight (g) as compared to the *Striga* infested control treatment (Table 4).

Combined analysis of both winter seasons indicated that, *Striga* significantly reduced wheat grain yield by 63.14 compared to *Striga* free control. Similar result was obtained by Ejeta (2007) who reported that, parasitic plants are acquired the ability to obtain nutrition from host plants and have adapted to prefer less fertile soil and consequently cause considerably loss to the crop.

Combined analysis of both winter seasons reported that, all treatments except (Datura 2.5%, Jatropha 2.5% and nitrogen at 120 lb/fed.) significantly increased wheat grain yield as compared to the *Striga* infested control treatment (Table 4). Nitrogen at 80 lb/fed., significantly increased wheat grain yield (kg/fed.) by 196.15 % as compared to the *Striga* infested control treatment.

Among all treatments nitrogen at 80 lb/fed., was the best treatment which achieved highest wheat grain yield (kg/fed,) and gave comparable grain yield (kg/fed,) to that obtained by *Striga* free control (Table 4). The grain yield (kg/fed.) increased when the level of nitrogen increased until certain level. These results might be due to the increase up of grain yield attributing characters and nutrient uptake of the crop under these levels as well as reduced *Striga* infestation at high application levels (Osman, 2019). These findings are in agreement with those obtained by Hugar*et al*. (2010) who reported that, the grain yield increased when the level of nitrogen increased. High levels of *Striga* infestation are often associated with low soil fertility (Oswald, 2005). Several reports have shown that nitrogen at high rates suppresses Striga infestation, while at low rates it enhance emergence of the parasite (Hugar *et al*., (2010). Also these results are in line with those obtained by Oswald (2005) who indicated that, low levels of *Striga* infestation are often associated with high soil fertility.

Table 1: Effect of Datura, Jatropha aqueous extracts and nitrogen fertilization on *Striga* emergence (plants/pot) in both winter seasons combined

Treatments	Number of Striga (plants/pot)		
	6 WAS	10 WAS	14 WAS
Datura 2.5%	1.67 b	2.67 b	3.33 a
Datura 5%	1.33 b	2.00 b	2.33 b
Datura 10%	0.67 c	1.00 c	1.33 c
Jatropha 2.5%	1.67 b	2.33 b	2.33 b
Jatropha 5%	1.67 b	2.00 b	2.00 b
Jatropha 10%	1.00 bc	1.33 bc	1.33 c
Nitrogen 40 lb/fed.	1.67 b	1.67 bc	1.67b c
Nitrogen 80 lb/fed.	0.33 c	0.33 c	0.67 c
Nitrogen 120 lb/fed.	1.00 bc	1.33 bc	1.33 c
Striga free control	0.33 c	0.33 c	0.33 c
Striga control	3.33 a	4.33 a	4.67 a
CV	6.36	4.89	6.06
SE±	0.10	0.14	0.25

WAS= weeks after sowing.

Means followed by the same letter (s) within each column do not differ significantly at 5% level of probability according to DMRT

Table 2: Effects of Datura, Jatropha aqueous extracts and nitrogen fertilization on *Striga* shoot fresh andshoot dry weights (g)in both winter seasons combined

Treatments	Striga shoot fresh weight (g)	Striga shoot dry weight (g)
Datura 2.5%	1.67 b	1.00 b
Datura 5%	1.67 b	1.00 b
Datura 10%	1.00 bc	0.67 c
Jatropha 2.5%	2.00 b	1.33 b
Jatropha 5%	1.67 b	1.00 b
Jatropha 10%	1.33 bc	0.67 c
Nitrogen 40 lb/fed.	1.67 b	1.33 b
Nitrogen 80 lb/fed.	0.33 c	0.17 c
Nitrogen 120 lb/fed.	1.17 b	1.00 b
Striga free control	0.33 c	0.18 c
Striga control	5.00 a	3.95 a
CV	17.09	20.19
SE±	0.15	0.14

Means followed by the same letter (s) within each column do not differ significantly at 5% level of probability according to DMRT

Table3: Effects of Datura, Jatropha aqueous extracts and nitrogen fertilization on wheat growth parameters in both winter seasons combined

Treatments	Shoot fresh weight (g)/ plant	Shoot dry weight (g)/ plant	Number of tillers/ plant	Plant height (cm)
Datura 2.5%	5.00 c	2.33 c	3.67 c	30.67 e
Datura 5%	7.00 b	4.33 b	4..00 c	36.83 d
Datura 10%	10.33 a	7.00 a	6.67 a	55.17 b
Jatropha 2.5%	5.00 c	2.67 c	2.00 d	35.10 d
Jatropha 5%	5.67 b	4.33 b	4.00 c	46.17 c
Jatropha 10%	6.67 b	4.67 b	5.67 b	58.50 ab
Nitroge40 lb/fed.	5.67 c	2.33 c	3.67 c	44.00 c
Nitrogen 80 lb/fed.	10.67 a	7.67 a	6.67 a	59.83 a
Nitrogen 120 lb/fec	5.33 c	2.67 c	5.33 b	33.33 de
Striga free control	10.33 a	7.33 a	7.00 a	60.33 a
Striga control	4.67 d	2.00 d	1.67 d	35.67 d
CV	20.80	0.42	34.24	4.80
SE±	0.91	15.68	0.91	1.25

Means followed by the same letter (s) within each column do not differ significantly at 5% level of probability according to DMRT

Table 4: Effects of Datura, Jatropha aqueous extracts and nitrogen fertilization on wheat yield in both winter seasons combined

Treatments	1000 grain weight (g)	Wheat grain yield (kg/fed)
Datura 2.5%	37.67 a	5.67 de
Datura 5%	37.33 a	6.63 cd
Datura 10%	48.00 a	7.50 c
Jatropha 2.5%	36. 67 a	4.67 e
Jatropha 5%	38.33 a	6.47 cd
Jatropha 10%	47.33 a	10.13 b
Nitrogen 40 lb/fed.	39. 33 a	9.50 b
Nitrogen 80 lb/fed.	48.67 a	13.83 a
Nitrogen 120 lb/fed.	37.00	5.90 cde
Striga free control	40. 00 a	12.67 a
Striga control	36.33 a	4.67 e
CV	9.48	12.86
SE±	0.62	0.55

Means followed by the same letter (s) within each column do not differ significantly at 5% level of probability according to DMRT

Conclusions:

1- Datura and Jatropha aqueous extracts reduced *Striga* emergence and *Striga* fresh and dry weights.

2- Nitrogen in the form of urea at tested rates effectively suppressed *Striga* emergence.

3- Effectiveness of Datura, Jatropha and nitrogen levels increased by increasing concentrations, or rates.

References

Adam, A.I. M. (2016). Efficacy of *Jatrophacurcas*Leave and Bark Powder against *Trogoderma granarium* (Evert's) (*Coleoptera: Dermestidae*). M.Sc., Thesis, Al Zaiem AL-Azhari University, Sudan.

Ahmed, N. E.; Sugimoto, Y.; Babiker, A. G.; Mohamed, O. E.; Inanaga, S.; Nakajima, H. (2001). Effects of *Fusarium solani* isolates and metabolites on *Striga* germination. *Weed Sci. 49: 354–358.*

Ahmed, M.A. (2007). The efficacy of four systemic insecticides using two methods of application against the green date palm pit scale insect (*Asterolicaniumphoenicis*Rao) (*Homoptera: Asterolicaniidae*) in northern Sudan. Acta Horticulturae, 736:369-389.

Asifullah, K.; FaizanUllah.; Sultan, M.; Muhammad, I.; F. Ullah. (2017). Alellopathic effects of *Jatrophacurcas* L. leaf aqueous extract on early seedling growth of *Parthenium hysterophorus.* Pakistan J. Agric.30 (1) 45-54.

Babiker, M.M.; Elamin, S.E.; Mukhtar, A.M. (2013). Impact of herbicides Pendimethalin, Gesaprim and their combination on weed control under maize (*Zea mays L.).* Journal of applied and industrial sciences, 1(5): 17 – 22.

Ejeta, G. (2007). The *Striga* scourge in Africa: a growing pandemic. In: Ejeta, G. and Gressel, J. (eds.). Integrating new technologies for *Striga control*: Towards ending the *witch-hunt,pp.3-16.*

Ejeta, G.; Larry, G.B.; Abdel Gabbar, B. (1992). Host plant resistance to Striga; 1stInternational crop science congress, Ames, lowa, USA.

Elkamali, H.H.; Khalid, S.A. (1996).The most common herbal remedies in Dongola Province, Northern Sudan. *Fitoterapia*; (*69):118-121.*

FAO, (1992). Production yearbook, 46: 74 – 75. FAO, Rome.

FAO, (2003). Yearbook production, (56) FAO statistics, series No. 176. Food and agriculture organization of the Unite Nation, Rome.

Fasil, R. (2002). *Striga hermonthica* in Tigray (Northern Ethiopia) Prospect for Control and Improvement of Crop Productivity through Mixed Cropping. Ph.D. thesis, Vrije University, Amsterdam, the Netherlands.

Gomez, K.A.; Gomes, A. A. (1984). Statistical procedures for Agricultural research, 2nd Edition. John Wily and Sons, Inc. New York.

Haussmann, B.I.; Geiger, H.H.; Hess, D.E., Hash, C T.; Bramel, P. (2000). Application of Molecular Markers in Plant Breeding.Training Manual for a Seminar Held at IITA.International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). Patancheru 502324, Andhra paradesh, India.

Hugar, A.Y.; Jayadeva, H.M.; Rangaswamy, B.R.; Shivanna, S.; Handrappa, H. (2010). Assessing the effect of nitrogen and harvesting stages on yield and yield attributes of sweet sorghum genotypes. Agricultural Science, 30 (2): 139 – 141.

Joel, D.M. (2002). The long-term approach to parasitic weeds control: manipulation of specific developmental mechanisms of the parasite. Crop Protect., 19: 753-758.

Lagoke, S.T.O.; Isah, K.M. (2010). Reaction of maize varieties to *Striga hermonthica* as influenced by food legume intercrop, spacing and split application of compound fertilizer. Nig. *J. Weed Sci., 23: 45-58.*

Mukhtar, A.M.; Babiker, M.M.; GamarElniaama, A.I. (2013). Chemical weed control in wheat (*Triticumaestivum*L) in Dongola Locality, Northern State, Sudan. Journal of Science and Technology, 14(2): 26 – 33.

Osman, Y.M.Y. (2019). Effect of Hargel, Jatropha Aqueous Extracts and Nitrogen Fertilization on *Striga* and Growth and Yield of Sorghum. M.Sc., Thesis. Sudan University of Science and Technology, Sudan.

Oswald, A. (2005). *Striga* control—technologies and their dissemination. Crop Prot., 24: 333- 342.

Parker, C.; Riches, C.G. (1993). Parasitic Weeds of the World: Biology and Control. CAB International, Wallingford, U. K. pp. 332.

Shayoub, M.; Haj, E.; Makawy, A.; Rasha, R.; Mona, A. (2013). Adverse reaction of *Solenostemma argel* leaves, extraction and alkaloids tablets administered to patients. Global J. Trad Med Sys, 2(1):14-18.

Yonli, D.; Traore, H.; Sereme, P.; Sankara, P.(2010). Use of local plant aqueous extracts as potential bio-herbicides against *Striga hermonthica* Del.Benth. in Burkina Faso. Asian journal of crop science, 2: 147-154.

Nile Valley University Publications

Nile Journal for Agricultural Sciences (NJAS)

(ISSN: 1585 – 5507)

Volume 08, No. 01, 2023

http://www.nilevalley.edu.sd

Genotype, Environment Interaction and Yield Stability Estimates of Some Sorghum (*Sorghum bicolor L. Moench*) Traits in Sudan

Mohammed H. Mohammed, Ali E. Hassan, El Tayieb I. Hassan and Abubaker Eltahir

Agriculture Research Corporation, Sudan

Correspondent author: email: phone: +249 115063284

Abstract

This research work was carried out during two seasons of 2016 and 2017 at four locations. Two of them are under irrigation and two under rain-fed conditions. The irrigated sites were Wad Medani and Suki, while the rain-fed sites were Gedarf and Damazin. The experiments at the four locations were testing7 sorghum genotypes against three checks (Tabat, Wad-Ahmed and HD-2) for their grain yield, yield stability and some important agronomic characters. The design at each site and season was a randomized complete block design (RCBD) with four replicates. Sowing was in the first week of July under irrigation and in the first to the third week of July under rainfed conditions depending on the rainfall. All other recommended cultural practices suitable to irrigation and rain fed conditions were adopted as recommended. Combined analysis showed that there were significant differences among tested genotypes. The results of AMMI analysis of variance showed that, the mean squares of genotypes, environments and genotypes environments interaction were highly significant ($p<0.01$) for grain yield. Genotype W638 recorded the highest grain yield (3.6 t/ha) followed by genotype Mena (3.2 t/ha) while the three checks HD-2, Tabat and W.Ahmed showed a mean grain yield of 2.9, 2.8, and 3.1 t/ha respectively. From these results, it was found that, the genotypes W638 and Mena out yielded all the checks and had a mean grain yield greater than the general mean of the irrigated environments (2.9 t/ha),while Maroa scored a grain yield comparable to Wad Ahmed (2.0 t/ha), but greater than Tabat (1.7 t/ha) and HD-2 (1.3 t/ha) and above the general mean of the rain fed environments (1.7 t/ha) .These results indicated that, genotypes W638 and Mena were stable and adaptable under irrigated conditions, while genotype Maroa was considered as stable and adaptable under rain fed conditions.

Keywords: environments, genotypes, sorghum, yield stability

تفاعل النمط الجيني والبيئي وتقديراستقرارالمحصول في بعض الطرزالوراثية للذرة الرفيعة في السودان

محمد حمزة محمد، علي التوم حسن، الطيب ابراهيم حسن و ابوبكرالطاهر

هيئة البحوث الزراعية، السودان

المستخلص

تم إجراء هذا البحث في موسمين خلال عامي 2016 و 2017 في أربعة مواقع.اثنان منهم تحت الري واثنان تحت ظروف الأمطار. المواقع المروية كانت في ود مدني والسوكي، أما المواقع المطرية فكانت القضارف والدمازين. كانت التجربة في المواقع الأربعة تختبر 7 طرز وراثية للذرة مقابل ثلاثة استخدمت كشاهد (طابت، ود أحمد وHD-2) من أجل محصول الحبوب وثباتها وبعض الصفات الزراعية المهمة.كان التصميم في كل موقع ومواسم الزراعة عبارة عن تصميم القطاعات الكاملة العشوائية (RCBD) بأربعة مكررات.تم البذر في الأسبوع الأول من يوليو تحت الري وفي الأسبوع الأول إلى الأسبوع الثالث من يوليو في ظروف الامطار اعتمادًا على هطولها .تم اعتماد جميع الممارسات الزراعية الأخرى الموصى بها المناسبة للري والظروف المطرية على النحو الموصى به.أظهر التحليل المشترك وجود فروق ذات دلالة إحصائية بين الطرز الوراثية المختبرة.أظهرت نتائج تحليل التباين AMMI أن متوسط المربعات لتفاعل الطرز الوراثية والبيئات والطرز الوراثية كانت ذات دلالة إحصائية عالية (p <0.01) في محصول الحبوب.سجل النمط الوراثي W638 أعلى محصول حبوب (3.6 طن / هكتار) يليه النمط الوراثي مينا (3.2 طن / هكتار) بينما أظهرت الشواهد الثلاثة HD-2 وطابتوود احمد متوسط محصول حبوب قدره 2.9 و 2.8 و 3.1 طن / هكتار على التوالي.من هذه النتائج ، وجد أن الطرز الوراثية W638 و مينا اكبر من جميع الشواهد وكان متوسط محصول الحبوب أكبر من المتوسط العام للبيئات المروية (2.9 طن / هكتار) ، بينما سجل مروةمحصول حبوب مماثل لودأحمد (2.0 طن / هكتار) ولكن أكبر من طابت (1.7 طن / هكتار) و HD-2 (1.3طن / هكتار) وأعلى من المتوسط العام للبيئات المطرية (1.7 طن / هكتار) وقد أشارت هذه النتائج إلى أن الطرز الوراثية W638 ومينامستقرة وقابلة للتكيف في ظل الظروف المروية ، بينما اعتبر التركيب الوراثي مروةمستقرًا وقابلًا للتكيف تحت ظروف الزراعة المطرية .

كلمات مفتاحية: الذرة الرفيعة، النمط الجيني، البيئة، استقرار المحصول

Introduction

Sorghum (*Sorghum bicolor* (L. Moench) is an important cereal crop and ranks fifth worldwide after wheat (*Triticumspp*), rice (*Oryzaspp*), maize (*Zea mays*) and barley (*Hordeum vulgre*) (FAO. 1995). It is grown over 42 countries (Belum *et al*., 2004). Developing countries are growing 90% of the world sorghum area and are producing 70% of the total sorghum production. Semi-arid tropical Asia and semi-arid tropical Sub-Saharan Africa grow about 60% of the world area (ICRISAT and FAO, 1996), while Sudan grows about 24% of Africa area and produces 17% of its production. Sorghum was first domesticated in the region of North East Africa and consists of cultivated and wild species. The region of Eastern Sudan and Ethiopia is considered a center of probable origin (Doggett and PrasadaRao, 1995). Doggett (1988) reported that, the greatest genetic diversity of cultivated and wild sorghum is present in East Africa. In Sudan, sorghum is the main staple food especially in rural areas and is used in different forms. Itplays a significant role for small and large scale farmers, it is the leading cereal crop by production, consumption as well as area cultivated. The national averages yield in Sudan was250 kg/fed (4200 m^2) which is very low compared to that obtained at research stations. This is due to the use of low yielding poor grain quality cultivars and poor crop management practices.

