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بسم الله الرحمن الرحيم

Introduction to the first issue

With this first issue, we are very pleased to announce the launch of the ***Nile Journal for Agricultural Sciences*** as a legitimate confinement of Nile Scientific Journal. It is a multidisciplinary, peer reviewed journal dedicated to researches in Agricultural Sciences.

There is a continuous effort experienced by scientists to develop agriculture and related sectors through applying new innovating technologies. However, a brilliant research work is meaningless unless its findings is highlighted and brought to the notice of other researchers and agriculturists, therefore, this journal could act as a common forum for active researches in agriculture and related fields to highlighting their inventions.

The journal will publish articles on a wide variety of issues of relevance to the broad subject area. Each paper will be thoroughly reviewed by 2 independent reviewers beside being in a contentious process of revision and internal judgment by members of editorial board whom will spare no effort to review and accept papers to the journal.

This issue contains seven papers. All contributions are written in English with Arabic abstracts. The papers represent different agricultural disciplines: crop protection, agricultural engineering, water-crop relations, plant ecology, crop science and plant breeding.

This inaugural issue owes much to many people. Thanks are due first to the manager of the research and publication unit at Nile Valley University; Prof. Mohamed I. Shukri, from whom the idea originated, for his wholeheartedly support, encouragement and advice.

Most of all, thanks are due to my colleague editors, Dr. Abdelazim Mohamed Ali, Prof. Abdelrahamn Ali Elmahadi and Dr. Hassan E. Elsayem who have so generously given their time and expertise to make this dream real. We also acknowledge the input of academic counsellors of the journal. Their reputation and great expertise in the field will have a significant contribution in shaping up the journal and making success. Hereinafter, on behave of the Editorial board I wish to thank the authors who submitted papers to the first issue of NJAS. We are grateful that they responded to our invitation.

Finally, we like to dedicate this very first issue to the memory of our late college professor Yahia Magzoub Abdalla who left fingerprints of faith, inspiration and devotion that will support in the endurance of this awaited birth.

Editorials

Nile Journal for Agricultural Sciences (NJAS)

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

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 one sided 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 of NJAS.

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 that follow 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. (2nd Edition), Academic Press, London, pp. 120- 128.

Book chapter

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

Conference proceedings

Basu, P.S.; Brajesh, S., Minhas, J.S.; Sing, B.; Khurana, S.M.; Shekhawat, G.S; Pandey, S.K. 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.

TABLE OF CONTENTS

Nile Valley University
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Research paper

Field Evaluation of Center Pivot Sprinkler Irrigation Systems, Atbara Food Security Scheme

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ABSTRACT

This study aimed to evaluate the performance of three center pivot sprinkler irrigation systems; A, B and C in the high terrace soil of a farm near Atbara, River Nile State. Catch-can tests were carried out to determine the performance of irrigation applied with the center pivot sprinkler irrigation systems under field conditions. The coefficient of uniformity (CU), distribution uniformity (DU), and application efficiency (AE), as performance parameters, were determined. The Center Pivot irrigation Model (CPM) was used to determine the average application depth (AgD) as well as the performance parameters CU, DU and AE. Field evaluation results indicated that for the three systems, A, B and C the CUs were 77.7, 84.1 and 92.5%, respectively, the DUs were 49.1, 71.6, and 87.1%, respectively, and the AEs were 79.7, 92.1 and 92.9%, respectively. Generally, among the three systems, both B and C showed higher performance than A. Hence, the test of performance for a center pivot sprinkler irrigation system should be carried out each season.