During the last 15 years, plant breeders in the Agricultural Research Corporation have successfully developed high yielding open pollinated varieties such as FW Ahmed, Ingaz (Ibrahim and Mahmoud 1992) and Tabat (Ibrahim *et al*., 1996). In addition, many other varieties suitable for both irrigated and rainfed sectors were also developed such as Butana and Bashayer (Elzein *et al.*, 2007) and AG-8 (Mohamed *et al.*, 2009). In the Sudan, the first hybrid developed is through the INTSORMIL collaborative program which started in 1979. That program succeeded in releasing the first hybrid in 1983 (HD-1) and since then, very few hybrids were released such as Hageen Rabih and Sheikan. Still, very few hybrids are famous to the farmers such as HD-1 and PAN 606. Recently, the plant breeders at the Agricultural Research Corporation succeeded in releasing three hybrids (DIA-07666, PAC-501 and E-1) suitable for irrigation and high rain fall areas of the Sudan (Elasha *et al.* 2011). Also, (Mohammed *et al.*, 2018) had released new sorghum hybrids for both irrigated and rain fed sectors. To increase the low national average sorghum grain yield of 250 kg/fed, hybrids could be among the most important technological packages for both irrigated and rain fed sectors. This study was carried out with an objective to evaluate some genotypes under irrigated and rain fed environments and to select among them the most stable under irrigated and rain fed environments

Materials and Methods

The experiment was carried during two seasons of 2016 and 2017 at four locations. Two locations were under irrigation and two under rain fed conditions. The irrigated sites were Wad Medaniand Suki, while the rain fed sites were Gedarif and Damazin. The genotypes tested under both irrigation and rain fed environments were W625,Maroa,Pro 4450,W 02W,Mena, W638 and Muzdalifa while Tabat, Wad Ahmed and HD-2 were used as checks.Land was prepared by disc ploughing, disc harrowing, leveling and ridging at the irrigated sites and by the wide level disc and ridging at the rain-fed sites. The design used at each site and season was a randomized complete block with four replications. Sowing was at the first week of July under irrigation and the first to the third week of July under rain fed conditions depending on the onset of the rainfall.

Under irrigation, the entries were sown to five rows, 5 m length on ridges of 0.8 m apart at 0.3 m intra row spacing and thinned to three seedlings per hill. Under rain fed conditions, they were also sown to five rows 5 m length, on flat at 0.8 m apart at 0.2 m intra row spacing and thinned to two seedlings per hill. In either season, urea at a rate of 80 kg and 40 kg /fed was applied under irrigation and rain fed sites respectively. Thinning to three and two seedlings per hill (for irrigated and rain fed sites respectively) was carried two to three weeks after emergence at each site during each season. Other cultural practices such as irrigation, weeding etc. were carried as recommended. The net harvested area at each site and season was three rows x 5 m length x 0.8 m for grain yield and 1 m length x 0.8 m x 3 rows for Stover. The data recorded at each site and season was; days to 50% flowering, panicle length, plant height; grain yield, Stover yield and 100 grain mass. The experiments for studying the distinction, uniformity and stability were run at the Gezira research station in season 2016-2017 to study the distinguished characters, the stability and the uniformity of the most promising genotypes. The Chemical analysis and the kisra (baking) quality tests were carried for the most promising genotypes. Samples of different genotypes were subjected to physical and proximate chemical analyses. Data were analyzed by IRRISTAT 2005 for separate seasons. Combined and stability analysis were also carried for both irrigated and rain-fed environments according to AMMI model (Gauch and Zobel, 1988 and Nachit *et al.*, 1992).

Results and Discussion

Stability and adaptability

Grain yield at the irrigated sites showed significant differences among the tested genotypes except at Medani in the first season (Table 1).This trait at Wad Medani ranged from (2.0-3.3 t/ha) in first season, from (2.4-4.17 t/ha) in the second season, while at Suki it ranged from (3.8-5.9 t/ha) to (1.1-2.6 t/ha) for the first and second seasons respectively (Table1). From the combined analysis, there were also significant differences between the tested genotypes for grain yield. Genotypes W638 showed the highest grain yield (3.6 t/ha) followed by Mena (3.2t/ha). From these results, it was found that, both W638 and Mena out yielded all other genotypes including the three checks. They also had a mean grain yield greater than the general mean of the irrigated sites (2.9 t/ha) (Table 1). At the rain fed sites, in both seasons there were significant differences among the tested genotypes ($P \leq 0.01$) as presented in (Table 1). The combined analysis showed that, there were significant differences among genotypes for grain yield. Similar results were reported by Elasha and Mohammed (2022), they found significant differences among sorghum hybrids over all environments. The genotypes Maroa and W. Ahmed had highest grain yield which was 2 t/ha. Maroa out yielded the two checks, HD-2 and Tabat and was comparable in grain yield to W. Ahmed and have a mean yield greater than the general mean of the rain fed sites which is 1.7 t/ha (Table 1).

Table 1.Mean of grain yield (t/ha) of ten sorghum genotypes evaluated over eight environments during season 2016 and 2017.

Site	Irrigated environments					Rain fed environments				
	Medani		Suki			Gedarif		Damazin		
	2016	2017	2016	2017	Mean	2016	2017	2016	2017	Mean
1. W625	2.65	2.00	3.8	1.7	2.5	1.05	1.95	1.9	1.14	1.5
2.Maroa	2.65	1.90	4.8	1.8	2.8	1.7	1.73	2.9	1.54	2.0
3.Pro 4450	2.67	2.43	4.3	1.2	2.7	1.8	1.82	3.0	0.83	1.9
4.W02W	2.87	1.49	4.9	2.3	2.9	1.5	2.04	2.3	1.46	1.8
5.Mena	2.95	2.89	4.3	2.6	3.2	1.3	2.01	2.9	0.85	1.8
6.W638	2.0	4.17	5.9	2.4	3.6	0.94	2.05	2.5	1.05	1.6
7.Muzdalifa	2.52	2.34	5.0	1.8	2.9	1.4	1.50	2.4	0.88	1.5
8.HD-2	2.8	2.46	5.2	1.1	2.9	1.5	0.0	3.0	0.61	1.3
9.TABAT	2.8	1.83	4.3	2.1	2.8	0.46	1.97	2.7	1.70	1.7
10.WAhmed	3.32	1.56	5.0	2.5	3.1	1.6	1.73	2.7	2.03	2.0
Mean	2.73	2.31	4.76	1.97	2.9	1.33	1.68	2.64	1.21	1.7
SE±	0.32ns	0.38*	0.36*	0.18*	0.27*	0.09**	0.06**	0.19**	0.09*	0.22**
CV%	23.8	32.9	15.0	17.8	18.3	9.6	6.8	14.5	14.1	23.9

*, **,*** significant at 0.05, 0.01 and 0.001 probability level, respectively

The combined analysis of variance according to the AMMI model is presented in (Table 2). Highly significant differences were observed for environments (E), genotypes (G) and their interactions GEI ($P \leq 0.01$), Same results were reported by (Mohamed *et al.*, 2022),who studied grain yield stability in sorghum. From total sum of squares due to treatments (G+ E+GEI), 83.3% of the variance was due to (E), the GEI accounted for 14.3%, while the genotypes explained only 2.3%. The partitioning of GE interaction through AMMI model analysis revealed that, the three terms (PCA1, PCA2 and PCA3) were significant and explained 49.7 %, 23.7% and 14.3% of variation due to GE interaction sum of squares, respectively (Table 7). Together, they accounted for 99.9% of GEI sum of squares and most of variation was explained by the first two principal component axes (PCA1 and PCA2).

Table 2. AMMI analysis of variance of the significant effects of genotypes (G), environments (E) and genotype-environments interaction (GE) on grain yield (t/h) and the partitioning of GE into AMMI scores.

Source	df	SS	MS	F	Efficiency%
Total	319	477.5	1.497		
Treatments	79	420.1	5.317	0.00000	
Genotypes	9	9.7	1.076***	0.00001	2.3
Environments	7	350.3	50.044***	0.00000	83.3
Block	24	7.7	0.322	0.10819	
Interactions	63	60.1	0.954***	0.00000	14.3
IPCA	15	29.9	1.996***	0.00000	49.7
IPCA	13	14.3	1.099***	0.00000	23.7
IPCA	11	8.6	0.779***	0.00024	14.3
Residuals	24	7.3	.303	0.15506	
Error	216	49.7	0.230		

*, **,*** significant at 0.05, 0.01 and 0.001 probability level, respectively

AMMI bi-plot of the first two principal components axes (PCA1 and PCA2) which usually showed stability of the genotypes across environments in term of principal component analysis and is used to identify adapted genotypes having stable performance across sites or under specific location. In this study, the first two principal components axes (PCA1 and PCA2) explained 73.4% of the total GE sum of squares (Fig.1and Table3). The genotypes Mena (2.5 t/ha) and W638 (2.6 t/ha) had mean grain yield more than the two checks HD-2 and Tabat and comparable to the check W. Ahmed (2.5 t/ha). Both genotypes (Mena and W638) were stable.

Table 3. PCA1 And PCA2 scores for yield of ten selected sorghum genotypes evaluated in eight environment

Genotype	NG	Gm	IPCAg[1]	IPCAg[2]	IPCAg[3]
G1	1	2.016	0.23857	0.19195	-0.48680
G2	2	2.386	0.27573	-0.23562	0.21494
G3	3	2.269	-0.06248	-0.75677	-0.37415
G4	4	2.362	0.45859	0.17243	0.36555
G5	5	2.494	-0.17701	0.17810	-0.67428
G6	6	2.653	-1.26924	0.53261	0.25057
G7	7	2.238	-0.21398	-0.08096	0.30644
G8	8	2.309	-0.31354	-0.74174	0.20692
G9	9	2.236	0.39510	0.52736	-0.24702
G10	10	2.558	0.66825	0.21264	0.43784

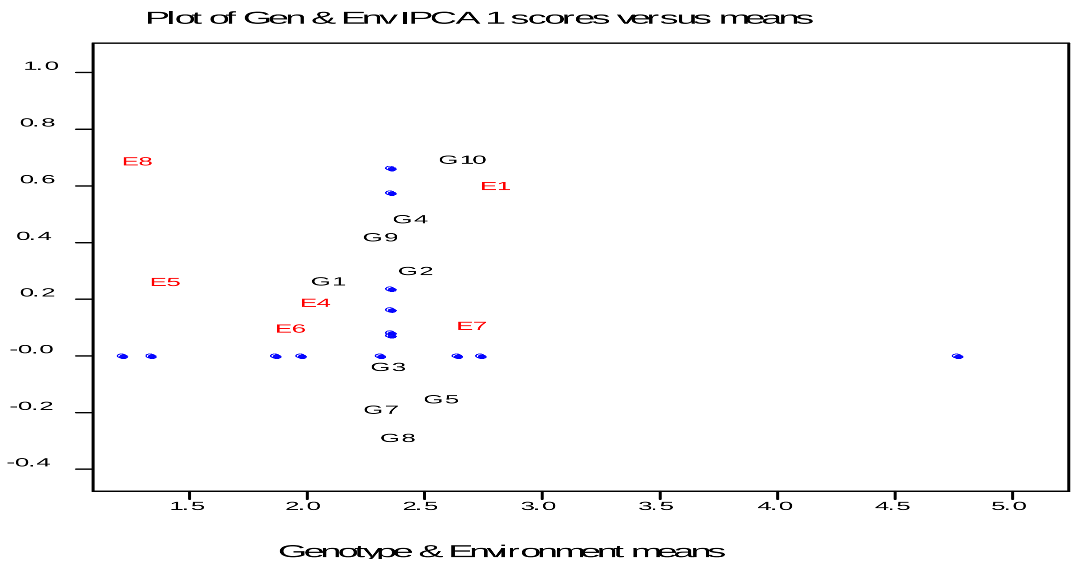

Fig.1. The AMMI bi plot of the main and PCA1 effects of both genotypes and environments on grain yield Of eight sorghum genotypes grown at eight environments during 2016 and 2017.

The best four genotypes selected according to AMMI estimate among all environments were genotypes Mena as was selected 5 times out of eight environments, genotype W638 as was selected 3 times out of four irrigated environments and genotype Maroa as was selected three times in four rain fed environments (Table 4). From the above results, the stable genotypes for grain yield were genotypes Mena and W63under irrigated conditions, also they had a mean grain yield of (3.2 t/ha) and (3.6 t/ha) compared to the general mean of the irrigated environments (2 t/ha), and genotype Maroa also had a mean grain yield of 2 t/ha higher than the two checks Tabat (1.7 t/ha) and HD-2 (1.3 t/ha) and comparable to W. Ahmed (2 t/ha) and had mean grain yield higher than the general mean of the rain fed environments.

Table 4.The best four genotypes in each environment for grin yield according to AMMI selections.

Number	Environment	Mean	Score	1	2	3	4
8	E8	1.211	0.6628	G10	G4	G9	G2
1	E1	2.735	0.5757	G10	G2	G4	G5
5	E5	1.332	0.2369	G8	G3	G2	G10
4	E4	1.971	0.1632	G6	G10	G9	G5
7	E7	2.635	0.0818	G3	G8	G5	G2
6	E6	1.863	0.0724	G5	G6	G10	G9
3	E3	4.761	-0.5333	G6	G8	G7	G10
2	E2	2.308	-1.2595	G6	G5	G8	G3

Conclusion

Seven sorghum genotypes were evaluated across four locations for two year (eight environments) to study Genotype x Environment interaction and yield stability. Genotypes W638 and Mena gave higher grain yield (3.6 t/ha) and (3.2 t/ha) compared to all checks and had mean grain yield higher than the overall mean (2.9 t/ha) and performed consistently well across the irrigated environments indicating good stability and adaptability under irrigated conditions. Genotype Maroa had higher grain yield (2 t/ha) compared to the two checks Tabat and HD-2 and had mean yield above than the general mean (1.7 t/ha) of the rain fed environments, indicating its stability under rain fed conditions.

References

Belum**,** V.S.; Reddy, R.S.; Sanjana, R.P. (2004). Sorghum Breeding Research at ICRISAT – Goals, Strategies, Methods.

Doggett**,** H; Parsada, Rao K.E. (1995). In Smartt J. and Simmonds N.W. (eds), Evolution of Crops Plants, 2nded, Longman, UK, pp. 173-180.

Doggett, H. (1988). Sorghum. Longman, London. 2ndedition. 512 pp.

Elasha, A., I.N.; Elzein, A.H.A. ; Assar, M.K.; Hassan, A.E.; Hassan, O.M. ; Elhassan, A.A. Elmustafa; H.A. Hassan (2011). A proposal for sorghum (*Sorghum bicolor (L.) Moench*) hybrids release for irrigated and rain- fed sectors of the Sudan.

Elasha, E.A.; Mohammed, M.H. (2022). Evaluation of grain sorghum hybrids *(sorghum bicolorL. Moench)* for use under rain fed conditions of Sudan. Gezira. J. of Agric. Science. Accepted paper (2022).

Elzein.I.N., Ahmed.T.E., Elasha.E.A., Mohamed.E.I., (2007). A proposal for the release of short maturing sorghum genotypes for drought prone areas of the Sudan. National Variety Release committee, Khartoum, Sudan.

FAO, (1995). Production Yearbook.Vol.49. FAO, Rome, Italy.

Finlay, K.W.; Wilkinson, G.N. (1963). The analysis of adaptation in plant breeding programs. Aust. J. Agric. Res. Vo.14: pp.742-54.

Gauch, H.G; Zobel, W.R. (1988). Predictive and postidictive success of statistical analysis of yield trials; Theoretical and Applied Genetics 76: 1-10.

ICRISAT (International Crops Research Institute for the Semi – Arid Tropics); and FAO. (Food and Agricultural Organization of the United Nations) (1996). Part I, sorghum, pp. 5-27. In: The world sorghum and millet economics: facts, trends and outlook.

IRRI.(2005).IRRISTAT for windows © 1998-2005.International Rice Research Institute, DAPO, Box 7777, Metro Manila, Philippines.

Mohamed, AH.; Gamar, Y.A.; Elgada, M.H.; Elhassan, O.M. (2009). Aproposal for the release of two early maturing high yielding and Drought tolerant sorghum genotypes. Wad Medani, Sudan.

Mohammed, M.H.; Elasha E.A.; Hassan, A E. ; Elmustafa, E.A.; Eltahir.A. (2018). Aproposal of sorghum (*Sorghum bicolor (L.)Moench)* hybrids release for irrigated and rain-fed sectors of the Sudan. National Variety Release Committee, Khartoum, Sudan,

Nachit, M.M.G; Nachit, H.K; Guach Zobel, RW.(1992). Use of AMMI and liner regression models to analyze genotype x environment interaction in durum Wheat. Theoretical and Applied genetics 83:597-601.

Ibrahim, O.E.; Elzein, I.N.; Babikir, E.A.; Suliman, I.A. (1996). Evaluation of the improved sorghum varieties and hybrids for yield potential, stability and quality, under Sudan irrigated and rainfed conditions. Proceedings of Sudan National Variety Release Committee, ARC, Wad Medani, Sudan.

Ibrahim, O.E; Mahmoud, M.A. (1992). Improved sorghum genotypes suitable for irrigated and rain-fed land of Sudan; Proceedings of Sudan National Variety Release Committee. Wad Medani, Sudan.

Nile Valley University Publications
Nile Journal for Agricultural Sciences (NJAS)
(ISSN: 1585 – 5507)
Volume 08, No. 01, 2023
http://www.nilevalley.edu.sd

Organic Farming for Producing Tomato (*Solanumlycopersicum L.*) in clay Soils of Gezira, Sudan

Elfatih Elaagib[1], Wisal H.[2] Ahlam E.[1]., Sara K.[2], Ali E.[3], and Abdelmagid A.[3]
1Land and Water Research Centre, ARC, Sudan
2 Horticulture Research Centre, ARC, Sudan
3 Plant Protection Research Centre, ARC, Sudan
Correspondent author: email: elfatihelaagib@gmail.com; Phone +249 123298459

Abstract

Fields experiments were carried out for two consecutive seasons (2014/15 and 2015/16) at Gezira Research Station Farm. The main objective was to evaluate the effects of farm yard manure (0, 5 and 10 ton/ha), repellent plant (coriander) and Thiovit Jet 80% Wettable (0 and 8.8 gram per liter) as an elemental sulfur for controlling the powdery mildew on organic tomato production. The treatments were arranged in split split and split plot design replicated three times in the first and second season, respectively. The results showed that the repellent plant numerically increased the marketable yield of tomato in the first season by 87% and significantly by 46% in the second season. Tomato grown with repellent plant recorded the high marketable yield in the two seasons. The addition of 5 ton/ha of farm yard manure recorded the high marketable yield (3359 kg/ha) in the first season while application of 10 tons FYM gave the high yield (7466 kg/ha) in the second season. However, the addition of sulfur resulted in insignificant effect on all the studied traits of tomato and this may be attributed to its late application which was at fruit setting stage. The repellent plant significantly increased the number of branches per plant in the first season and only numerical increase in the second season, whereas both doses of FYM only recorded a slight increase in the plant height in the second season. The interaction between the three studied factors on all tomato traits was not significant except for the number of branches and the percent of the total soluble solids in the first season. Also a significant interaction was obtained between farm yard manure and sulfur which was reflected in plant height and sun scald where that between repellent plant and farm yard manure was shown in the percent of total soluble solids.

Key words: farm yard manure, repellent plant, elemental sulfur, organic farming, organic tomato

الزراعةالعضوية لانتاج الطماطم في الترب الطينية بالجزيرة، السودان

الفاتح العاقب[1]، وصال مكي[2]، احلام السماني[1]، سارة خليل[2]، علي البدوي[3]، عبد الماجد عدلان[3]

1 مركز بحوث الاراضي والمياه، هيئة البحوث الزراعية، السودان
2 مركز بحوث البساتين هيئة البحوث الزراعية، السودان
3 مركز بحوث وقاية النباتات هيئة البحوث الزراعية، السودان
ممثل الباحثين: email: elfatihelaagib@gmail.com; Phone +249 123298459

المستخلص

نفذت تجارب حقلية لموسمين متتالين (15/2014 و 16/2015) في المزرعة البحثية لمحطة بحوث الجزيرة بهدف تقييم تاثير روث الابقار (صفر، 5 و 10 طن/هكتار)، نبات طارد للحشرات(كسبرة) و الكبريت العضوي (صفر و 8.8 جم/لتر) للتحكم في مرض البياض الدقيقي وذلك لانتاج طماطم عضوية. نظمت التجارب في نظام القطع المنشقة – المنشقة في ثلاث مكررات في الموسم الاول. وضع نبات الكسبرة في الاحواض الرئيسية، روث الابقار في الاحواض المنشقة والكبريت في الاحواض المنشقة-المنشقة. لم تتم اضافة الكبريت في الموسم الثاني، عليه وضع نبات الكسبرة في الاحواض الرئيسية وروث الابقار في الاحواض المنشقة.اشارت النتائج لزيادة رقمية (غير معنوية) في انتاج الطماطم التسويقي في الموسم الاول بلغت 86% وفي الموسم الثاني بزيادة معنوية بلغت 46%.سجلت الطماطم المنتجة في معية نبات الكسبرة انتاج تسويقي عالي في الموسمين المتتاليين. كما سجلت اضافة 5 طن روث ابقار/هكتار انتاج تسويقي عالي بلغ 3359 كجم طماطم/هكتار في الموسم الاول، بينما سجلت اضافة 10 طن روث ابقار/هكتار انتاجية عالية بلغت 7466 كجم طماطم/هكتار في الموسم الثاني. ولكن لم تسجل اضافة الكبريت المعدني اي زيادة معنوية في انتاج الطماطم في كل الصفات التي درست. هذا وقد سجلت معية نبات الكسبرة في وجود روث الابقار زيادة معنوية في عدد الفروع لنبات الطماطم في الموسم الاول وزيادة رقمية (غير معنوية) في طول النبات في الموسمين. وهذا ولم تسجل اي من جرعتي روث الابقار اي زيادة معنوية في كل الصفات التي درست ما عدا زيادة طفيفة جدا في طول النبات في الموسم الثاني. لم يكن التفاعل بين العوامل الثلاثة (روث الابقار، نبات الكسبرة والكبريت) اي زيادة معنوية في كل الصفات التي درست الا في كل من عدد الفروع للنبات والمواد الصلبة الزائبة في الموسم الاول. كما كان هنالك تاثير معنوي للتفاعل بين نبات الكسبرة وروث الابقار علي النسبة المئوية للمواد الصلبة الذائبة.

كلمات مفتاحية:روث الابقار، نبات طارد للحشرات، الكبريت العنصري، الزراعة العضوية، طماطم عضوية

Introduction

Tomato (*Solanumlycopersicum* L.) is widely cultivated vegetable crop in the world. It is an important cash crop for smallholders and medium scale commercial farmers (Naika*et al.*, 2005). Tomato is considered as one of the most important vegetables in Sudan due to its economic and nutritional values, it occupies about 28% of the total area of vegetables in Sudan which produces about 950 thousand tons of tomatoes per year (Mohammed 2009).Tomatoes prefer light textured soils with optimum pH ranges from 6.0 to 7.5 and the crop is most sensitive to salinity particularly at germination stage and the yield reduction is 25% at 5 dS/m (SYS, 1993).Nitrogen, phosphorus and potassium are critical nutrient elements for tomato growth and development. Nitrogen is associated with vegetative growth and biomass accumulation, phosphorus to seed and root development, while potassium is associated with fruit development and quality (Jones, 2008). Tomato is considered a crop with major fertilization requirements. It is considered as the second important significant vegetable crop in the world after onion. Tomato contains valuable vitamins, for instance vitamins A and C and also it contains fibers, and is known as free from cholesterol. At present, tomatoes are utilized at a higher rate in the developed countries than in the developing countries (Badr *et al.*, 2010). The main producing areas of tomato in Sudan are: Gezira, Khartoum, Kassala, Gadarif, Sennar and the Blue Nile States.

Organic farming is a production system that avoids the use of chemical fertilizers, pesticides and growth regulating hormones. Tomato crop is raisedby the use of organic manures; crop rotation; legumes, green manure and biological pest control (Panda, 2011). Different vegetable crops are produced in the Sudan using the conventional system which allows the use of chemical compounds. Recently, world - wide, more attention has been given to organic farming.This kind of agriculture sustains the health of soils, ecosystems and people (human beings). Organic farming is considered as a result of the increasing global health awareness, which necessitates a high need for finding other options for producing safety products and at the same time keeps the soil environment healthy. As known, these products can only be accepted and marked as organic if they are produced under soils not treated with chemical compounds for at least three years.The United States Composting Council (USCC) (2008) stated that humus provides plant nutrients, beneficial microorganisms; improves soil structure, water holding capacity and stabilized soil pH; helps to control weeds, pests and diseases, and the soil to resist erosion by wind and water. Panda (2011) stated that the various benefits of organic farming are: a) organic food is normally priced 20-30% higher than conventional food; b) it does not involve capital investment as high as that required in chemical farming; c) farmers have a wealth of traditional knowledge that can be used in this kind of agriculture rather than for chemical farming.

Production of organic vegetables in the Gezira is lacking. Generally, organic agriculture is of low cost, more profitable, and safe to the environment compared to the conventional system. Tomato is very important for human nutrition and mostly consumed directly after harvest without cooking and for this reason it is better to be produced under organic system rather than under conventional system. Most of the soils in the Sudan are deficient in nitrogen and available phosphorus and have low contents of organic matter. Therefore, addition of different organic manures to these soils is expected to improve their chemical fertility, increase the moisture retention and water percolation, decrease the soil bulk density, enhance root penetration and encourage the overall plant growth.

Pests are the main constraint facing tomato production in the Sudan and farmers mostly rely on chemical pesticides for the control of these pests. However, the abuse of pesticidesis becoming a human concern. Now the tendency is to use non-chemical measures such as botanical materials and cultural practices for the management of the pests.

The main objectives of the study were to:

- Assess the effect of farm yard manure, coriander (as a repellent plant) and sulfur on growth and productivity of organic tomato.
- Reduce the use of synthetic chemical compounds.
- Improve the physical, chemical and biological properties of the soil.
- Avail healthy and safety organic tomato for human consumption.

Materials and methods

The experiments were conducted for two consecutive seasons at Gezira Research Station farm (2014/15 and 2015/16). Soil samples were collected from four depths (0 – 25, 25 – 50, 50 – 75 and 75 – 100 cm) for routine analysis. In the first season, the treatments were consisted of three levels of farm yard manure (FYM): 0, 5 and 10 t/ha; two rates of sulfur (S):0 and 8.8 gram per liter; the trade name of the used sulfur is Thiovit Jet 80% Wettable Granule. It is a fungicide for controlling the powdery mildew. The combinations of the two factors (FYM and S) were evaluated under two conditions; with or without coriander (*Corianderum sativium*L) which was used as a repellent plant (RP). The treatments were arranged in split split plot design replicated three times in the first season; the main plots, sub plots and sub - sub plots were assigned to RP, FYM and S, respectively. In the second season, RP was assigned to main plots whereas FYM to sub plots and S was not used. A trench was manually made on the top of the two sides of each bed (140 cm apart), then the FYM was added and covered with soil before transplanting of tomato seedlings. Seeds of tomato (Joddy variety) were sown on 17/11/2014under the supervision of Central Trading Company in Khartoum and transplanting of seedlings was on 27.12.2014 and on 21/12/2015 in the second season. The seedlings were spaced at 50 cm on each side of the bed. The coriander was sown three weeks before transplanting of tomato seedlings; whereas sulfur was only applied in the first season on 18/2/2015 (at fruit setting). Data were collected on plant height, number of branches per plant, percent of total soluble solids (%TSS) and yield of tomato which included the marketable and none marketable yields. None marketable yield consists of fruits infested by blossom end rot, sun scald, insects and culls.

Results and discussion

The soil of the experimental site is none saline and slightly sodic at the top 50 cm. It has clay texture, alkaline reaction and low nitrogen content, organic carbon and available phosphorus. Generally, the soil bulk density is high especially in 25 –50 cm (1.9 g/cm^3) and 75 – 100 cm (1.91 g/cm^3) soil depths. In the first depth (25-50 cm), the high bulk density may be attributed to plowing at a fixed depth (20-25 cm) for a long time especially when the soil was moist, whereas the high values of bulk density below 75 cm are presumably attributed to overburden. Generally, the soil is classified as fine, smectitc, super activeisohyperthermic, TypicHaplusterts and was correlated to Remaitab none sodic soil series.

Table (1): Some physical and chemical soil properties of the experimental site

Soil property	Soil depth (cm)			
	0 - 25	25–50	50– 75	75 – 100
% Sand	8	10	7	8
% Silt	44	26	25	31
% Clay	48	64	68	61
pH (paste)	8.4	8.7	8.1	8.1
EC (dS/m)	0.7	2.0	0.9	0.5
ESP	14	15	2	3
% N	0.080	0.040	0.172	0.218
% O.C	0.250	0.281	0.125	0.125
CEC (cmol (+)/ kg soil	54	50	54	51
Avail P (ppm)	4.6	7.2	5.2	6.0
Soil bulk density (g/cm^3)	1.85	1.90	1.86	1.91

The data of the main effect of repellent plant and farm yard manure in the two seasons and sulfur in first season on marketable yield, blossom end rot, sun scald and culls of tomato fruits are displayed in Tables (2, 3 and 4), respectively. The data in Table 2 showed that the repellent plant numerically increased the marketable yield of tomato from 1525 to 2845 kg/ha which was equivalent to87%, whereas in the second season, it statistically significantly increased the marketable yield by 46% (i.e. from 4748 to 6926 kg/ha). This high increment indicated the effect of the repellent plant in promoting and increasing the production of marketable organic tomato. It was observed that tomato grown under repellent plant recorded the higher marketable yield in the two seasons compared to that without repellent plant. The effect of repellent plant was significant on blossom end rot, sun scald, culls in the first season, significant on the marketable yield in the second season (Table 2).

Table (2): Effect of repellent plant on tomato (kg/ha) marketable yield, blossom end rot, sun scald and culls (2014/15 and 2015/16)

Treatment	Marketable yield	Blossom end rot	Sun scald	Culls	Marketable yield	Blossom end rot	Sun scald	Culls
	Season 2014/15				Season 2015/16			
With RP	2845	2864	753	1641	6926	165.1	956	6425
Without RP	1525	1458	471	799	4748	146.9	804	5102
S.E±	493	102	31	234	482.4	56.7	216.7	1181.5
Sig.	NS	*	*	*	*	NS	NS	NS
C.V	17	31	35	34	16.9	36.2	24.6	20.5

*, **, *** and NS indicated significance at ($P \leq 0.05$), ($P \leq 0.01$), ($P \leq 0.001$) and not significant, respectively. RP = repellent plant.

The farm yard manure in the first season significantly increased the culls whereas in the second season it significantly increased the marketable yield, blossom end rot, sun scald and culls. Generally, the positive influence of farm yard manure on crop production was reported by Elaagib (2007) Ibrahim *et al*(2002) and Elghball (2002). In this context Ali (1998) found that the use of organic manures is highly encouraged for sustainable agriculture and conservation of soil fertility. Also the benefits of compost for plant production and soil properties were reported by Kassim and Ali (1989).

The data in Table (3) indicated that the addition of 5 tons FYM/ha in the first season numerically increased each of the marketable yield of tomato, blossom end rot and sun scald over their respective values of the addition of 10 tons FYM/ha, whereas the increase of culls was significant ($P \leq 0.05$). These results are rather difficult to justify because it is generally known that an increase in addition of FYM is usually associated with an increase of water holding capacity, soil aeration (reduction of soil bulk density), good root penetration and ramification and plant nutrients. However, these results were completely reversed in the second season because the addition of 10 tons FYM/ha invariably and statistically increased each of the marketable yield of tomato, blossom end rot, sun scald and culls over their respective values of the addition of 5 tons FYM/ha.

Table (3): Effect of FYM (ton/ha) on marketable yield of tomato (kg/ha), blossom end rot, sun scald and culls (2014/15 and 2015/16).

FYM (ton/ha)	Marketable yield	Blossom end rot	Sun scald	Culls	Marketable yield	Blossom end rot	Sun scald	Culls
	Season 2014/15				Season 2015/16			
0	1260	1593	433	863	3833	80.5	661	3537
5	3359	2751	731	1603	6212	156.3	905	5796
10	1937	2138	672	1194	7466	231.2	1074	7957
S.E±	504	386	112	244	342.9	46.73	276	1186.3
Sig.	NS	NS	NS	*	***	***	*	***
C.V	17	31	35	34	16.6	30	31.4	20.6

*, ***, NS = Significant at $P \leq 0.5$, $P \leq 0.001$ and not significant, respectively.

The data in Table 4 showed the insignificant effect of sulfur on the four studied traits in the first season and this might be attributed to the late application of sulfur at fruit setting stage of tomato.

Table (4): Main effect of sulfur on tomato marketable yield, blossom end rot, sun scalds and culls, season 2014/15.

Treatment)	Marketable Yield (kg/ha)	Blossom end rot (kg/ha)	Sun scald (kg/ha)	Culls (kg/ha)
Sulfur (8.8 g/l)	2194	2180	599	1180
Without sulfur	2176	2141	623	1260
S.E±	87	157	50	99
Level of Sig.	NS	NS	NS	NS
%C.V	17	31	35	34

NS = Not significant.

The data of the effect of the three studied factors RP, FYM and sulfur on tomato 50% flowering, plant height, number of branches per plant and percentage of total soluble solids (TSS %) are presented in Tables (5, 6 and 7), respectively. As is evident from Table (5) the repellent plant had only significant increase in the number of branches per plant in the first season.

Table (5): Effect of repellent plant on fruits of tomato, 50% flowering, plant height (cm), branches/plant and TSS%, (2014/15 and 2015/16).

Treatment	50% Flowering	Plant height	Branches per plant	TSS %	50% Flowering	Plant height	Branches per plant	TSS %
	Season 2014/15				Season 2015/16			
With RP	38	44.5	11	3.8	47.04	60.83	4	3.4
Without RP	40	42.8	9	4.1	47.50	56.49	4	3.4
S.E±	0.3	0.7	0.2	0.1	0.274	3.33	0.19	0.064
Sig.	NS	NS	*	NS	NS	NS	NS	NS
C.V	3	8	13	22	1.2	5.7	4.7	1.9

*, NS = Significant at P ≤ 0.5, and not significant, respectively

The data in Table (6) revealed that the control treatment in season 2014/15 invariably gave higher values of each of 50% flowering, plant height and number of branches /plant than their respective values of the 5 tons/ha and 10 tons/ha treatments. However, in season two the control treatment only recorded higher values of 50% flowering and number of branches/plant over their corresponding values of the 5 tons FYM/ha and 10 tons FYM/ha treatments. It was observed that for all the studied traits the data of 5 tons FYM/ha and the 10 tons FYM/ha were very comparable implying the futility of applying 10 tons FYM/ha.

Table (6): Effect of FYM (ton/ha) on tomato 50% flowering, plant height (cm), branches/plant and TSS%, (2014/15 and 2015/16).

FYM (ton/ha)	50% Flowering	Plant height	Branches per plant	TSS%	50% Flowering	Plant height	Branches per plant	TSS%
	Season 2014/15				Season 2015/16			
0	40	45.3	11	4	48.69	58.6	4.1	3.4
5	38	43.0	9	4	46.75	58.7	3.8	3.5
10	38	42.7	10	4	46.38	58.7	4.0	3.4
S.E±	0.6	1.1	0.3	0.1	0.323	3.03	0.32	0.17
Sig.	NS	NS	*	NS	***	NS	NS	NS
C.V	3	8	13	22	1.9	5.2	8.0	5.1

*, ***, NS = Significant at P ≤ 0.5, P ≤ 0.001 and not significant, respectively.

The effect of sulfur in the first season (2014/15) on 50% flowering, plant height, number of branches per plant and %TSS was not significant (Table 7).

Table (7):Effect of sulfur on traits of tomato (50% flowering, plant height, number of branches/plant and %TSS) season 2014/15

Treatment)	50% Flowering (days)	Plant height (cm)	No. of branches/plant	TSS (%)
Sulfur (8.8 g/l)	39	43.5	11	4.1
Without sulfur	39	43.9	10	3.9
S.E±	0.3	0.9	0.3	0.2
Level of Sig.	NS	NS	NS	NS
%C.V	3	8	13	22

NS = Not significant

A significant (P ≤ 0.05) interaction between RP, FYM and S was reflected in the number of branches per plant and %TSS in the first season (Table 8).

Table (8): Effect of repellent plant, farm yard manure and sulfur on traits of tomato (number of branches/plant and %TSS), season 2014/15

Repellent plant	CFYM	Sulfur (g/l)	Branches/plant	TSS (%)
With repellent plant	0	0	12	4.0
		8.8	13	3.3
	5	0	11	4.0
		8.8	9	4.3
	10	0	11	4.0
		8.8	11	3.3
Without repellent plant	0	0	12	3.3
		8.8	9	5.3
	5	0	8	4.3
		8.8	8	3.3
	10	0	10	4.7
		8.8	8	4.
SE±			0.7	0.5
Level of Sig.			*	*
%C.V			13	22

* = Significant at P ≤ 0.05

Also a significant (P ≤ 0.05) interaction was observed between FYM and S in plant height and tomato fruits damaged by sun scald (Table 9), and between RP and FYM in the %TSS (Table 10).