Keywords: *Application efficiency, coefficient of uniformity, distribution uniformity, soil moisture content*

تقييم نظم الري بالرش المحوري بمشروع الأمن الغذائي عطبرة

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أجريت هذه الدراسة لتقييم أداء ثلاث نظم ري بالرش المحوري أ، ب و ج. نفذت هذه الدراسة بولاية نهر النيل جنوب مدينة عطبرة بمزرعة في أراضي التروس العليا. استخدمت علب القياس لتقييم أداء نظام الري بالرش المحوري تحت ظروف الحقل. المعاملات التي استخدمت لتقييم وتحليل الأداء شملت معامل الانتظامية (CU)، ومعامل انتظامية التوزيع (DU)، وكفاءة الإضافة (AE). البرنامج الحاسوبي "الري المحوري CPM" أستخدم لحساب معدل إضافة مياه الري (AgD) بالإضافة لحساب معاملات تقييم الأداء CU و DU و AE. نتائج التقييم الحقلي أوضحت أن معامل الانتظامية للثلاث نظم ري أ و ب و ج هي 77.7 ، 84.1 و 92.5 % على التوالي. من الناحية الأخرى، أوضحت النتائج أن معامل انتظامية التوزيع هي 49.1 ، 71.6 و 87.1 % وكفاءة الإضافة هى 79.7 و 92.1 ، 92.9 % للثلاث نظم ري أ، ب، وج على التوالي. من الناحية العامة أوضحت نتائج تقييم الأداء أن نظامي الري بالرش المحوري ب، وج كان أدائهما أفضل من أ عليه فإن دراسة كفاءة نظام الري المحوري يجب أن تطبق سنوياً.

Introduction

The role of irrigation development is to improve production and input efficiency in areas where the climate limits production potential. The global climate change and scarcity of water resources have further reduced the amount of water available for agriculture.

Irrigation systems improvements becomes very imperative because of the serious constraint faced by irrigators due to water scarcity and the ensuing competition for water by other higher-valued industrial concerns and urban uses. This trend is expected to continue due to improvements in water application efficiency and labor reduction associated with sprinkler irrigation systems (Ahaneku, 2010).

An ideal irrigation system should apply the correct amount of water, minimize the losses, and apply the water uniformly. Valin *et al*. (2012) stated that when the sprinkler irrigation system is properly designed and managed more than 90% of water applied can be utilized by the crop. Irrigation performance assessment will enable irrigation managers to measure and determine actual performance; identify which factors are responsible for less than ideal performance and determine the relative impact of these factors and how they might be addressed.

Center-pivot sprinkler irrigation systems have experienced a wide diffusion worldwide because of their advantages relative to other irrigation systems. Therefore, it is important to characterize the significance of several design and management factors affecting the efficiency and uniformity of these systems (Montero *et al.*, 2003).

Since no irrigation system can apply water precisely to all areas of the field, it becomes necessary to estimate the uniformity of water application in order to assess the performance of the system. A non-uniform application will result in areas of under-watering as well as areas of over-watering. This will result in reduced yields as well as decreased system efficiency (Acar *et al.*, 2010). To help keep a center pivot irrigation system at peak efficiency, on-farm evaluations can be used to measure a system's average irrigation amount and identify uniformity problems that cannot be seen visually.

The uniformity of water application under a center pivot could be determined by setting out identical catch-cans along the length of the pivot, bringing the irrigation system up to proper operating pressure, and letting the system pass over them. The two most common methods of expressing uniformity are the coefficient of uniformity (CU) and distribution uniformity (DU).

The coefficient of uniformity (CU), proposed by Christiansen (1942) and modified by Heerman and Hein (1968), is the most popular uniformity coefficient used with center pivot catch-can data to include a term representing the distance from the center to the catch-can. It is recommended by the American Society of Agricultural and Biological Engineers (R2007) to evaluate the uniformity of water application as follows:

$$CU = 100\left[1.0 - \frac{\sum Ss\left|Ds - D\right|}{\sum DsSs}\right] \quad (1)$$

Where, CU is the coefficient of uniformity, Ds is the applied water depth for one collector position, D is the average applied water depth for all collectors and Ss is the distance to equally spaced collectors.