Table (9):Effect of farm yard manure and sulfur on sun scald and plant height of tomato, season 2014/15

CFYM (t/ha)	Sulfur (g/l)	Sun scald (kg/ha)	Plant height (cm)
0	0	449	42.3
	8.8	417	48.3
5	0	572	44.1
	8.8	889	41.8
10	0	778	43.9
	8.8	566	41.5
SE±		86	1.5
Level of Sig.		*	*
%C.V		35	8

* = Significant at P ≤ 0.05

Table (10): Effect of repellent plant and farm yard manure on tomato TSS (%), season 2014/15

Repellent plant	CFYM (t/ha)	TSS (%)
With RP	0	3.7
	5	4.2
	10	3.7
Without RP	0	4.3
	5	3.8
	10	4.3
SE±		0.17
Level of Sig.		*
%C.V		22

* = Significant at P ≤ 0.05

Conclusions

1. Tomato grown with repellent plant (coriander) recorded the high marketable yields.
2. The insignificant effect of sulfur on all studied traits of tomato may be attributed to its late application at fruit setting stage.
3. Addition of 5 tons/ha of FYM was seemed to be quite enough for producing organic tomato in the soil under investigation.
4. The results revealed the possibility of producing organic tomato in Gezira Vertisols.
5. The interactions between the three studied factors on all tomato traits were not significant except for the number of branches and TSS.
6. Since the application of any chemical compounds is not allowed in the organic farming, therefore for successful and sustainable organic production of tomato, the following points shall be considered:

- Transplanting of tomato seedlings is recommended at the end of October or first week of November.
- Good selection of a uniform site that not infested by weeds especially noxious weeds such as Ankog and Nageila.

Recommendation

Based on the results of the present study, the application of 5 tons of FYM/ha coupled with growth of coriander as a repellent plant are recommended for production of organic tomato under the Remaitab none sodic phase of the Gezira Vertisols only on very small farms because huge quantities of FYM for large farms at present are unattainable in Sudan.

References

Ali, N, A. (1998). Organic fertilization in Sudan. Paper presented in the first scientific colloquium (19-20 Oct. 1998), Land and Water Research Centre, Agricultural Corporation, Wad Medani, Sudan.

Badr, M.A.; Abou Hussein, S.D.; ElTohamy, W.A.; Gruda, N. (2010).Nutrient uptake and yield of tomato under various methods of fertilizer application and levels of fertigation in arid lands.GesundePflanzen 62(1):11-19.

SYS, C., E.*Van Ranst*, J., Debaveye and F. Beernaert(1993). Land evaluation, part three, crop requirements. Published by the international training centre (ITC) for post graduate soil scientists, University of Gent.

Elghball, B (2002). Soil properties as influenced by phosphorus-and nitrogen- based manure and compost application. Agrn. J. 94: 128-135.

Elaagib, E. (2007). PhD thesis entitled: wheat grain yield on Mukabrab soil series as affected by disc ploughing, chiseling, farm yard manure and nitrogen. Faculty of Agricultural Sciences, Gezira University Sudan.

Ibrahim, S. H.: Mohamed A. B.: Osman, H. N.;Hashim, A. A. (2002). Fertilizing with urea and farm yard manure for higher cotton yields and better soil conditions in the Gezira. Paper presented in the national crop husbandry committee meeting, Agricultural Corporation, Wad Medani, Sudan.

Jones, J.B. (2008). Tomato Plant Culture: In the Field, Greenhouse, and Home Garden. Second Edition.CRC Press Taylor & Francis Group. Florida. USA. 399 pp

Kassim, G. M.: Ali, M. A. (1989). Soil microbiology.Faculty of agriculture, University of Elmoseil Printing Press, Elmoseil Iraq.

Mohammed A. Seedahmed (2009). Sudanese tomatoes are ready for transformation: an efficient protocol for regeneration of a Sudanese local cultivar of tomato (*Solanum lycopersicon Var. Alla Karim*). International Journal of Biotechnology and Biochemistry ISSN 0973-2691 Volume 5 Number 3 pp 231-241,

Naika, J. vanLidt, de Jeude, M. de Goffau, Hilmi, M.; van Dam, B. (2005).Cultivation of tomato production, processing and marketing. Agromisa Foundation and CTA, Wageningen, 1–92.

Panda, S.C. (2011). Principles and practices of organic farming, AGROBIOS (INDIA), agrobios @ sify.com.

United States Composting Council (USCC).(2008). Compost and its benefits.USCC factsheet.Excerpted from the field guide to compost use, The United States Composting Council. Pp. 1-2.

Nile Valley University Publications
Nile Journal for Agricultural Sciences (NJAS)
(ISSN: 1585 – 5507)
Volume 08, No. 01, 2023
http://www.nilevalley.edu.sd

The Effects of Shelterbelts on some Climatic factors in Mechanized Rain-fed Agricultural Schemes in Ghadambaliya Area, Gedarif State-Sudan.

Moatesum Babiker Mohammed [1,2], Yasir Yousif Abdalla[2] andNazar Nasr eldeen Babiker[3]

1. Faculty of Forest Sciences and Technology – University of Gezira
2- College of Forestry and Range Science – Sudan University of Science and Technology.
3- Faculty of Agricultural Sciences – University of Gezira.
Correspondent author: Moatesum1985@gmail.com Mobile + 0249 129208776

Abstract

The study was conducted in Gedarif state, Ghdambeliya area during the period (February-March) 2022, to assess the effect of shelterbelts on soil moisture, soil temperature and evaporation, where three shelterbelts were chosen. Average heights of shelterbelts were measured to determine the distance between the belt and the sites from which soil samples were taken; distances were, 5xheight, 10xheight, 15xheight, 20xheight, 25xheight and 30xheight behind the belt, distances in front of the belt were, 2.5xheight, 5xheight and 10xheight; and one soil sample was taken from inside the belt to describe the soil between trees, and one soil sample was taken from unprotected area. The temperature was measured with a thermometer at a depth of 5 and 10 cm, also the evaporation measured by beach tube inside the belt and unprotected area. The data was subjected to analysis of variance and mean separation method using the software statstix-10 and SPSS.The results showed that the soil temperatures inside the shelterbelts were significantly lower compared to the soil temperatures in the unprotected area, also the results indicated that the soil moisture inside the shelterbelts were higher compared to the soil temperatures in the unprotected area. The result showed that the evaporation rate inside the belt was significantly reduced compared to the unprotected area.

Keywords: Shelterbelts, Evaporation, Soil moisture, Soil temperature, Gadambalyia

تأثيرات الأحزمة الشجرية على بعض العوامل المناخية بمشاريع الزراعة الآلية المطرية بمنطقة القدمبلية، ولاية القضارف-السودان

معتصم بابكر محمد [1،2] ، ياسر يوسف عبد الله[2] و نزار نصر الدين بابكر[2]

1 كلية علوم وتكنولوجيا الغابات - جامعة الجزيرة – السودان
2 كلية علوم الغابات والمراعي - جامعة السودان للعلوم و التكنولوجيا- السودان.
3 كلية العلوم الزراعية - جامعة الجزيرة – السودان
ممثل المؤلفين: **Moatesum1985@gmail.com Mobile + 0249 129208776**

المستخلص

أجريت هذه الدراسة بولاية القضارف في منطقة القدمبلية خلال الفترة من (فبراير- مارس) 2022 لإبراز أثر الأحزمة الشجرية علي رطوبة التربة، درجة حرارة التربة والتبخر. حيث تم إختيار ثلاثة أحزمة شجريةوتم قياس متوسط إرتفاع الأحزمة وذلك لتحديد المسافة بين الحزام ومواقع أخذ عينات التربة وكانتالمسافات كالآتي: 5× إرتفاع، 10×إرتفاع، 15×إرتفاع، 20×إرتفاع، 25×إرتفاع، 30×إرتفاع الحزام خلف الحزام. المسافات أمام الحزام كانت 5.2×إرتفاع، 5×إرتفاع، 10×إرتفاع الحزام و أخذت عينة من داخل الحزام لوصف التربة بين الأشجاركما اخذت عينة في منطقة غير محمية وتم تكرار هذه التجربة ثلاثة مرات في كل حزام.تم قياس درجة حرارة التربة في الموقع بميزان حرارة علي عمق 5سم و10سم. كما تم قياس التبخر داخل الحزام وفي المنطقة غير المحمية بواسطة انبوبة بيشى (beach). تم تحليل البيانات باستخدام statstix-10 وSPSS. أظهرت النتائج أن درجة حرارة التربة داخل الأحزمة الشجرية كانت أقل بشكل ملحوظ مقارنة بدرجات حرارة التربة في المنطقة غير المحمية ، كما أوضحت النتائج أن رطوبة التربة داخل الاحزمة الشجرية اعلى من رطوبة التربة في المنطقة غير المحمية. ايضاً أظهرت النتائج أن معدل التبخر داخل الحزام قد انخفض بشكل كبير مقارنة بالمنطقة غير المحمية

الكلمات المفتاحية: الأحزمة الشجرية، التبخر، درجة حرارة التربة، رطوبة التربة، القدمبلية

Introduction

The Gedaref state is the first part of the Sudan in which mechanized rain fed farming was introduced. Mechanization first started in Ghadambaliya area north of the Gedaref state then extended south and south west.(Ahmed, 2015). Shelterbelts planting began in Sudan in the forties in many locations, including Nuri in the northern State and Gundato near Shendi, and in the fifties Naishaishiaba belt was planted outside the city of Wad Medani, and in the sixties shelterbelts belts were planted outside the city of Khartoum (Green Belt), (Abdelmagid and Eiman, 2010). The shelterbelts should constitute about 10% of total mechanized farm area. Inclusion of shelterbelts in the mechanized farming system started in 1994. (Elamin and Elmadina, 2014). Shelterbelts are strips of trees, shrubs, and grasses planted in rows raised at right angle to the wind direction, to reduce wind velocity and give general protection to roads, canals, agricultural fields, woody stems, branches and thick foliage help reduce wind hazard (Nair, 1989). Shelterbelts are planted mainly for protection against the damaging effects of winds and wind-blown sands. However they have many benefits such as: Preventing soil erosion, improving the microclimate for growing crops, vegetables and fruits and sheltering people and livestock, they can also serve other functions such as fencing and boundary demarcation. Where wind is a major cause of soil erosion and moisture loss in dry areas, windbreaks can increase and sustain crop productivity. Shelterbelts may also supply wood and non-wood products. (Rocheleau *et al*.,1988). In arid regions, Shelterbelts save the moisture (from rainfall or irrigation) in the soil. Al Motawa (1985) reported that protected soil may have up to 7% more moisture than unprotected ones. He further stated that the reduction of the evapotranspiration in the shelterbelts itself or adjacent plants are usually one of the most evident effects of windbreaks not only during hot periods but alsoin cool wet ones. Reduction of wind velocity reduces evaporation from both open water surfaces and soil surfaces, particularly during seasons of high temperatures and can reduce water loss from irrigation canals and from sprinkler irrigation systems. Evaporation is the loss of water from open bodies, such as lakes, reservoirs, rivers, wetlands and bare soil, but transpiration is the loss from living plant surface. Several factors other than physical characteristics of the water, soil and plant surface are affecting the evaporation process. The more important factors include solar radiation, surface area of open bodies of water, wind speed, density and type of forest plantations, availability of soil moisture, root depth, reflected land surface characteristics and season of year. Rain is considered the main source of irrigation in mechanized rain-fed agricultural schemes in the study area, and the annual amount of rainfall is not constant and mostly insufficient for successful cropping season, and the exposure of this water to evaporation affects crop productivity.(Ahmed, 2015). Also soil moisture and soil temperature affect crop productivity, shelterbelts play a major role in this field.This area was not addressed well by previous studies, likewise in the irrigated schemes. This study can provide some information that helps farmers and decision-makers to make use of how can shelter belts benefit rain fed agriculture. The objectives of this study were to determine the effects of shelterbelts on soil temperature, soil moisture and evaporation, in rain-fed agricultural schemes in Ghadambliya Area.

Material and Methods

Features and specifications of the selectedshelter belts

Gedarif State-Sudan, under consideration, lies southeast of Khartoum. It occupies, the southern part of Kassala state in eastern Sudan. It lies between latitudes 12^o 45' N and 14^o 15' N and longitudes 34^o E and 37^o E (Approximately). The areas under study isabout 45kms from Gedarif. It lies between latitude 14^o N and 14^o -15^o longitudes 35 ^{o} E – 35.30 ^{o} E (Ahmed and Desougi, 2015).Three shelterbelts were selected:The first belt in the northern area, Kilo 6, was 4 kilometers long, 300 meters wide, and the distance between trees was 3 × 3 meters, and the predominant trees were*Acacia seyal*. The average height was 4 meters, and the average trunk diameter was 9cm, and it was planted in 2008. The second belt in the northern area also has a length of 4.5 km and a width of 400 meters. The distance between trees was 3× 3 meters. The average height was 4 meters and the average trunk diameter was 9 cm, and the predominant trees are *Acacia seyal*, and it was planted 2008. The third belt is located in the central area. It is called Abu Jinnah belt. It was 3 km long and 200 meterswidth. The distance between trees was 5× 5 meters, the predominant trees were*Acacia seyal.*The average height is 3meter and the average trunk diameter was 7cm, and It wasplanted in 1998 Fig (1,2 and 3).

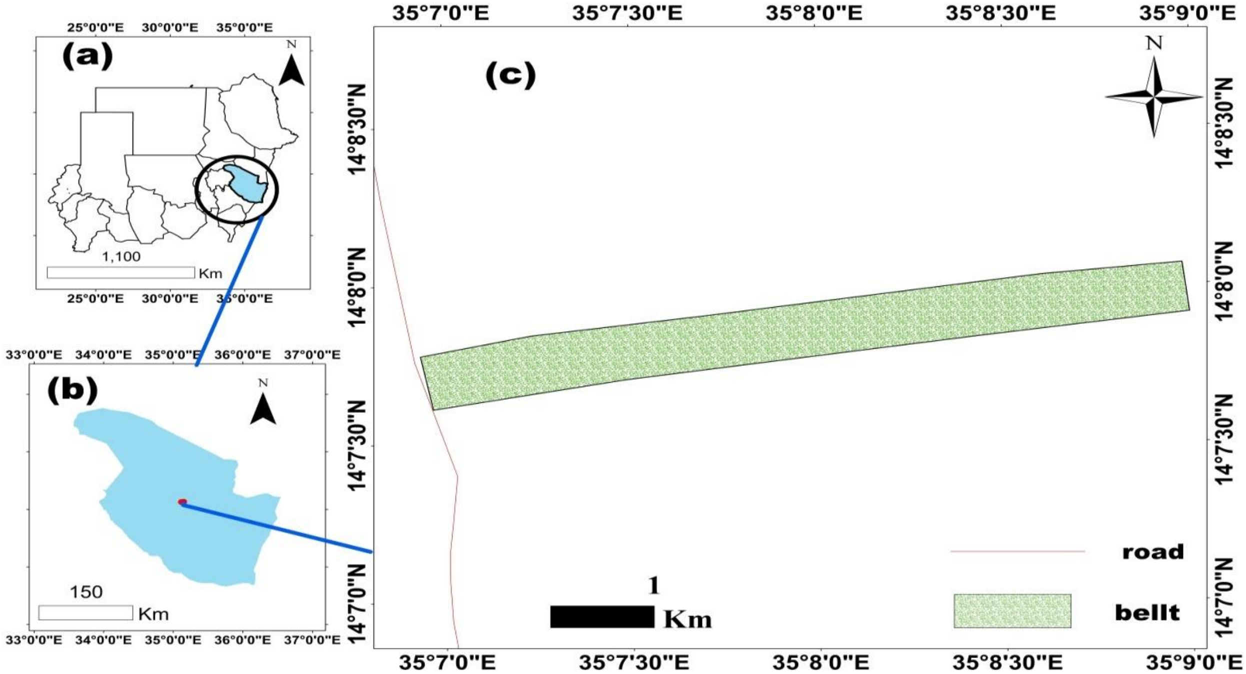

Figure: (1) Kilo 6 (A) shelterbelt

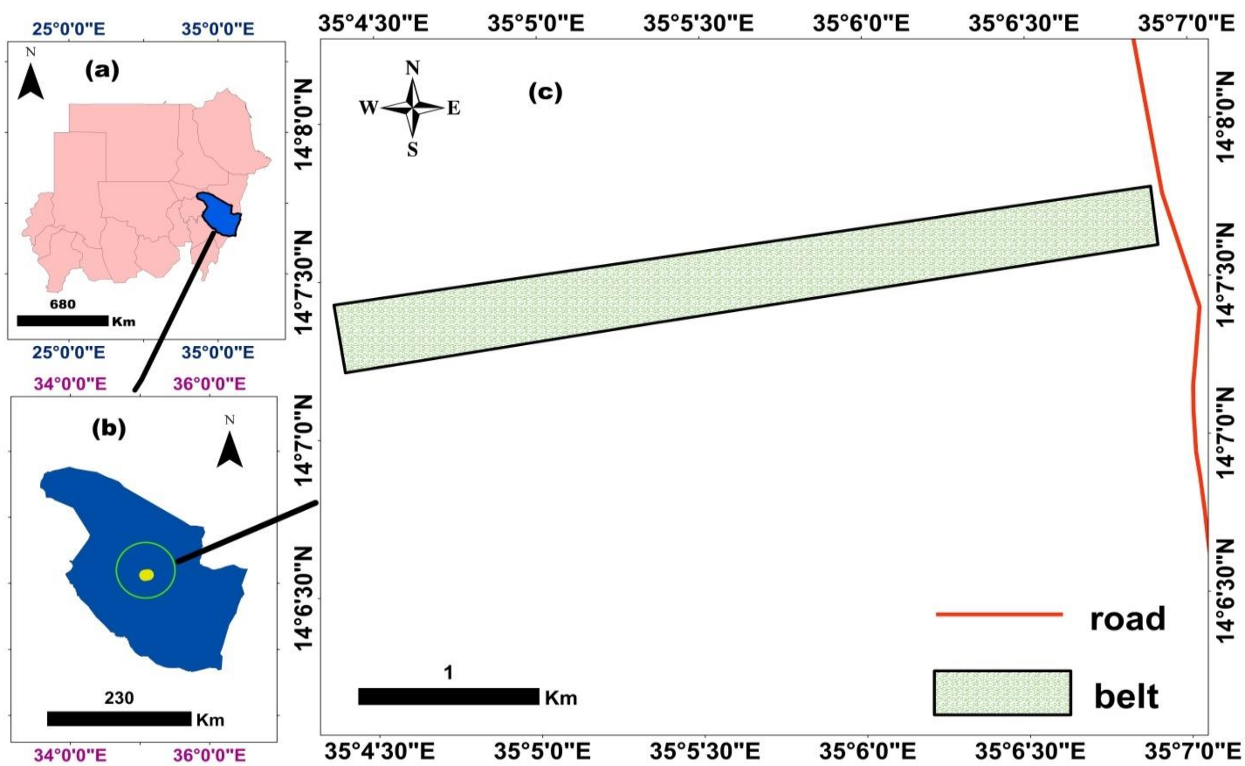

Figure: (2) Kilo 6 (B) shelterbelt

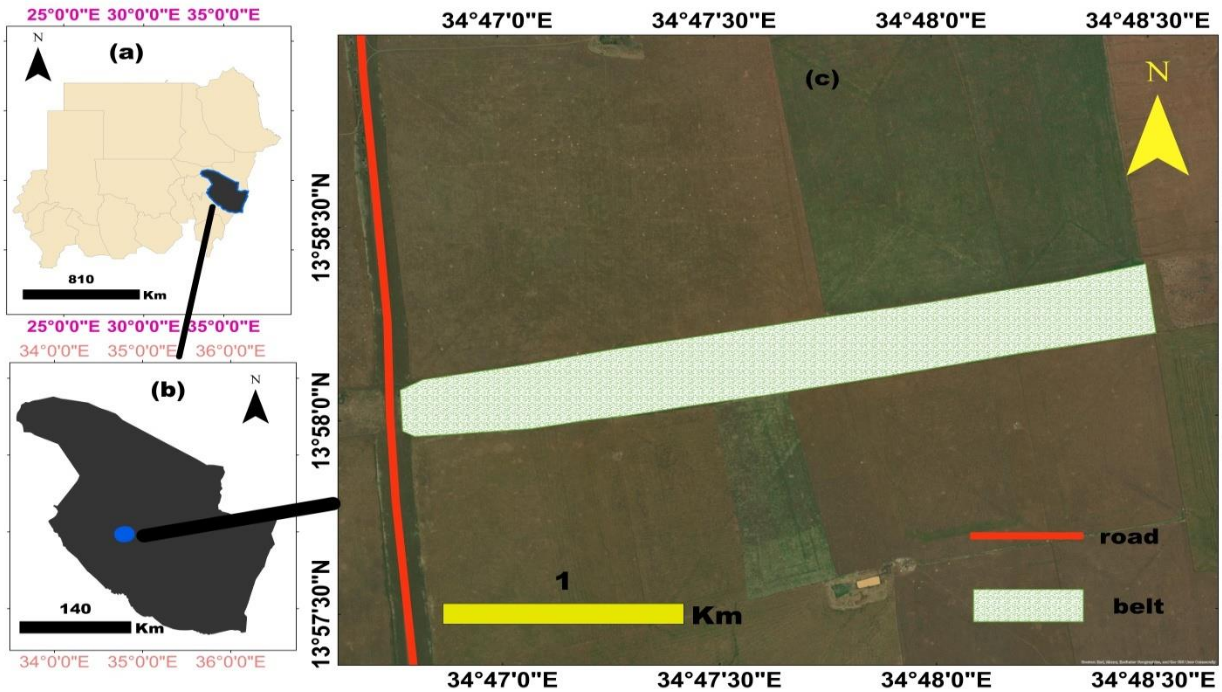

Figure: (3) Abu Jinnah shelterbelt

Experimental design

Three lines were chosen in each of the three selected shelter belt. In each line, ten points were identified at different distances according to height of the shelterbelt 2.5H, 5H and 10H on the windward side;5H, 10H, 15H, 20H, 25H and 30H on the leeward side, and one pit was dug in the middle of the belt to describe soil characters. Also three samples were selected in each shelterbelt located outside the protected area. Suunto Clinometer was used for total tree height measurement as recommended by Mohammed *et al.*, (2022). Soil temperature were measured at depth of 5and 10 cm and soil moisture in each sample (33 samples) in each belt, (99 samples) in the three shelter belts were considered for measurements. Soil samples were taken by the Auger device and collected in plastic bags and transferred to the laboratory of the Mechanized Agriculture Authority in Gedarif state to determinatesoil moisture using Moisture Analyzer (KERN DBS, 60-3) as recommended by (Rasheed *et al*., 2022).The soil temperature was measured using the soil thermometer in the field.Piche tubes at height 2m were used to estimate the amount of evaporation inside the shelterbelt and unprotected area. Evaporation was measured twice a day, six in the morning and six in the evening for five days.The data was subjected to analysis of variance and mean separation method using the software statstix-10 and SPSS.

Results and discussion

Table (1). Mean soil moisture and soil temperature as detected in different shelter belts sites

Shelterbelts	Mean soil temperature 5 cm	Mean soil temperature 10 cm	Mean soil moisture
Kilo 6A	35.727 A	32.879 B	9.3094A
Kilo 6B	34.091 B	32.333 B	9.3012 A

Abugenah	35.879 A	34.242 A	8.4670 B
P	0.008**	0.013**	0.011**

Note: Means carrying the same letters are not significantly different
P= probability, p> 0.05= not significant, P≤ 0.05, 0.04, 0.03, 0.02= *, P≤ 0.01, 0.001, 0.000 = **

Table (1) showed that the highest soil temperature for both depths 5 and 10 cm was recorded in the Abu Jinnah Shelterbelts compared to Kilo 6A and Kilo 6B belts which was recorded the lowest soil temperatures, and this is attributed to the narrow and short height of the Abu Jinnah belt compared to the rest of the Shelterbelts. Also the study reported that the lowers moisture content was recorded in the Abu Jinnah Shelterbelts compared to Kilo 6A and Kilo 6B shelter belts. The result coincided with that reported by(Fengmin Luo *et al*., 2021) Who stated that under the influence of a large-scale shelterbelts, air temperature, land ground temperature and evaporation respectively decreased 5.13% ~ 24.74%, 2.38% ~ 20.09% and 7.06% ~ 17.68%.

Table (2) Effect of distance from the shelterbelts on soil moisture and soil temperature

Area	**Distance from the belt (m)**	**Mean soil temperature 5cm(c°)**	**Mean soil temperature 10cm(c°)**	**Mean Soil moistures (%)**
Protected area	Windward 10H	38.778 A	35.889 A	8.930 AB
	Windward 5H	37.444 AB	34.556 ABC	8.3156 B
	Windward 2.5H	38.889 A	34.889 AB	8.8889 AB
	Leeward 5H	33.889 CD	32.333 CD	8.6878 AB
	Leeward 10H	33.333 D	32.222 CD	9.0144 AB
	Leeward 15H	32.889 D	32.778 BCD	9.6833 A
	Leeward 20H	33.111 D	32.778 BCD	9.2900 AB
	Leeward 25H	32.556 D	31.333 D	9.4278 AB
	Leeward 30H	32.222 D	30.444 D	9.5600 A
Inside the shelterbelts	Inside Belt	35.778 BC	31.556 D	9.1400 AB
Un protected	Un protected	38.667 A	35.889 A	8.3467 B
	P	0.000 **	0.000 **	0.342 n.s
	Grand mean	35.23	33.15	9.02
	C.V %	7.16	7.9	14.11

Means carrying the same letters are not significantly different
C.V = coefficient of variation, n.s = not significant

Table (2) showed that the soil temperature behind the Shelterbelts (Leeward) and inside the shelterbelts were significantly lower compared to the soil temperatures in front of the shelterbelts (Windward) and the unprotected area, this indicates the clear effect of the Shelterbelts on lowering the soil temperature. There is also a similarity between the temperature of the belt area and behind the shelterbelts at windward 5H.On the other hand, there were no significance differences between the inside belt and windward 2.5H, 5H and 10H.These results are in agreement with the findings of Osman (2010) andFengmin Luo *et al*.(2021) who reported that Soil temperature is reduced behind shelterbelts compared with unprotected ground. Also, the results showed that there were no significant differences between the different distances2.5H, 5H and 10H behind the shelterbelts. Also, there were no significant differences between the different distances behind the shelterbelts (Leeward)5H, 10H, 15H, 20H, 25H, and 30H at both depths. Whereas, at a depth of 10 cm, the results showed that the soil temperature of the Behind the belt (leeward side) and the Inside the shelterbelts area decreased significantly compared to the unprotected area and the In front of the Shelterbelts area(Table2). And the results also showed that the temperature at a depth (5) is higher than the temperature at a depth (10). Also the results indicated that the soil moisture inside the shelterbelts was higher compared to the soil temperatures in the unprotected area. These results are in agreement with the findings of Osman (2010).

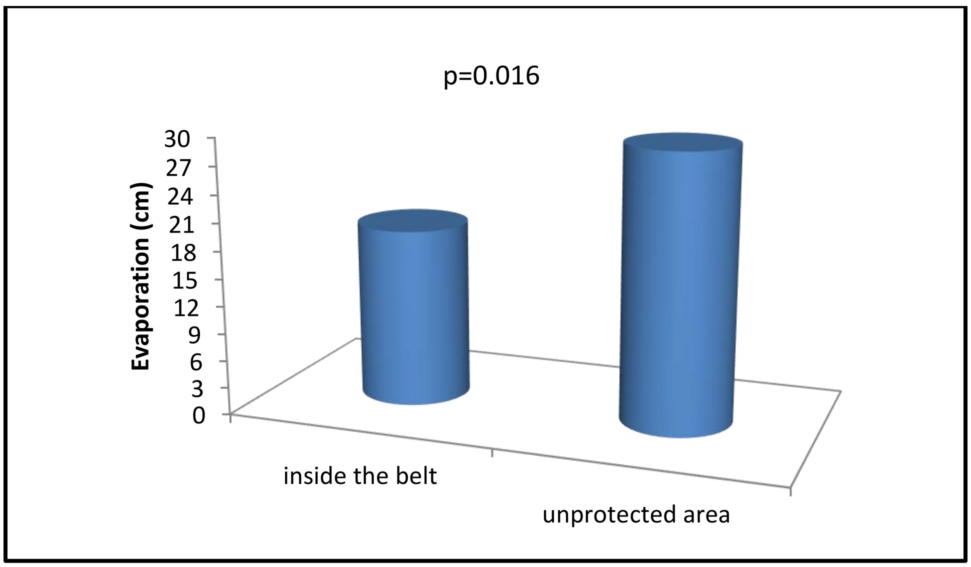

Figure (4) Evaporation inside the shelterbelt and unprotected area

*= significant different

Figure (4) showed that the evaporation rate inside the shelterbelt was significantly reduced compared to the unprotected area. Similar results were observed by (Fengmin Luo *et al*., 2021) who found that the evaporation showed a downward trend inside shelterbelt. Generally the reduction of wind velocity reduces evaporation from both open water surfaces and soil surfaces, particularly during seasons of high temperatures and reduce water loss from irrigation canals and from sprinkler irrigation systems (Dongsheng *et al.*, 1999).

The stability of the microclimate was maintained and natural disasters were reduced by shelterbelts (Zhang *et al*., 2011). Our results showed that under the influence of a large-scale shelterbelts, air temperature, ground temperature and evaporation decreased significantly. The microclimate of shelterbelts was conducive to the overwintering of plants and kept them from the damage of high temperature in summer. Therefore, it played a vital role in plant growth, nutrient accumulation and quality improvement (Fang *et al*., 2020). The relative humidity was found to be increased in some studies by 0.5% ~ 18.6%, whereas the evaporation was also decreased 18.4 ~ 12.828 mm by shelterbelts in the northeastern edge of Ulan Buh Desert. This played a positive role in increasing soil moisture and inhibiting crop transpiration, thereby increasing crop yields and improving the soil quality in long time (Fang *et al*., 2020)

Saturated water vapor was formed when the temperature inside shelterbelt was lower than that outside shelterbelt. The canopy blocked the exchange of airflow between inside and outside shelterbelt. In addition, the water vapor diffusion from inside to outside shelterbelt was reduced by the decrease of wind speed, which resulted in a higher relative humidity inside than outside shelterbelt(Yang,1993).

Conclusion

1-Microclimate was improved by shelterbelts in Ghadambaliya area, including soil moisture, Soil temperature and evaporation inside shelterbelt.

2- Influence of large-scale shelterbelts was better than narrow-band shelterbelts in terms of their impact on soil temperature and soil moisture.

References

Ahmed, E.A. (2015). Effect of Mechanized Rain fed Farming on Vegetation Cover and Effect of Shelterbelts on Environment at Ghadambaliya Gedaref State. M.Sc.Thesis, Sudan University of Science and Technology.

Ahmed, E.A.; Desougi, M.A. (2015). Potential impact of rain fed mechanized farming and shelter belts establishment on the environment, case study Ghadambaliya, Gedarif, Sudan. Repository of Sudan University of Science and Technology. http://repository.sustech.edu/handle/123456789/13520

Abdelmagid, T.D.; Eiman, R.E. (2010). Shelterbelt for dry land development case of Sudan. Seminar proceeding 2010 Khartoum, Sudan.

Al Motawa, Subhi (1985). Influence of shelterbelts. University Editions. University of Kuwait.

Dongsheng, Z.; Brandle, J.; Hubbard, K.; Hodges, L.; Daningsih, E.(1999). The response of muskmelon growth and development to microclimate modification by shelterbelts. Hort Science: 34 (1): 64-68.

ElAmin, K.B.; ElMadina, A.M. (2014). Farmers Perceptions and Attitudes towards the Shelterbelts Establishment in Farms, Gedarif State, Sudan. SUST Journal of Agricultural and Veterinary Sciences,Vol. 15 No.(2).

Fang, L.D.; Ning, Q.R.; Guo, J.J. (2020). Hydraulic limitation underlies the dieback of Populus pseudo-simonii trees in water-limited areas of northern China. Forest Ecology and Management. 483:118764. DOI: 10.1016/j.foreco. 2020.118764.

Fengmin, Luo; Zhiming, Xin; Junliang, Gao; Yuan, Ma; Xing, Li; Huaiyuan, Liu (2021). Ecological Effect of Oasis Shelterbelts in Ulan Buh Desert. OI:http://dx.doi.org/10.5772/intechopen.98679.

Mohammed, M.I.E.; Hamid, A.M.E.; Ndakidemi, A.P.; Treydte, C.A. (2022). The stocking density and regeneration status of *Balanites aegyptiaca* in Dinder Biosphere Reserve, Sudan. Journal Trees, Forests and People, 8 (100259).

Nair, P.K.R. (1989). Agroforestry Systems in The Tropics. Kluwer Academic Publishers, ICRAF, Nairobi.

Osman, H.K. (2010). Shelterbelts Effects on Soil Temperature in The River Nile State. M.Sc. Thesis, University of Khartoum. Sudan.

Rasheed, W.; Muhammad, Tang, Jialiang; Sarwar, Abid; Shah, Suraj; Saddique, Naeem; Khan, U. Muhammad; Khan, I. Muhammad; Nawaz, Shah; Shamshiri, R. Redmond; Aziz, Marjan and Sultan, Muhammad (2022). Soil moisture measuring techniques and factors affecting the moisture dynamics: A comprehensive review. Journal of Sustainability, 14(11538).

Rocheleau, D.; Weber, F.; and Field- Juma, A. (1988). Agroforestry in Dry Land Africa : Science and Practice of Agroforestry 3.ICRAF,Nairobi ,Kenya

Yang, Y.P. (1993). Research on shelterbelt of Upper Yangtze River (Chuanjiang). Beijing: Science Press: 7-31.

Zhang, P.; Zhao, X.F.; Zhang, T. (2011). Leaching salinity effect of drip irrigation on soil of oasis shelter forests in arid area. Transac. of Chinese Society of Agri. Eng. 27(5):25-30.

Nile Valley University Publications
Nile Journal for Agricultural Sciences (NJAS)
(ISSN: 1585 – 5507)
Volume 08, No. 01, 2023
http://www.nilevalley.edu.sd

Wheat Economics and Future Policy Options in Sudan

Elgilany A. Ahmed, Hamid H. M. Faki, Adil Ahmed

Agricultural Economics Research and Policy Center, Shambat, Sudan
Correspondent author: E-mail: elgilanya@yahoo.com, +249 128471055

Abstract

In Sudan, wheat is considered as one of the main strategic crops beside sorghum and millet. It contributes to rural and urban livelihoods and food security. The gap between the production and consumption of wheat is still large and exceeds 100% of the total production, which leads to the burden of the high import bill. This research deals with some important macro and micro economic aspects that aim to support opportunities for expansion of wheat production in Sudan within the framework of its competition in the cropping structure. While the analysis of its content benefited from the available secondary data and information in relation to the subject, it was largely based on a field survey conducted in the year 2021 targeting the main three States of wheat production in the country namely, Gezira, Northern and River Nile States. The sample size and data collection are fully representing the different agricultural systems was determined by using the multi-stage stratified sample technique. The survey consists of a questionnaire directed to samples of wheat growers in the selected areas. The study also looks to draw the relevant policy options for increasing wheat production, trade and development. Moreover, it applies scientific research methods to achieve its aims. Policy Analysis Matrix (PAM) was used to analyze the effects of government policies, competitiveness and comparative advantage on the wheat production. Descriptive statistics also used to illustrate the potential and feasibility of the crop. Finally, the study concluded that wheat import bill constitutes a huge burden, which requires providing support for wheat expansion by raising wheat productivity to the highest levels through advance technologies utilization, providing wheat subsidies for storage to benefit from the high prices after harvest, which raises the profitability of wheat to compete with the profitability of other crops and supporting prices of inputs at wheat production areas.

Keywords: Wheat economics, wheat import, policy options, Sudan.

اقتصاديات القمح وخيارات السياسة المستقبلية في السودان

الجيلاني عبد الحفيظ أحمد، حامد حسين محمد فكي، عادل أحمد

مركز دراسات بحوث وسياسات الاقتصاد الزراعي، هيئة البحوث الزراعية، شمبات، السودان
ممثل المؤلفين: E-mail: elgilanya@yahoo.com, +249 128471055

المستخلص

يعتبر القمح في السودان من أهم المحاصيل الإستراتيجية إلى جانب الذرة الرفيعة والدخن .يساهم في سبل كسب العيش الريفية والحضرية والأمن الغذائي .لا تزال الفجوة بين إنتاج واستهلاك القمح كبيرة وتتجاوز 100٪ من إجمالي الإنتاج ، مما يؤدي إلى عبء ارتفاع فاتورة الاستيراد .يتناول هذا البحث بعض الجوانب الاقتصادية الكلية والجزئية الهامة التي تهدف إلى دعم فرص التوسع في إنتاج القمح في السودان في إطار تنافسه في التركيبة المحصولية .في حين استفادت الدراسة من تحليل محتوي واسع من البيانات والمعلومات الثانوية المتاحة فيما يتعلق بالموضوع ، فقد استند بشكل كبير إلى مسح ميداني تم إجراؤه في عام 2021 واستهدف الولايات الثلاث الرئيسية لإنتاج القمح في الدولة وهي الجزيرة والشماليةونهر النيل .تم تحديد حجم العينة وجمع البيانات التي تمثل النظم الزراعية المختلفة بشكل كامل باستخدام تقنية العينة الطبقية متعددة المراحل .يتكون المسح من استبيان موجه لعينات من مزارعي القمح في المناطق المختارة .تتطلع الدراسة أيضًا إلى رسم خيارات السياسة ذات الصلة لزيادة إنتاج القمح وتجارته وتنميته .علاوة على ذلك ، تطبق أساليب البحث العلمي لتحقيق أهدافها .تم استخدام مصفوفة تحليل السياسات (PAM) لتحليل آثار السياسات الحكومية والتنافسية والميزة النسبية لإنتاج القمح .يستخدم الإحصاء الوصفي أيضًا لتوضيح إمكانات وجدوى المحصول .وأخيراً خلصت الدراسة إلى أن فاتورة استيراد القمح تشكل عبئاً ضخماً يتطلب دعم التوسع في إنتاج القمح من خلال رفع إنتاجية القمح إلى أعلى المستويات من خلال استخدام التقنيات المتقدمة ، ودعم تخزين القمح للاستفادة من ارتفاع الأسعار بعد الحصاد ، الأمر الذي يرفع ربحية القمح لمنافسة ربحية المحاصيل الأخرى ودعم أسعار المدخلات في مناطق إنتاج القمح .