The distribution uniformity (DU) was computed by dividing the average low quarter caught in the cans by average depth caught in all cans as applied by Harrison and Perry (2010):

$$DU=\left[\frac{\text{Average low quarter caught in the cans}}{\text{Average depth caught in all cans}}\right] \ldots\ldots..(2)$$

The average application depth was determined by dividing the pumped volume by the application area (Almasraf *et al.*, 2011):

$$\text{Average application depth (m)} \; \frac{\text{time per revolution (Hrs)} \times \text{system flow rate (m}^3\text{/Hrs)}}{\text{irrigated area (m}^2\text{)}} \ldots (3)$$

Rodrigues and Pereira (2009) reported that when the center pivot sprinkler irrigation system has low distribution uniformity, water productivity as well as economic efforts are low. Valin *et al.* (2012) stated that improving center pivot sprinkler irrigation systems design and management resulted in increasing water application uniformity, reducing energy used with lower pressure, and controlling negative environmental impacts such as excessive water and fertilizer operational losses.

Further, the application efficiency (AE) is an indicator of water that is lost during the process of supplying water to the field due to evaporation and wind drift losses. It is defined as the volume of water applied to the surface divided by the volume of water exiting in the sprinkler emitter (Rinders, 2001):

$$AE = 100 \times \left[\frac{M \times Ap}{Vs}\right] \ldots \ldots . . (4)$$

Where, AE is the application efficiency (%), Ap is the plot area (m^2), M is the mean application depth (mm) and Vs is the volume exiting from sprinkler or emitter during CU test (m^3).

According to Harrison and Perry (2010), the basic interpretation of uniformity coefficients of center pivot irrigation systems is as follows: 90 to 100 % excellent; no changes required, 85 to 90% good; no changes required unless problem area is obvious, 80 to 85% fair; no improvement needed but system should be monitored closely and below 80% poor; where improvements needed. Rinders (2001) added that in every 1% drop in CU, crop yield might drop by 2%.

Performance evaluation may be carried out soon after the system's installation, and periodically repeated. Improvement of DU and well management of the irrigation system may lead to substantial savings in cost and the volume of water applied (Hill and Heaton, 2001).

Sprinkler irrigation systems, especially center pivot and linear move irrigation systems, have been recently introduced in limited area in Sudan, mostly in River Nile State.

The objective of this study was to evaluate the hydraulic performance of three center pivot sprinkler irrigation systems under River Nile State conditions.

Materials and Methods

This study was conducted at the Farm of Arab Company for Agricultural Production and Processing, River Nile State, at latitude 17^o 48- N, longitude

34º 00- E and altitude 346.5 m above mean sea level. Field evaluations were made on three center pivot sprinkler irrigation systems (A, B and C) during winter season 2006/2007, where some performance indicators; such as uniformity coefficient (CU), distribution uniformity (DU), and application efficiency (AE), were evaluated.

Catch-cans test was used to evaluate the three systems performance. Under each system there were two straight lines perpendicular to the direction of travel of the machine. Each line consists of 44-52 catch-cans which were identical in size and shape. The catch-cans were located separated uniformly by 7 m. The amounts of water caught in the catch-cans were measured volumetrically by measuring cylinders and then converted into depths by dividing the amount caught into the catch-can by cross sectional area. The Center Pivot irrigation Model (CPM) developed by Alsayim and Saeed (2011) was used to determine the average application depth (AgD), coefficient of uniformity (CU), distribution uniformity (DU) and application efficiency (AE). The CPM model was developed using Microsoft Visual Basic 6.0 and was run in Windows. The program was interactive for designing a new system and/or for evaluation of an existing system.

The climate data were obtained from Sudan Meteorological Authority, Atbara station which is adjacent to the experimental field. It included the means of rainfall data, maximum and minimum temperatures, relative humidity, sunshine, wind speed at 2m height and evaporation rates. Monthly mean values for 30 years (1971– 2000) are presented in Table (1).

The physical properties of research cite soil was examined at Hudeiba Agricultural Research Station laboratories. The soil was high terrace soil classified as sandy clay loam. Samples for soil moisture content and corresponding bulk density were taken from each tower of the two systems (B and C) at two depths 0-20 cm and 20-40 cm, by using a cylinder with 4.8 cm diameter and 1 m height (Table 2).

The studied three center pivot irrigation systems obtained their water via an earth canal by pumping from the River Nile. The three systems consisted of eight towers with a total length of 419, 423 and 428 m for the three systems A, B and C, respectively.

Equidistant nozzles (1.9 m) of the type Inv Wobbler ¾M were used in each of the three systems. Water flow rates were measured by flowmeters and the pressure head at the pivot point was measured.

Results and Discussion

Coefficient of uniformity (CU)

The hydraulic performance indicators of the studied three center pivot sprinkler irrigation systems are shown in Figures (1, 2, 3 and 4). Among the three tested systems, C gave the highest coefficient of uniformity (92.5%), followed by B (84.1%) and A (77.7%). The lower value of CU for the third system was still under acceptable range. The CU values must be more than 80% as acceptable range (Harrison and Perry, 2010). Usually, in sprinkler irrigation systems, low CU values could be attributed to the inaccurate arrangement in nozzle size along the system beside not following the colure code recommended by manufacture.

Also, the low value of CU under center pivot system can be attributed to clogging of nozzles and/or nozzles being worn out as mentioned by Griffiths and Lecler (2001). However, the system operator justified that, the low CU values of system A is due to unavailability of spare parts in time.

Distribution uniformity (DU)

The distribution uniformity (DU) values for A, B and C systems as illustrated in Figures 1, 2, 3 and 4 were 49.1, 71.6 and 87.1%, respectively. These results could be considered reasonable except for system A as compared to 80% value recommended by Harrison and Perry (2010).

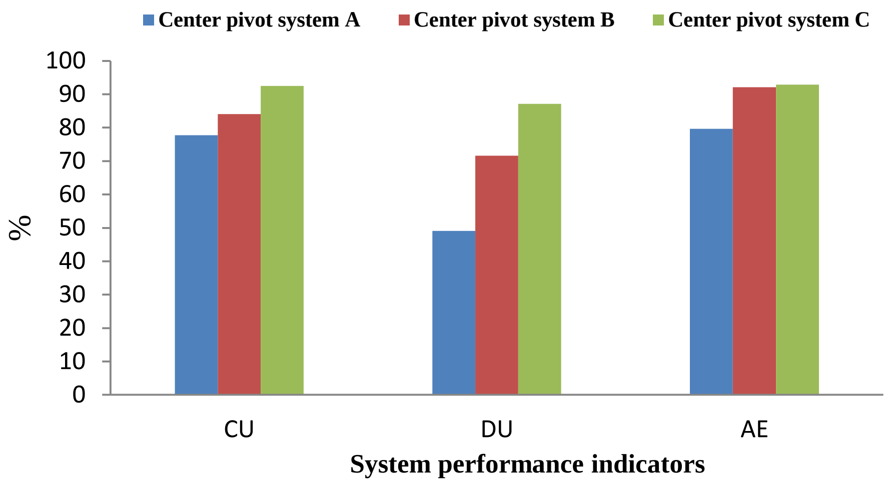
Table 1: Climatological normals (1971–2000), Atbara Station

Mon.	Air temperature in ºC				Mean dry Temp.	Bright sunshine duration		Relative humidity %	Rain fall in mm				EVAP. pitch MM	Wind Mean Speed at 2 m $m\ s^{-1}$
	Maximum		Minimum						IN MMS	No. of rain days				
	MEAN	HST	MEAN	LST	IN ºC	HRS	%	MEAN		>=0.1	>=1.0	>=10.0		
JAN	29.8	39.1	14.2	6.3	22.0	9.9	88	36	0.0	0.0	0.0	0.0	13.5	2.2
FEB	31.8	41.4	15.1	5.5	23.4	10.3	90	31	0.0	0.0	0.0	0.0	15.0	2.2
MAR	35.7	45.7	18.4	10.8	27.0	10.1	84	24	0.0	0.0	0.0	0.0	18.1	2.2
APR	40.0	46.3	22.1	15.0	31.1	10.6	85	23	0.4	0.2	0.1	0.0	20.1	1.9
MAY	42.6	47.5	26.5	18.9	34.5	9.8	75	23	3.2	0.7	0.5	0.1	20.4	1.6
JUN	43.2	48.0	28.0	21.6	35.6	8.6	65	22	1.0	0.3	0.2	0.0	20.7	1.6
JUL	41.2	47.7	27.3	19.5	34.3	8.7	65	32	15.1	1.4	1.3	0.4	19.0	1.9
AUG	40.6	46.5	26.9	19.5	33.8	8.6	67	37	26.5	2.2	2.0	0.9	18.0	1.9
SEP	41.6	47.6	27.4	20.0	34.5	8.6	71	32	8.6	1.1	1.0	0.3	18.5	1.9
OCT	39.7	44.5	25.2	16.0	32.5	9.8	83	31	3.0	0.5	0.5	0.1	17.4	1.6
NOV	34.9	40.7	20.1	11.7	27.5	10.2	90	36	0.0	0.0	0.0	0.0	14.7	1.9
DEC	31.1	38.5	16.0	6.5	23.6	9.7	88	40	0.0	0.0	0.0	0.0	13.2	1.9
Year	37.7	48.0	22.3	5.5	30.0	9.6	79	31	57.7	6.7	5.4	1.8	17.4	-