كلمات مفتاحية: اقتصاديات القمح ، استيراد القمح ، خيارات السياسات ، السودان

Introduction

The Republic of Sudan is the third largest country in Africa, covering an area of approximately 1,886,068 km^2 and divided administratively into 18 states. Sudan had a population of 41.8 million inhabitants in 2018, according to the Central Bureau of Statistics of Sudan, and its economy revolves mainly around traditional agriculture and livestock husbandry. Agriculture is the backbone of the Sudan's economy and is crucial for the country's food security. Although between 1960 and 2020 agriculture ranked second to services in terms of contribution to real gross domestic product (GDP) each adding, respectively 35.2% and 48.7%; recently, it generates47.4% of employment with 69% of the own-account businesses operating in the sector. Accordingly, the sector is not only the main source of livelihood for the majority of population, but it is also the main employer of skilled labor. About 35.7% of skilled workers reported operating in the sector in 2014 compared with 11% skilled workers engaged in the services sector (ERF, 2021). Sudan's agriculture is distinguished by three crop production systems: the irrigated, mechanized rain-fed and traditional rain-fed farming systems.

Sudan is one of the most vulnerable to climate change countries as more than two thirds of the population and twelve states out of the country eighteen states are fully located on drylands, i.e., depending entirely on rainfall for their livelihood. Productivity of the main food and cash crops in the three crop production systems is very low compared to the regional, international and national research standards (Osman and Ali, 2010). The agriculture sector is expected to regain its role as a key source of foreign exchange. The loss of oil revenues in 2011 after the separation of South Sudan has been followed by resurgence in agriculture's share in the country's exports, reaching 55% in 2019 as reported by the United Nations International Trade Statistics Database, and helping cushion some of the impact of the loss of oil revenues. This improvement has been mainly led by the good performance of major agricultural export commodities like livestock, sesame, gum Arabic, and cotton. For at least three of Sudan's key exports sheep, goats, and gum Arabic—the ability to export in processed forms presents significant upside potential. Overall, the agricultural trade balance remains negative due to the high food import bill, which mainly goes for imports of wheat and wheat flour, sugar, and oils (World Bank 2015). Compares the performance over the agricultural and the oil eras, as seen, the average value added share of industry has increased by 8.9 percentage points.

Wheat (*Triticum spp.*) cultivation in the world goes back into history. It was one of the first domesticated food crops and for 8,000 years has been the basic staple food of a high portion of civilizations in the world and continues to be the most important food grain source for humans. The crop is occupied over 240 million ha than any other commercial crop and the annual global production exceeds 0.6 billion tons. World trade for wheat is greater than for all other crops combined, and it provides more nourishment for humans than any other food source.

Although sorghum and millet are considered as the traditional cereals for Sudanese households' consumption, but nowadays the majority have changed towards the wheat consumption in the form bread in its different forms. It contributes to rural and urban livelihoods and food security. Over the past two decades, wheat production, which is almost entirely irrigated, has been fluctuating and declining due to declining yields and soaring input costs. Since the end of 1990s decade, the Government liberalized agriculture and removed all support programs. Those policies have affected a lot of wheat growers to consider wheat as a secondary crop and extend the lucrative cash crops areas, such as legumes, pulses and vegetables. No doubt wheat importation constitutes the largest burden among agricultural food imports and a major discount to the country's modest foreign exchange resources. In 2020, wheat imports quantity for Sudan was 2,200 thousand tones. According to the data of the Bank of Sudan, the average quantities of imported wheat and flour during the last decade amounted to 2,181,113 tons (wheat equivalent) with an average value of $890.436 million. The wheat bill during that period constituted an average of 42% of the value of food imports and 10% of the total value of the country's imports.

This research has been carried out in the year 2021 targeting the main three States of wheat production in the country namely, Gezira, Northern and River Nile States. The region is considered as one of the most promising areas in the country, it is enjoing relatively cooler weather during the winter season and retiched fertile alluvial soils, moreover, it has a comparative advantages compared to other parts of the Sudan in producing relatively high-value agricultural crops. Nile River is known as one of the longest rivers in the world, it is considered as the main source of irrigation water for the agricultural cultivated areas, particularly for the mentioned winter crops production which are considered as the principle crops for farmers and agricultural companies in the region, while the summer and autumn season crops are ranked after them due to some environmental advantages and some economical aspects.The farming system of the States is consisted numerous types of irrigated schemes such as the public irrigated schemes, forien investmet schemes, agricultural companies, private and cooperative schemes with different production relationship systems. These schemes are regarded as main potential ones for developing agriculture in general and specifically to produce winter season crops due to their high acreage share, possess capital, mechinaries, and comprise high number of farmers. The research sellected the River Nile and the Northern States where agricultural schemes include governmental, private, cooperative schemes. The research obsarved some critical constraints regarding determination of crop combination in area of the study. These problems contribute mainly to the low levels and fluctuation of winter crops yield include inadequate practices of crops technical packages used by farmers, misuse of agricultural resources, stress caused and inflicted by changing of environmental and climatic conditions especially temperature beside the widespread of different diseases, insects, pests, weeds and power failure that a companied by lack and high cost of fuel and spare parts to operate the pumps. Numerous research mentioned that the high cost of production coupled with low levels of crop yields and instable source of power has contribute to difficult for the tenants to realize the full potential of the State. In addition, development is considered by serious limitation on the two basic resources namely, land and water. Regarding irrigation water in the State, there were many hindrances contributed to inefficiency of irrigation water use and affected crop production in the irrigated schemes in RNS such as inadequate supply of irrigation inputs in proper time and at right prices. Generally, improvement of the farming system in the region considering climatic change, food security and economic requirements of the local populations is regarded as a great challenge for researchers, policy makers, scientists, agricultural administrators in public and private sectors, related organizations, and investors. Finally, the study was applied PAM analysis approach to examine the impact of government policies on wheat production to evaluate the contribution of the sub-sector to economic empowerment. Furthermore, PAM might help policy makers in comparisons of before and after the policy change as well as measures policy impacts. It shows successful public investment when raise the value of output or lower the cost of inputs. Also, it is a simple tool and powerful to communicate with policy makers for preparing agriculture strategies particularly in developing countries as well as with donor support such as World bank, UNDP and others.

Methodology

This research deals with some important macro and micro economic aspects that aim to draw the relevant policy options for increasing wheat production, trade and development and to support opportunities for expansion of wheat production in Sudan within the framework of its competition in the cropping structure. While the analysis of its content benefited from the available secondary data and information in relation to the subject, it was largely based on a field survey conducted in the year 2021 targeting three states of wheat supply in the country namely, Gezira, Northern, and River Nile States. The sample size and data collection are fully representing the different agricultural systems in the areas of the study, it was determined by using the multi-stage stratified sample technique. The survey consists of a questionnaire directed to samples of wheat growers in the selected areas. The study utilized both primary and secondary data and employed PAM to analyze the collected data. PAM defined as a mathematical framework that helps divide the commodity system into its essential components, namely, private profitability estimated at special prices (prices in the local markets), social profitability calculated at social prices (prices in the world markets), and the difference between the two measures of profitability. The policy analysis matrix is specifically designed to analyze market distortions and price policy interventions and their impacts on the commodity system. Where, inputs divided into non-tradable inputs that not internationally traded, such as services and land where the demander and the producer must be in the same location (Jenkins and Harberger, 2011), and tradable inputs that are internationally traded, such as seed, fertilizer, pesticide, etc. It is a policy analysis tool based on a very simple and basic equation. PAM helps policy makers by addressing three central agricultural issues: *'Profit = Revenues – Costs'*. Agriculture Policy Environments Estimation is based on private (financial prices) and social prices (economic). Impact of new public investment mostly the divergence between two types of profitability comes from policy intervention.

Data collection: The research depends on both primary and secondary data. The primary data were obtained mainly from interview by using a structured questionnaire beside field observation. Data collected included inputs requirements, market prices for inputs and outputs, transportation cost and returns. The secondary data were obtained from relevant sources; it included production aspects, import and export information and the exchange rate.

Sampling technique: Multi-stage sampling technique was applied for selecting respondents. The first stage involved the purposive selection of the main states of wheat production in the country namely, Gezira, Northern and River Nile States. The questionnaire was designed with the aim of collecting primary data for the sample chosen for the study targeting River Nile and Northern States. The questionnaire aimed to captures the suitable information that attains the objectives of the study. Due to the absence of official records for farmers in the two states, the research noticed that most of the farmers within the agricultural pattern are homogenous (i.e. similar, irrigation technology system, crop combination, inputs, ….), and after referring to the numbers of farmers as well as other similar previous studies in the States under the study, a sample size of 450 farmers was selected from the three States, 150 respondents for each state and distributed over the different agricultural schemes. The sample of the Gezira State was totally collected from the Gezira Scheme, while for the River Nile State was collected from Al Ddamer locality and implied four districts, namely Al-Damer, Al-Makabrab and Al-Alayab, and from Berber locality, also information was collected from the Al-Kafaa-Al-Rajhi scheme, representing the different farming systems in the State. The same procedure was employed in the Northern State where a sample size of 150 farmers was selected from the schemes in Dongola locality with focusing on four districts, namely Al-Gould and Al-Manasir Al-Jadidah, and Al-Dabbah (El Daman El Egtimai Scheme).

Analytical technique: The policy analysis matrix is a quantitative mathematical, analytical method and used to analyze comparative advantage by measuring the impacts of governmental intervention policies and market distortions on the vertical commodity system or commodity chains from farm to final consumption and export point. The PAM is a matrix of two accounting identities; one set defining profitability and the other defining the difference between private and social values of a commodity system. The framework of PAM is shown in Table 1.

Table 1: Policy Analysis Matrix (PAM)

Tradable inputs	**Revenue**	**Production Cost**	**Profit**	**Revenue**
		Tradable inputs	Domestic factor	
Private price	A	B	C	D
Social price	E	F	G	H
Policy transfer	I	J	K	L

Source: Monke and Pearson, 1989

Private profitability (D) = A - (B+C)
Social profitability (H) = E - (F+G)
Output transfer (I) = A - E
Input transfer (J) = B - F
Factor transfer (K) = C - G
Net policy transfer (L) = D - H

The main equations and calculation methods of the Policy Analysis Matrix:

Private Profitability (D)**:** The private profitability demonstrates the competitiveness of the agricultural system given current technology, prices of inputs and outputs, and policy. Measures A, B, C, and D, it is the difference between private (observed) revenue (A) and private costs (B+C) values at actual market prices (private values) received or paid by farmers, marketers or processors in the agricultural system. The private profitability calculations show the competitiveness of the agricultural system, given current technologies, output values, input costs, and policy transfers. The private values implicitly included the effects of all policy interventions in both direct and indirect subsidies, taxes, and all market distortions and failures (Pearson and Monke, 1987).

Social Profitability (H):The social profitability is a measure of comparative advantage and efficiency because inputs and outputs are valued in prices that reflect scarcity values. It is the measured at social prices, which is the differences between social revenues (E) and social values costs (F + G) of domestic factors and tradable inputs prices at social opportunity cost (social values). Social values provide a benchmark policy environment for comparison as these were considered those that would hypothetically occur in free market without policy intervention (Pearson and Monke, 1987).

Social Cost Benefit Ratio (SCBR): A good alternative for the DRC is the social cost-benefit ratio (SCBR), which accounts for all cost and avoids classification errors in the calculation of DRC (Masters and Winter-Nelson, 1995).

Nominal Protection Coefficient (NPC):is referring to the level of protection of the main product.This is used to determine the relationship between the market price and the shadow price of the products (Fabian, 2005). This can be calculated for the output and input. Moreover, if the NPC is more significant than 1, the system takes advantage of the protection and if less than one the system is subject to taxes ,where NPC is the ratio of the revenue in the private prices (A) compared to the income of the social costs (E). While the *Effective Protection Coefficient (EPC)*is referred to as the overall level of protection, taking into account the impact of policies on the value of tradable products and tradable inputs, it is the ratio of value-added in private market prices (A – B) to value-added in social market costs (E – F). EPC, another indicator of incentives, is used to measure the degree of policy transfer from product market-output and tradable-input-policies. EPC nets out the impact of protection on inputs and outputs, and reveals the degree of protection accorded to the value added process in the processing activity of the relevant commodity (Samarendu and Jagadanand, 2003). *Profitability coefficient (PC) or Policy Transfer* is measure policy reflection on the profitability of the system. If PC greater than 1, the system benefits from net transfers from the sector, but if it is smaller than 1, the economy benefits from net transfers from the system, price must be explained by the effects of policy or by the existence of market failures (Pearson *et al.*, 2003). Distorting policies that lead to an inefficient use of resources enhance the stated divergence.

There are three indicators used for comparisons of the relative efficiency or comparative advantage among to agricultural commodities. The first indicator is the domestic resource cost DRC: is a measure of relative efficiency of domestic processing by comparing the opportunity cost of domestic processing to the value generated by the product. The ratio can be used to compare different economic activities in terms of social cost of domestic resource employed in earning or saving a unit of foreign exchange. If the DRC is smaller than 1, the system has a comparative advantage, which means that we use local resources of lower value than global resources. If the DRC is greater than 1, the system does not have a comparative advantage, and social profitability is negative where it is the ratio of the non-tradable inputs in the social prices (G) compared to value-added in social costs (E – F). Another indicator of the system's comparative advantage, it takes into account the full cost of production of the social prices (F + G), which is more appropriate for the relative position of the different systems when they have different cost structure (tradable and non-tradable). Where DRC is biased in favor of the system containing on a larger scale of tradable inputs, but the Social costs benefit SCB calculated dividing the total costs in the social prices on the revenues of the social prices (F + G)/E

Financial cost-benefit (FCB) is a competitive system index, if FCB is smaller than 1, the system is competitive, and if it is greater than 1, the system is not competitive and the financial profitability is negative. FCB is the ratio of Non-tradable inputs (C) to value-added in private prices (A – B).

Nominal Protection Coefficient on Output (NPCO): The NPCO shows how much domestic prices differ from social prices and it is calculated by dividing the revenue in private prices (A) by the revenue in social prices (E).

Nominal Protection Coefficient on Input (NPCI): The NPCI shows how much domestic prices of tradable inputs differ from their social prices. This ratio indicates the impact of policy transfers that cause a divergence between the two prices. The NPCI on tradable inputs in wheat production is therefore defined as private price of input (B) divided by social price of input (F).

Subsidy Ratio to Producers (SRP): Subsidy ratio to producers (SRP) is the net policy transfer as a proportion of total social revenues. The SRP shows the proportion of revenues in world prices that would be required if a single subsidy or tax were substituted for the entire set of commodity and macroeconomic policies (Christo, 2010).

Results and Discussion

Policy Matrix Analysis

The research looking to build components estimates of policy analysis matrix (PAM). The calculation of production inputs costs and revenues at private and social prices would ease the filling of the rows and columns of the sample. The matrix built based on the production of one feddan and State level, and the average of the sample SDG/fed of the wheat production, Table2 shows the results of the policy analysis matrix for the production of wheat in Sudan 2020 on at State level. To determine the private profitability of wheat, the first row in the PAM, private budgets by market prices were calculated. The study was evaluated the total revenue, the total cost and the gross profits were calculated for wheat in all states.

The research compared wheat private budgets in all States of the study, Gezira, River Nile State and Northern States; the results of the matrix indicate that the wheat in the States are profits earned to the producers in the private prices, where D values were positive. was more profitable in River Nile State than Gezira and Northern States and it was more competitive as illustrated in Table (2).

The study also determined the second row for PAM namely, the social profitability (H) of wheat. The calculation of the social (efficiency) prices will reflect the import parity prices of inputs and outputs, decompose non-tradable inputs into their private and social prices, estimate the social prices (opportunity costs) of factors and calculate the capital recovery costs of fixed assets. To avoid quality differentials in wheat outputs international prices, a unit value was used as the reference prices for the different types of wheat. The units' values were calculated as the value of the imported commodity divided by the total quantity imported to Sudan. The unit value data come from Sudan's Custom Statistics Book. To get their free on board prices (F.O.B), the cost of insurance and freight, which obtained from shipping companies or fright forwards in Port Sudan, was subtracted. The costs of all non-tradable inputs (goods and services) should be decomposed into their tradable inputs and domestic factor cost components. These costs, standardized on units such as hours or measures of volume or weight, then can be substituted into the appropriate components of the Private and Social budgets. The researcher decomposed tractor and its thresher services.

Pearson *et al*. (2003) declared that because of the complexity of possible market failures and distorting policies affecting rural credit, it is virtually impossible to measure the extent of these divergences. In principle, social return to capital is represented by the rate of return on the next public or private investment. In Sudan the commercial banks were determined the private interest rate of capital around 10% per year. The social opportunity cost principle was followed to find the social cost of land cultivated by wheat in its best alternative crops that more profitable like onion and sorghum. The researcher estimated the capital recovery cost of a pump as a common fixed asset owned by farmers. Table (2) depicted that the price policy does not encourage to the efficient use of domestic resources, while the results also revealed that the divergences revenues (I) were positive in all the States matrices of the study, which were the results of the difference between the private prices revenues (A) and the social prices revenues (E). That means the private revenues are higher than the social revenues of all the matrices, which indicates the high government intervention for wheat subsector in Sudan, resulted from the government intervention through making the price of the wheat production in a local price higher than global price, and market failures. The divergences of non-tradable inputs (K) were zero for labor in the results of the matrix for all the provinces, which means that the labor inputs in social prices are equivalent to tradable inputs in private prices, which indicates that there is no any subsidy or tax on non-tradable inputs. The positive value of the net effect (L) resulted in policy matrix analyses Table 2 for every State of this study indicates that the wheat production in Sudan is more profitable for producers with market distortions than the profitability without market distortions. Government intervention policies in the wheat commodity system reflected on the output prices, which are for the benefit of domestic producers for short-term (Mohammed, 2015).

Table 2: The results of the policy analysis matrix for the production wheat in Sudan

State	Tradable Inputs	Revenue	Cost				Profits
			Tradable Inputs	Non-tradable Inputs (Domestic Resources)			
				Labor	Capital	Land	
Gezira	Private	20,105,625	11,011,119.59	32,248	2,450	321,690	8,738,117
	Social	1,887,944	111,541	32,248	3,920	334,070	1,406,164
	Divergences	18,217,681	10,899,578	0	-60,000	-12,380	7,390,483
River Nile	Private	28,879,555	24,699,275.99	119,387	3,679	299,270	4,057,214
	Social	4,663,976	239,549	119,387	3,920	1,049,250	3,251,871
	Divergences	24,215,579	24,459,727	0	-60,000	-749,980	565,831
Northern	Private	28,445,471	24,459,766.78	156,123	3,898	315,710	3,825,684
	Social	4,354,656	77,681	156,123	3,898	780,000	3,336,954
	Divergences	24,090,815	24,382,085	0	-60,000	-464,290	233,020

According to the estimated policy analysis matrix for wheat subsector in Sudan, shown in Table 2 for the matrix of the States and the average of the total sample. We can calculate the protection coefficients and comparative advantage measures, which are economic indicators that can measure the impact of government intervention on inputs and outputs prices and market failures, as well as the resources use efficiency. Table (3) shows States' PAM results interpretations and their indicators, which have been calculated as follow:

The Profitability Coefficient (PC)

PC used to measure policy reflection on the profitability of the system. If PC greater than 1, the system benefits from net transfers from the sector, but if it is smaller than 1, the economy benefits from net transfers from the system, where it is the ratio of the profit in the private prices (D) compared to the advantage of the social prices (H) (Pearson *et al.*, 2003).

The PAMs of wheat as illustrated in Table (2) shows positive private and economic profitability in all States and the private ones were greater than the social ones. That indicated high rates of private profitability coefficients as depicted in the Table and The Gezira State was higher than others States. However, Hussien (1992) studied wheat and sorghum competitiveness and profitability in Gezira scheme in the period (1986/87/1989/90); he found that wheat proved to have more private and economic profitability than sorghum from both the farmers and government point of view. While Ali (2002) assessed the profitability of wheat production in the Gezira scheme during 1991/92 (self-sufficiency-year), he mentioned that it used its domestic resources efficiently based on adoption of the recommended technical packages and enhancement of the suitable government policies. The obtained results were also matched with (Ibrahim, 1993) in River Nile and Northern States, they were greater than one. As a result, the average of Sudan was found greater than one, indicating profitability.

International Value Added (IVA)

Ali (2002) evaluated three successful seasons of wheat production in the Gezira scheme and Northern States between1992-1995.His study was computed the IVA, it revealed that wheat had international absolute competitiveness. In addition, wheat highly outstripped sorghum with its positive IVA in the Gezira scheme as Hussein (1992) stated in his study, moreover, the same results were found for River Nile and Northern States in the study of Ibrahim (1993). IVA of wheat shows foreign exchange earnings or savings and hence they were internationally competitors in all States of the study, because they were positive as illustrated in Table (2).

Nominal Protection Coefficient on Inputs (NPCI)

The NPCI shows how much domestic prices of tradable inputs differ from their social prices. This ratio exceeds one for wheat in all States of the study and indicating high implicit taxes. In Gezira, River Nile and Northern States the NPCI ratios were greater than one by 99%, 103% and 315%, respectively with an average of 140% in the whole Sudan that revealed very high implicit taxes. In general, these results interpretations pointing to high cost of private prices of tradable inputs than its social prices, meaning of policies distortion caused due to high taxes or an appropriate exchange rate that lead farmers' losses. That enhances Osman (2004) declaration that Sudan has not been providing huge subsidies to its agriculture.

Nominal Protection Coefficient on Outputs (NPCO)

The NPCO shows how much domestic prices differ from social prices. The research unveiled that the NPCO ratios of wheat in Gezira, River Nile and Northern States were higher than one by 11%, 6% and 7%, respectively with an average of 7% in the whole country indictor. Most output transfer caused by distorting polices-trade restrictions or taxes/subsides- and disequilibrium exchange rates arising from macro-economic policies that are not in balance. The private output prices of were higher than their social prices that probably come from implicit taxes, indicated that farmers had been received an implicit subsidy in producing wheat.

Effective Protection Coefficient (EPC)

EPC is one of the indicators of incentives, is used to measure the degree of policy transfer from product market-output and tradable-input-policies. This ratio is greater than one for wheat in Gezira State only. That shows positive impacts of incentives that represented in subsidy to farmers in outputs prices. Ali (2002) found that NPC and EPC ratios indicated the existence of subsidies on wheat inputs in the Gezira scheme during 1996/97 and 1997/98. NPC ratios were of 1.61 and 1.03 for seasons 1996/97 and 1997/98, respectively. EPC ratios were 2.18 and 1.10 respectively for the same seasons while EPC > NPC ratio revealed that 0.57% and 0.07 taxed wheat inputs in seasons 1996/97 and 1997/98, respectively. NPC and EPC ratios in the Northern Region for season 1999/2000 were 1.60 and 1.72 respectively while EPC > NPC indicated that the government taxed wheat inputs in that season. Hussein (1992) concluded that the nominal and effective protection coefficients implied that wheat faces equal rates of nominal and effective protection, but sorghum is more taxed in real terms than in nominal terms. The subsidy ratio for producers of cereals indicated inefficient subsidy policy. The overall finding is that the price policies of wheat and sorghum provided relative disincentives for their production and resulted in their non-competitiveness in the period between 1986- 1990 in the Gezira scheme. While, in the River Nile and Northern States were less than one which implicated no subsidy of wheat output and that, on contrary of Ibrahim (1993) findings.

The Domestic Resource Cost Coefficient (DRC)

DRC is a measure of relative efficiency of domestic processing by comparing the opportunity cost of domestic processing to the value generated by the product. DRC ratio reflects the country's comparative advantages, not only with respect to capital, land and labor, but also within agriculture. The results of the study in Table (2) shows that the DRC ratios of wheat in all States were less than one; indicating that the value of domestic resources used to produce them were less than their values added in social prices. Production of wheat in these States, therefore, represents an efficient use of the country's resources. This result was consistent with Ali (2002) findings of wheat in the Gezira scheme as well as the Northern States. The DRC ratio values “less than unity” indicated that the crop used its domestic resources efficiently throughout the period studied in the States of the study. The crop was more competitive in the Northern States than in the Gezira State. These results also were consistent with Ibrahim (1993) outcomes in the River Nile and Northern States two decades ago.

Table 2: Indicators of the policy analysis matrix for the States of the Study

Indicator	Gezira	River Nile	Northern	SUDAN
PC	6.214151225	1.247655125	1.247655125	2.12090652

IVA	1,776,402	4,424,428	4,276,974	3,492,601
NPCI	98.72	103.11	314.87	140.33
NPCO	10.64948307	6.19204591	6.532197728	7.09944664
EPC	5.119620441	0.944818027	0.931898112	1.64733835
DRC	0.20842014	0.265018805	0.219786353	0.23799775

Conclusion and Recommendation

The Policy Analysis Matrix (PAM) methodology was used to determine the level of competitiveness in the production of wheat in the three states in the normal season of 2020/21.The study results showed that wheat was more competitive in all states. The results of agricultural policy analysis of the wheat subsector growers in the States of the study showed that wheat generates private profits in all State under the Study namely, Gezira, Northern and River Nile States, indicating wheat had positive private and economic profitability and the private ones were greater than the social ones. They were internationally competitors and realized foreign exchange earnings. The results of NPCI ratios generally showed high cost of private prices of tradable inputs than its social prices, meaning of distorting policies caused due to high taxes or an appropriate exchange rate those lead farmers' losses. While, NPCO ratios results showed that the private output prices of wheat were higher than their social prices that indicted farmers had been received an implicit subsidy in producing wheat. The EPC ratio in Gezira state shows positive incentives effects represented in subsidy to farmers in outputs prices while they were negative in other states and a positive one in an average in Sudan. Production of wheat had comparative advantage in all states; therefore, represent an efficient use of the country's resources. Based on the finding of the study one may recommend the following with regard to wheat subsector:

(1) Credit is necessary to shifts production. So; the government should ease accession to credit and loans to spur agriculture development. Although the Agriculture Bank supply wheat farmers with improved varieties, fuel, fertilizer and help them in land preparations, but most of them came late which result in low productivity that swamps farmers in debts and increases their tendency to migrate to cities in search of wage labor.

(2) The government should decrease indirect taxes (value added, customs and standards fees…etc.) of tradable inputs like fertilizers, chemicals, fuel and spare parts.

(3) If the government wants to persist with its food security policies, higher productivity gains will have to occur in wheat production, or else large wheat imports will take place and because any noneconomic target is inherently costly, the policy makers should use macroeconomic instruments to make wheat production economically attractive.

References

Ali, S.A.R (2002). The Prospect of Wheat Production under World Trade Organization. (Case Study in Gezira Scheme versus Northern Region). M.Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.

Fabian, T. (2005). Commodity Chain Analysis; Impact Analysis Using Shadow Prices, Food and Agricultural Organisation of the United Nations, Rome, Italy. Pg. 17.

Ibrahim, I.O. (1993). Economics of Crop Production in the Northern Region. A case Study of Kariema Abu-Hamad Area. M.Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.

The Economic Research Forum (ERF). (2021). ERF Working Paper No. December, 2021. 21 Al-Sad Al-Aaly Street Dokki, Giza Egypt.

Osman A.K.; Ali, M.E.K. (2010). Crop production under traditional rain-fed agriculture. Proceedings of the National Symposium on: Sustainable Rain-Fed Agriculture in Sudan. Al-Sharga Hall, University of Khartoum, Khartoum, Sudan 17 –18 November 2009. Published by: UNESCO Chair of Desertification Studies, University of Khartoum.

Jenkins, G.P.; Harberger, A.C. (2011). Cost-Benefit Analysis for Investment Decisions (Ch. 11). Cost-Benefit Analysis for Investment Decisions (2011 Manuscript, pp. 1-38).

Hussien, A.I.M. (1992). Agricultural Price Policy in Sudan; A Case Study of Sorghum and Wheat. M.Sc. Thesis. Faculty of Agriculture, University of Gezira, Sudan.

Pearson, S.; Gotsch, C.; Bahri, S. (2003). Applications of the Policy Analysis Matrix in Indonesian Agriculture (p. 368). Retrieved from. https://books.google.com.co/books?id=NrLoroQvkRMC&pg=PA19&lpg=PA19&dq=Applications+of+the+Policy+Analysis+Matrix+in+Indonesian+Agriculture&source=bl&ots=PMuVD6_FVx&sig=A91gRlrNW1DK6ny_5mXcEhLZTW8&hl=es&sa=X&ei=nm_iVM7PEITYgwTU3YHIBQ&ved=0CEYQ6AEwBA#v=onep

Pearson, S. and Monke (1987). The Policy Analysis Matrix: A manual for Practitioner, the progma corporation, falls church, Washington, D.C.

Masters, W.A.; Winter-Nelson, A. (1995). Measuring the comparative advantage of agricultural activities: domestic resource costs and the social cost-benefit ratio. Am. J. Agric. Econ: 77: 243-250.

Mohammed, N.J. (2015). *Measuring of The Comparative Advantage and Competitiveness on Wheat Production in Iraq by Using Policy Analysis Matrix* (No. 1025, p. 260).

Monke, E.; Pearson, S.R. (1989). *The Policy Analysis Matrix for Agricultural Development*. Cornell University Press, Ithaca and London. https://doi.org/10.1080/03768359008439507

Osman, A.H. (2004). The Sudanese Agricultural Development Strategy (SADS) 2003-2007; A critical Review. M.Sc. Thesis, University of Reading, U.K.

Samarendu, M.F.C. Jagadanand, C. (2003). Assessing the competitiveness of Indian cotton production: A policy analysis matrix approach. J. Cotton Sci., 7: 65–74.

Christo, J. (2010). The Competiveness and Efficiency of the South African Broiler Industry: A Publication of the National Agricultural Marketing Council, South Africa. June, 2010.

World Bank (2015). Sudan Country Economic Memorandum: Realizing the Potential for Diversified Development. Washington, DC.

Nile Valley University Publications
Nile Journal for Agricultural Sciences (NJAS)
(ISSN: 1585 – 5507)
Volume 08, No. 01, 2023
http://www.nilevalley.edu.sd

تأثير مبيدي قول 24 إي سي واستومب 500 إي سي علي مكافحة الحشائش، نمو وانتاجية الحلبة (*Trigonellafoenum-graecum*)

<u>مختار عبد العزيز محمد عثمان</u>، هاجر عبد المعروف عبد الوهاب وأمال عبد الحليم نصر خيري

كلية العلوم الزراعية – السليم – جامعة دنقلا

ممثل المؤلفين: 0920345890&0911162653&0122843150:mukhtarazizm@gmail.com

المستخلص

أجري هذا البحث خلال موسمين شتويين متعاقبين للعامين 2018/19م و2019/20م بمزرعة كلية العلوم الزراعية بالسليم .وحدة شرق النيل . محلية دنقلا. الولاية الشمالية، الواقعة بين خطي عرض °16 و ° 22 شمالاً وخطي طول °20 و °32 شرقاً لتقييم ومقارنة تأثير مبيدى الحشائش قول (أوكسى فلوروفين) EC %24 بمعدل1.7، 2.4 و 2.5 كجم. مادة فعالة (م.ف) للفدان و أستومب (بنديميثالين) EC 500 بمعدل 1.7، 2.5 و 3.4 كجم .م.ف للفدان المستعملان قبل الانبثاق على الحشائش وإنتاجية الحلبة لتحديد أنسب معاملة لمكافحة الحشائش وتحقق أعلى إنتاجية. أظهرت النتائج أن الحشائش السائدة في موقع التجربة كانت حشائش عريضة الأوراق. مبيد الحشائش قول كان الأفضل في مكافحة الحشائش رفيعة الاوراق بينما مبيد الحشائش استومب كان الأفضل في مكافحة الحشائش عريضة الأوراق. مبيدي قول بالجرعة 2.4 و2.5 واستومب بالجرعة 2.5 و 3.5 كجم م.ف/الفدان قللا معنوياً الوزن الجاف للحشائش (جم/ 2). الجرعة العالية لمبيد الحشائش قول (2.5 كجم م.ف/فدان) حققت أقل وزن جاف للحشائش (جم) وتلتها الجرعة العالية (3.5 كجم م.ف/فدان) لمبيد الحشائش استومب. الجرعة العالية لكل من مبيدي الحشائش قول (2.5 كجم م.ف/فدان) واستومب (3.5 كجم م.ف/فدان) والإزالة اليدوية المستمرة للحشائش طول الموسم أعطت زيادة معنوية في مؤشرات النمو وعدد القرون في النبات والإنتاجية (كجم/فدان). أشار تحليل نتائج الموسمين الشتويين مجتمعة إلي أن منافسة الحشائش لمحصول الحلبة قللت معنوياً إنتاجية البذور (كجم/فدان) بنسبة 33.33%. أوضح البحث أن الجرعة العالية لكل من القول (2.5 كجم/فدان) والأستومب (3.4 كجم/فدان) هي الأفضل.

كلمات مفتاحية: أستومب، قول، قبل الانبثاق، منافسة الحشائش

Effect of Goal 24% EC and Stomp 500 EC on Weed Control, Growth, Yield of Fenugreek *(Trigonellafoenum-graecum)* in Northern State, Sudan

Mukhtar Abdel Aziz Mohamed Osman, Hagir Abdel Marouf Abdel Wahab and Amal Abdel Haleem Nasur Kheyri

Faculty of Agricultural Science, El Selaim, University of Dongola

Correspondent author: mukhtarazizm@gmail.com 0122843150 & 0911162653 & 0920345890

Abstract

This research was conducted during two consecutive winter seasons of the years2018/19 and 2019/20 at the Demonstration Farm of the Faculty of Agricultural Sciences- El Selaim – ShergElneel Unit - Dongola Locality - Northern State, located within Latitude 16° and 22° N, and Longitude 20°and 32° E to evaluate and compare the effect of two herbicides Goal (oxyflourofen) 24% E. C. at 1.7, 2.4 and 2.5 kg. a.i/fed., and Stomp (pendimethalin) 500 E. C., at 1.7, 2.5 and 3.4 kg.a.i/fed., applied pre-emergenceon weed and yield of Fenugreek to determine the most suitable weed control treatment to achieve high yield. Results showed that, broad-leaves weeds were predominant in the experimental site. Goal herbicide was the best for controlling narrow leaved weeds while Stomp herbicide was the best for controlling broad-leaved weeds. Goal at 2.4 and 2.5 and Stomp at 2.5 and 3.5 kg a. i./fed significantly reduced weed biomass (g/m^2). The high rate of Goal herbicide (2.5 kg a. i./fed) achieved least weed biomass (g) and was followed by the high rate of Stomp (3.5 kg a.i./fed). The high rate for each herbicide Goal (2.5 kg a.i./fed), Stomp (3.5 kg a.i./fed) and continuous hand weeding full season significantly increased growth parameters, number of pods/plant and the yield (kg/fed.). Combined analysis of both winter seasons indicated that, weed competition for fenugreek crop significantly reduced seed yield (kg/fed.) by 33.33%. The research reported that, the high rate for each herbicides Goal (2.5kg/fed.) and Stomp (3.4 kg/fed.) were the best.

***Keywords*:** Stomp, goal, pre-emergence, weed competition

المقدمــة

تنتمي الحلبة (*Trigonella foenum-graecum*) fenugreek الى العائلة Fabaceae وهي محصول بقولي حولي وتعتبر من المحاصيل الغذائية الهامة وتستخدم بذورها في تغذية الإنسان بينما تستخدم مجاميعها الخضرية كعلف للحيوانات. كذلك يستخدم هذا المحصول كسماد أخضر لرفع خصوبة التربة (Bagri *et al.,* 2014). ويستخدم دقيق الحلبة مخلوطاً مع دقيق القمح أو الذرة لعمل الخبز لاحتوائه على المواد الغروية التي تساعد على تماسك العجينة. وتزرع الحلبة أيضا كنباتات رعوية للحيوانات ومن الممكن أيضاً تغذية الحيوانات على البذور (Bagri *et al.,* 2014؛ Fagaria *et al., 2014*).