HST: Highest
LST: Lowest
Source: Sudan Meteorological Authority, Atbara Station

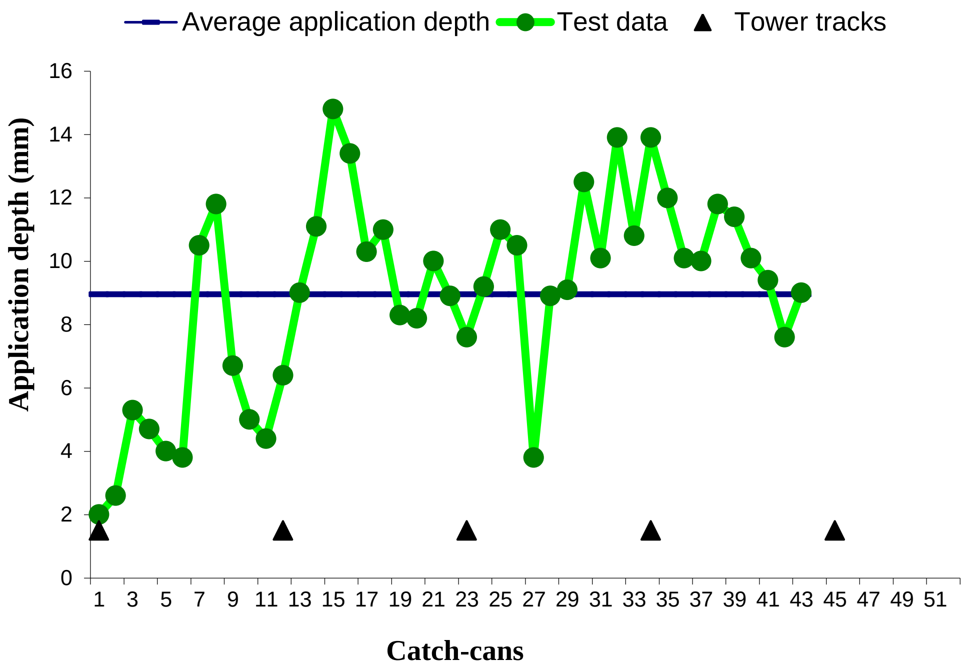
Table 2: Soil moisture content and bulk density for the two center pivot sprinkler irrigation systems B and C.

Tower No.	Depth (0-20 cm)				Depth (20-40 cm)			
	Center pivot sprinkler irrigation system **(B)**		Center pivot sprinkler irrigation system **(C)**		Center pivot sprinkler irrigation system **(B)**		Center pivot sprinkler irrigation system **(C)**	
	Moisture (%)	**Bulk Density (g/cm^3)**	**Moisture (%)**	**Bulk Density (g/cm^3)**	**Moisture (%)**	**Bulk Density (g/cm^3)**	**Moisture (%)**	**Bulk Density (g/cm^3)**
1	15.8	1.8	23.3	1.5	15.4	1.8	25.5	1.4
2	15.4	1.8	16.3	1.8	16.9	1.6	17.8	1.7
3	13.7	1.8	17.8	1.7	11.1	1.9	17.6	1.7
4	18.3	1.6	17.3	1.8	18.2	1.6	16.2	1.8
5	16.5	1.7	14.7	1.6	15.5	1.6	21.9	1.6
6	14.1	1.7	18.9	1.8	13.2	1.6	19.3	2
7	16.2	1.7	19.3	1.7	16.9	1.7	19.3	1.7
8	14.5	1.7	18.6	1.7	15.1	1.6	21.3	1.7
mean	**15.6**	**1.7**	**18.3**	**1.7**	**15.3**	**1.7**	**19.9**	**1.7**



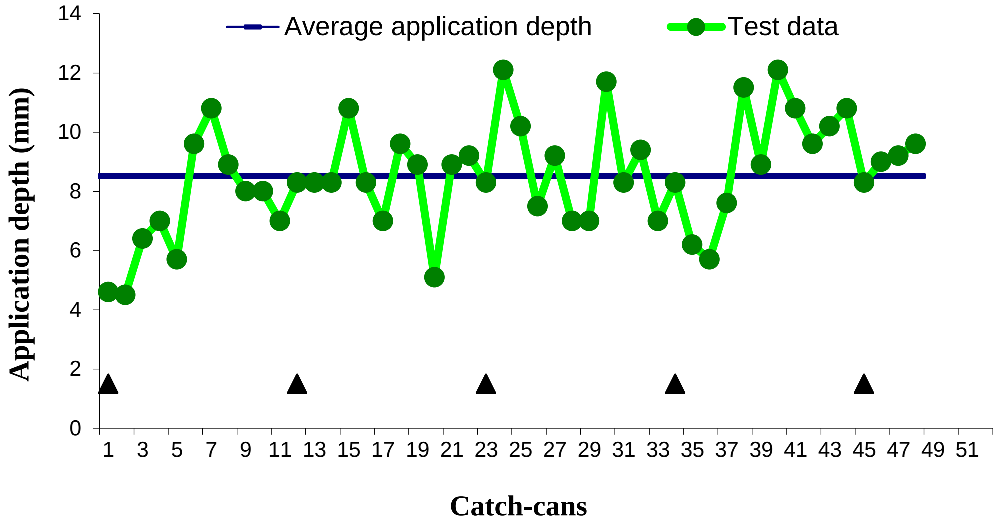
CU: Coefficient of uniformity, DU: Distribution uniformity and AE: Application efficiency

Figure 1: Hydraulic performance indicators for the three center pivot sprinkler irrigation systems



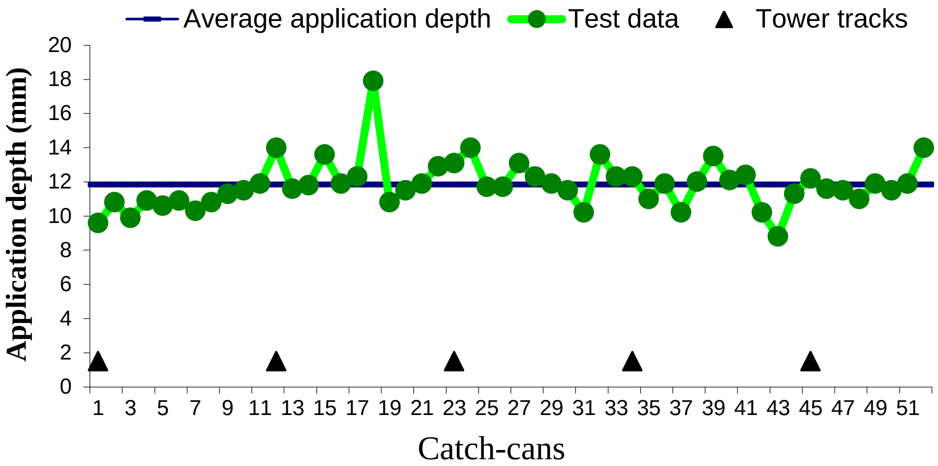
Coefficient of uniformity (CU) = 77.7 %, Distribution uniformity (DU) = 49.1 %
Application efficiency (AE) = 79.7 %