تشكل الآفات الزراعية المختلفة وخاصةً ولا سيما الحشائش أهم عوائق الإنتاج الزراعي حيث تعتبر من أخطر الآفات الزراعية التي تسبب خسائر كبيرة في إنتاجية المحاصيل خاصةً محصول الحلبة وذلك عن طريق منافستها له على الماء، الغذاء، المكان والضوء وكما تستنفد خصوبة التربة وبالتالي ينعكس سلباً علي إنتاجية ونوعية المحاصيل بما فيها الحلبة وتستنفد خصوبة التربة (Mohamed *et al.,* 2013؛ حسين، 2013 وقمر، 2012).

يمكن مكافحة الحشائش تقليدياً باستخدام الطرق الميكانيكية وتتمثل في حرث الأرض والإزالة اليدوية. أيضاً يمكن مكافحتها كيميائياً عن طريق استخدام مبيدات الحشائش الاختيارية والتي تتميز بقدرتها على مكافحة الحشائش دون حدوث ضرر للمحاصيل النامية معها (عثمان، 2014 ؛ حسين، 2013). تطبيق مبيدات الحشائش يجب أن يكون في الوقت المناسب وبالجرعات الموصي بها (الخضر، 2007م).

الهدف الرئيسي من إجراء هذه التجربة هو تقييم تأثير مبيدى الحشائش قول (أوكسي فلوروفين) وأستومب (بنديميثالين) المستعملان رشاً قبل الانبثاق على الحشائش من حيث عددها ووزنها الجاف وتحمل وإنتاجية الحلبة في محاولة لتحديد أنسب معاملة لمكافحة الحشائش و تحقق أعلى إنتاجية.

الطرق والمواد

أجريت التجربة خلال موسمين شتويين متعاقبين للعامين 19/2018م و20/2019م بمزرعة كلية العلوم الزراعية– جامعة دنقلا- الولاية الشمالية. تقع الولاية الشمالية بين خطي عرض 16 و 22 شمالاً وخطي طول 20 و 32 شرقاً وحدودها الشمالية هي الحدود المشتركة بين السودان ومصر وتمتد غربا حتى حدود الجماهيرية الليبية (الطيب، 2019م). تتصف التربة التي أجريت عليها التجربة بأنها تربة طينية و تحتوى على 20.7% رمل، 17%غرين و 33.6.% طين أو طفل (قمر، 2012).

صممت التجربة عن طريق التصميم العشوائي الكامل بأربع مكررات. تم إعداد التربة جيداً وتم تقسيمها إلى أحواض وتمت زراعة بذور الحلبة صنف بلدى يدوياً في كل حوض في صفوف مسطحة تبعد عن بعضها مسافة 70سم والمسافة بين الحفر 30سم وذلك في 13 نوفمبر في كل موسم.

تم تطبيق مبيدي الحشائش قول (أوكسي فلوروفين) 24% EC وأستومب (بنديميثالين) 500 إي سي (500 EC) قبل الانبثاق باستخدام رشاشة ظهرية تم معايرتها بمعدل 150 لتر للفدان وشملت المعاملات: قول 24% EC بمعدل1.7، 2.4 و 2.5 كجم. م.ف للفدان وأستومب 500 إي سي (500 EC) بمعدل 1.7، 2.5 و 3.4 كجم مادة فعالة (م.ف) للفدان. بالإضافة إلي معاملة خالية من الحشائش طول الموسم وأخرى موبوءة بالحشائش طول الموسم للمقارنة.

تأثير معاملات المبيدين على الحشائش في كل معاملة تم قياسه عن طريق حساب عدد كل نوع بمفرده في المتر المربع باستخدام إطار خشبي مربع بعد 4 أسابيع من تطبيق المبيدين. أيضاً تم تحديد الوزن الجاف بالجم فى المتر المربع في كل معاملة عدا المعاملة الخالية من الحشائش طول الموسم. كذلك تم حساب النسبة المئوية لمكافحة الحشائش النجيلية وعريضة الأوراق مقارنة بالشاهد فى كل معاملة.

بعد 8 أسابيع من الزراعة تم تسجيل ارتفاع النبات بالسم، عدد الأوراق في النبات، عدد الفروع في النبات فى كل معاملة. عند الحصاد تم تسجيل عدد القرون فى النبات، وزن 100 حبة وإنتاجية البذور (كجم للفدان).

البيانات التي تم الحصول عليها تم تحليلها إحصائياً كما جاء في كتاب Gomez وGomes، (1984)عن طريق تحليل التباين (ANOVA) باستخدام حزمة التحليل لبرنامج علم الاجتماع (SPSS).

النتائج والمناقشة

تطبيق مبيد القول على الحشائش أدى الى مكافحة الحشائش رفيعة الأوراق وتراوحت هذه المكافحة من جيدة إلى ممتازة بنسب تراوحت من 70% الى 96% بينما تطبيق مبيد الحشائش استومب أدى إلى مكافحتها وهذه المكافحة تراوحت من ضعيفة الى جيدة بنسب تراوحت من 46% الى 70% (جدول 1). كافح مبيد الحشائش قول الحشائش رفيعة الأوراق بصورة أفضل من مبيد الحشائش أستومب (جدول 1). هذه النتائج مشابهة للنتائج التي تحصل عليها Mohamed and Elamin (2011) الذين أوضحوا أن مبيد القول كافح الحشائش رفيعة الأوراق بصورة جيدة ومرضية بينما مكافحتها بمبيد الأستومب كانت ضعيفة.

أدي تطبيق مبيد الحشائش قول إلي مكافحة الحشائش عريضة الاوراق حيث تراوحت هذه المكافحة من ضعيفة إلى جيدة بنسب تراوحت من 43% الى 68% بينما تطبيق مبيد الاستومب على الحشائش عريضة الاوراق أدى الى مكافحتها بصورة تراوحت من جيدة الى ممتازة بنسب تراوحت من 62% إلى 92% (جدول 1). مبيد الحشائش استومب كافح الحشائش عريضة الاوراق بصورة افضل من مبيد الحشائش قول (جدول 1). هذه النتائج توافق النتائج التي توصل اليها Mohamed and Elamin (2011) الذين أشاروا إلي أن مبيد الأستومب كافح الحشائش عريضة الأوراق بصورة ممتازة بينما مكافحتها بمبيد القول كانت ضعيفة.

اعطي مبيدي الحشائش قول بمعدل 2.4 و2.5 واستومب بمعدل 2.5و 3.5 كجم م.ف/الفدان نقص معنوي في الوزن الجاف للحشائش مقارنة بالشاهد. أقل نقص في الوزن الجاف للحشائش حققته الجرعة العالية (2.4 كجم م.ف./الفدان) لمبيد الحشائش قول وتلته الجرعة العالية (3.4 كجم م.ف./الفدان) لمبيد الحشائش استومب بالرغم من عدم وجود فرق معنوي بينهما (جدول 1). هذه النتائج متطابقة مع نتائج تحصل عليها Mohamed and Elamin (2011) الذين ذكروا أن مبيدي القول والأستومب قللا معنوياً الوزن الجاف للحشائش. الحشائش عريضة الأوراق كانت سائدة في موقع التجربة بنسبة 76.8%.

أشار تحليل الموسمين الشتويين مجتمعة إلي أن استخدام الجرعتين المتوسطة والعالية لكل من مبيدات القول والاستومب والإزالة اليدوية للحشائش حتى نهاية الموسم أدي إلى زيادة معنوية في ارتفاع النبات بالسم مقارنة بالشاهد.

اعطي تطبيق مبيدي قول بالجرعة 2.4 و2.5 واستومب بالجرعة 3.4 كجم م.ف. زيادة معنوية في ارتفاع محصول الحلبة وهذه الزيادة كانت مشابهة للإزالة اليدوية حتى نهاية الموسم (جدول 2). هذه النتائج مماثلة للنتائج التي أشار اليها Mohamed and Elamin (2011) الذين أشاروا إلي أن تطبيق مبيدي قول وأستومب حققا زيادة معنوية في ارتفاع النبات.

أعطت كل جرعات مبيدي الحشائش قول واستومب (عدا الجرعة المنخفضة لمبيد الحشائش استومب) والإزالة اليدوية للحشائش حتى نهاية الموسم زيادة معنوية في عدد الأوراق للنبات مقارنة بالشاهد. أعطت الجرعة العالية لكل من مبيدي قول واستومب زيادة معنوية في عدد الأوراق للنبات وكانت مشابهة للعدد الذي حققته الإزالة اليدوية المستمرة للحشائش (جدول 2). هذه النتائج مطابقة للنتائج التي توصل اليها Mohamed and Elamin (2011) الذين أشاروا إلي أن تطبيق مبيدي قول وأستومب حققا زيادة معنوية في عدد الأوراق في النبات.

الجرعة العالية لكل من القول والاستومب والإزالة اليدوية المستمرة للحشائش أعطت زيادة معنوية في عدد الفروع في النبات مقارنة بالشاهد وكانت زيادة هذه الجرعتين مشابهة لتلك التي حققتها الإزالة اليدوية المستمرة للحشائش (جدول 2).

الجرعتين المتوسطة والعالية لكل من مبيدي الحشائش قول واستومب والإزالة اليدوية المستمرة للحشائش حتى نهاية الموسم أعطت زيادة معنوية في عدد القرون في النبات مقارنة بالشاهد. الجرعة العالية لكل من مبيدي الحشائش قول واستومب أعطت عدد قرون مشابهة للإزالة اليدوية المستمرة للحشائش حتي نهاية الموسم (جدول 3). هذه النتائج مطابقة للنتائج التي توصل اليها Bedry and Abbas (2011) الذين أوضحوا أن تطبيق مبيدي قول وأستومب حققا زيادة معنوية في القرون في النبات.

كل معاملات مبيدي الحشائش المستخدمة والإزالة اليدوية للحشائش حتى نهاية الموسم لم تحقق زيادة معنوية في وزن 100بذرة مقارنة بالشاهد (جدول 3). هذه النتائج تؤيد النتائج التي أشار اليها Mohamed and Elamin (2011) الذين أشاروا إلي أن تطبيق مبيدي قول وأستومب لم يحقق زيادة معنوية في وزن 100بذرة.

أشار تحليل نتائج الموسمين الشتويين مجتمعة إلي أن منافسة الحشائش لمحصول الحلبة أدت إلي نقص في الإنتاجية (كجم/فدان) بنسبة 33.33% مقارنة بإنتاجية الإزالة اليدوية المستمرة (جدول 3).. يعزي هذا النقص الكبير في إنتاجية الحلبة إلي تأثير الحشائش سلباً علي مختلف مكونات الإنتاجية وذلك عن طريق منافستها للمحصول علي الماء، الغذاء، الضوء والمكان. هذه النتيجة تؤيد ما توصل إليه Bagri *et al.* (2014) وFagaria *et al.* (2014) الذين أشاروا إلي أن منافسة الحشائش لمحصول الحلبة أدت إلي نقص في الإنتاجية بنسبة كبيرة.

أشار تحليل الموسمين الشتويين مجتمعة إلي أن الجرعة المتوسطة والعالية لكل من مبيدي الحشائش قول واستومب والإزالة اليدوية المستمرة للحشائش طول الموسم أدت إلى زيادة معنوية في إنتاجية الحلبة (كجم/فدان) وهذه الزيادة الناتجة من جرعتي كل من المبيدين كانت مشابهة لإنتاجية الإزالة اليدوية المستمرة حتى نهاية الموسم (جدول 3).

الزيادة في الإنتاجية يمكن أن تعزى إلى مكافحة الحشائش أولاً بأول بواسطة معاملات مبيدي الحشائش المستعملة وهذا أدى إلى انعدام المنافسة من قبل الحشائش وبالتالي امتص النبات الكمية التي احتاجها من الماء والكربون والعناصر المعدنية وهذا أدي إلي قوة النمو الخضري وبالتالي انعكس هذا إيجابا على الإنتاجية ومكوناتها. هذه النتائج تؤيد النتائج التي توصل إليها Bedry and Abbas (2011) و Mohamed and Elamin (2011) الذين أوضحوا أن تطبيق مبيدي قول وأستومب حقق زيادة معنوية في انتاجية المحصول بنسبة كبيرة.

أشار تحليل الموسمين الشتوين مجتمعة إلي أنه بمقارنة معاملات مبيدي الحشائش مع بعضها البعض اتضح أن الجرعة العالية لكل من القول (2.5 كجم/فدان) والأستومب (3.4 كجم/فدان) هي الأفضل حيث حققا أعلي إنتاجية بذور للحلبة ومشابهة لإنتاجية معاملة الإزالة اليدوية المستمرة حتي نهاية الموسم.

للحصول على إنتاجية وفيرة من محصول الحلبة ينصح باستخدام الجرعة العالية من أحد هذين المبيدين كمعاملة قبل الانبثاق بدلاً عن إزالة الحشائش يدوياً حتى نهاية الموسم.

جدول (1): تأثير معاملات مبيدي الحشائش قول 24 إي سي وأستومب 500 إي سي على مكافحة الحشائش ضيقة وعريضة الأوراق ووزنها الجاف (جم/م^2) بعد 4 أسابيع من التطبيق خلال الموسمين الشتوين مجتمعة

المعاملات	الجرعة كجم م.ف./فدان	النسبة المئوية للمكافحة %		الوزن الجاف للحشائش (جم/م^2)
		الحشائش رفيعة الأوراق	الحشائش عريضة الأوراق	
قول 1	1.7	70	43	16ab
قول 2	2.4	82	51	11bc
قول 3	2.5	96	68	5c
استومب1	1.7	46	62	18ab
استومب2	2.5	55	68	10bc
استومب3	3.4	70	92	6c
موبوءة طول الموسم	.	0.00	0.00	24a
نظيفة طول الموسم	.	100.00	100.00	.
الخطأ القياسي(SE)	.	.	.	0.19
معامل الاختلاف (CV%)	.	.	.	20.18

المتوسطات ذات الحروف المتشابهة في نفس العمود لا تختلف عن بعضها معنوياً تحت مستوى الاحتمالية 0.05 وفقاً ل Duncan's Multiple Range Test (DMRT)

جدول (2): تأثير معاملات مبيدي الحشائش قول 24 إي سي وأستومب 500 إي سي على مؤشرات النمو في محصول الحلبة خلال الموسمين

المعاملات	الجرعة كجم م.ف./فدان	ارتفاع النبات (سم)	عدد الأوراق في النبات	عدد الفروع في النبات
قول 1	1.7	26c	56b	6c
قول 2	2.4	46a	60b	9c
قول 3	2.5	49a	67a	9ab
استومب1	1.7	19c	44bc	5c
استومب2	2.5	40b	65b	7c
استومب3	3.4	44a	70a	8ab
موبوءة طول الموسم	.	23c	28c	5c
نظيفة طول الموسم	.	46a	72a	12a
الخطأ القياسي (SE)	.	0.67	0.66	0.15
معامل الاختلاف(CV%)	.	8.55	22.36	13.88

المتوسطات ذات الحروف المتشابهة في نفس العمود لا تختلف عن بعضها معنوياً تحت مستوى الاحتمالية 0.05 وفقاً ل Duncan's Multiple Range Test (DMRT)

.

جدول (3): تأثير معاملات مبيدي الحشائش ول 24 إي سي وأستومب 500 إيسي على الانتاجية ومكوناتها في محصول الحلبة خلال الموسمين الشتويين مجتمعة

المعاملات	الجرعة كجم م.ف./فدان	عدد القرون في النبات	وزن 100 بذرة بالجم	الإنتاجية كجم/فدان
قول 1	1.7	36bc	0.002a	785c
قول 2	2.4	59b	0.002a	857b
قول 3	2.5	81a	0.003a	1009a
استومب1	1.7	40bc	0.002a	792c
استومب2	2.5	54b	0.002a	901b
استومب3	3.4	82a	0.003a	1003a
موبوءة طول الموسم	.	34c	0.002a	730c
نظيفة طول الموسم	.	90a	0.003a	1095a
الخطأ القياسي (SE)	.	0.17	0.46	0.15
معامل الاختلاف (CV%)	.	22.19	12.74	15.91

المتوسطات ذات الحروف المتشابهة في نفس العمود لا تختلف عن بعضها معنوياً تحت مستوى الاحتمالية 0.05 وفقاً ل Duncan's Multiple Range Test (DMRT) .

المراجـع

الطيب، نهلة عبد العزيز الماحي (2019م). أثر مبيدات حشائش الأوكسي فلوروفين والبندميثالين والإيمازيثابير علي الحشائش وإنتاجية الحمص بدنقلا. رسالة ماجستير ، جامعة دنقلا، السودان.

حسين،عاطف خضر عوض الله (2013). المكافحة الكيميائية للحشائش فى الفول المصرى. رسالة ماجستير - جامعة دنقلا-السودان.

عثمان، مختار عبدالعزيز محمد (2014). الحشائش وطرق مكافحتها، الطبعة الأولي. مطابع السودان للعملة المحدودة، الخرطوم، السودان

الخضر، علي عثمان (2007م). مقاومة الحشائش. أساسيات إنتاج المحاصيل الحقلية. مكتبة الشريف الأكاديمية للنشروالتوزيع. ص ص 142 – 147.

قمر، النعمة آدم ابراهيم (2012م). مكافحة الحشائش كيميائياً في محصول القمح بمحلية دنقلا- الولاية الشمالية. رسالة ماجستير، جامعة دنقلا، السودان.

Bagri, P.R.; Naruka, I.S.; Shaktawat, R.P.S.; Rathore, S.S ; Singh, D.(2014). Weed management in fenugreek (*Trigonella foenum-graecum* L.) International Journal of Agricultural Sciences 4(2):36-4.

Bedry, K.A.M.; Abbas, E.M.E. (2011). Chemical control of wildsorghum (*Sorghumarundinaceum* (Del.) Stapf.) in faba bean (*Viciafaba L.)* in the Northern State of Sudan. University of Khartoum Journal of Agricultural Sciences, 19(1): 78 – 90.

Fagaria, V.D.; Gupta K.C.; Ranis, A.B. (2014). Integrated weed management in fenugreek (*TrigonellaFoenum- graecum* L.) in semi-arid regions of Rajasthan. International Journal of Agricultural Sciences: 10(1) 302-304.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research, 2nd Edition.John Wily and Sons, Inc. New York.

Mohamed, M.A.M.; Atif, K.A.; Babiker, M.M. (2013). Chemical weed control in faba bean (*Viciafaba* L.) in Dongola Locality, Northern State, Sudan. Journal of Science and Technology, 14(2): 34-42.

Mohamed, M.A.; Elamin, S.E. (2011). Effect of some soil-applied herbicides on growth, yield and weed control in faba bean (*Viciafaba* L.). University of Dongola Journal for Scientific Research, (1): 255 – 268