Figure 2: Uniformity test results for center pivot sprinkler irrigation system A



Coefficient of uniformity (CU) = 84.1 %, Distribution uniformity (DU) = 71.6 %
Application efficiency (AE) = 92.1 %

Figure 3: Uniformity test results for center pivot sprinkler irrigation system B



Coefficient of uniformity (CU) = 92.5 %, Distribution uniformity (DU) = 87.1 %
Application efficiency (AE) = 92.9 %

Figure 4: Uniformity test results for center pivot sprinkler irrigation system C

The low values of DU obtained may be attributed to improper replacing of the same nozzle size along the system according to operation manual. However, the uniformity of center pivot sprinkler irrigation systems is influenced by center pivot pressure, wind speed, nozzle wear, climatic condition and variation in pressure (Rinders, 2001).

Application efficiency (AE)

As shown in Figure (1) the application efficiency (AE) values obtained by the three systems are considered within the acceptable range (79.7 - 92.9%) proposed by Almasraf *et al.* (2011).

Concerning water losses, system A gave the highest value (20.3%). Correspondingly, Playa´n *et al.* (2005) reported that wind speed, as a meteorological variable, is more directly related to the sprinkler irrigation performance through its effects on the uniformity coefficient and wind drift and evaporation losses. However, Mustafa (2004) reported that the percentage of water losses for center pivot and linear move system under Sudan conditions ranges between 10 and 34.9%.

Soil moisture content

Table (2) shows the results of soil moisture content and corresponding soil bulk density for each tower for the systems B and C. The soil bulk density was 1.7 g cm^{-3} for both systems, which indicates that the two systems have the same soil type. Figure (5) represents the soil moisture content for the system B. The results showed clear variation in soil moisture content along sprinkler line (towers). This variation can be clarified by the variation of application depths caught by the catch-cans (Figure 3). On the other hand, the results of moisture content for system C showed slightly variation in soil moisture content along the sprinkler line (Figure 6) and this emphasis by high values of system performance indicators (CU=92.5% and DU=87.1%) (Figure 4).

Conclusions

In order to conserve water resources, close attention has to be paid to the performance of irrigation systems. Irrigation systems such as center pivot sprinkler irrigation systems should be evaluated on a regular basis to ensure that the systems are well maintained and are performing according to design. The distribution uniformity of a system must be as uniform as possible to ensure higher yields and efficient application of water.

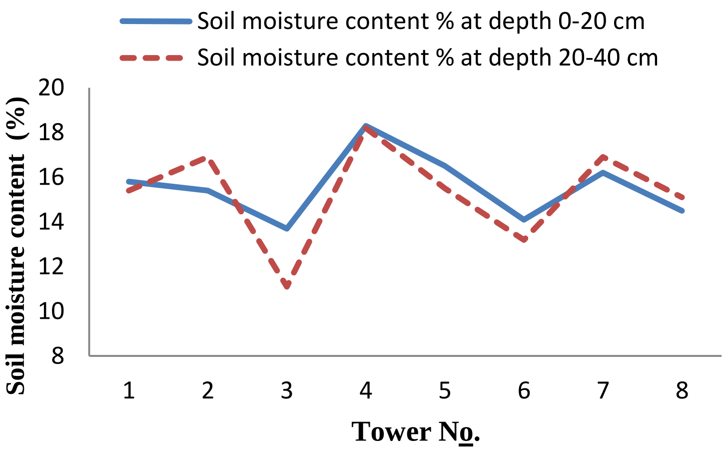


Figure 5: Soil moisture content for center pivot sprinkler irrigation system B

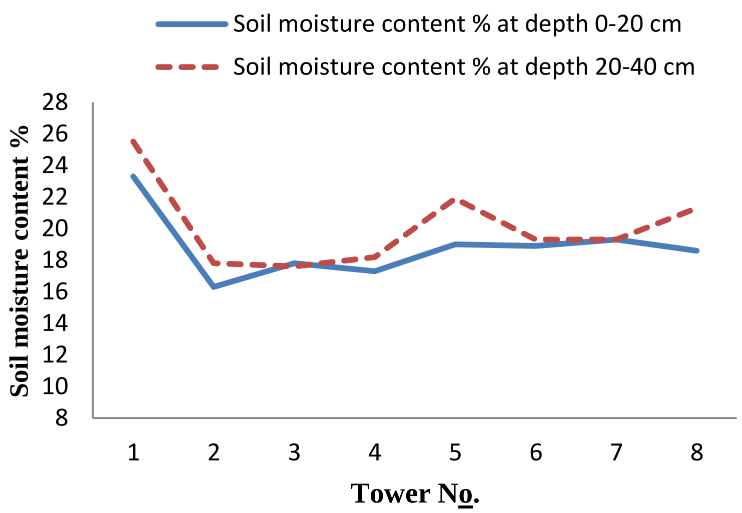


Figure 6: Soil moisture content for center pivot sprinkler irrigation system C

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Research paper

Effect of Irrigation Intervals on Growth and Yield of Semi-dry Date Palm Cultivars in River Nile State, Sudan

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ABSTRACT

The experiment was conducted at Korgus area 17 km south of Abu Hamad in the River Nile State during two seasons (2005/6 and 2006/7) to study the effect of irrigation intervals on growth and yield of two semi-dry date palm cultivars; Mishrig Wad Laggai and Mishrig Wad Khateeb. The treatments were three irrigation intervals (10 days, 20 days and 30 days). The parameters studied were annual gain in leaves number per plant, plant height, plant stem diameter (cm) and yield (kg/tree). The results showed that the irrigation intervals had significant effect on all parameters measured. The 10 days irrigation interval gave the maximum mean values for all parameters in both seasons, followed by 20 days irrigation interval, whereas the 30 days irrigation interval gave the lowest values. The effect of irrigation intervals on plant stem diameter and yield showed significant difference between the two date palm cultivars, but the number of leaves per plant and plant height were not affected.

Keywords: *Date palm cultivars, growth, irrigation intervals, yield*

تأثير فترات الري على نمو وإنتاجية أصناف التمور شبه الجافة بولاية نهر النيل، السودان

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أجريت التجربة بمنطقة كرقس التي تقع جنوب محلية أبو حمد (17 كيلومتر) بولاية نهر النيل خلال موسمي 2006/2005 و 2007/2006 بغرض دراسة أثر فترات الري على نمو وإنتاجية نوعين من أصناف النخيل شبه الجافة (مشرق ود لقاي ومشرق ود خطيب). كانت المعاملات هي فترات ري مختلفة (10 أيام، 20 يوماً و 30 يوماً). صفات النمو الخضرى للاشجار التى تمت دراستها كانت مقدار الزيادة السنوية في طول النبات، محيط الساق، عدد الأوراق بالإضافة إلى إنتاجية النخلة بالكيلوجرام. نفذّت التجربة بتصميم القطاعــات كاملة العشوائية بثلاث مكررات. أظهرت النتائــج أن لفترات الري تأثيرات معنويــة في كل الصفــات المقاسة. كما أعطت فترة الري كل 10 أيام أعلى المتوسطات لكل الصفات والإنتاجية للموسمين يتبعها فترة الري كل 20 يوماً وأخيراً فترة الري كل 30 يوماً والتي أعطت أقل قيم. أظهر تأثير فترات الري على الزيادة السنوية لمحيط ساق النبات فروق معنوية بين صنفي نخيل البلح، بينما لم تتأثر صفتى عدد الاوراق وطول النبات.

Introduction

Date palm (*Phoenix dactylifra l.*) has an important economic position in the Sudanese fruit production. The date palm is the principal horticultural crop of Northern Sudan. The number of date palms in River Nile State is estimated as one million trees, in an area of 5463.45 hectares. River Nile State is distinguished by soft and semi-dry cultivars like Mishrig Wad Khateeb and Mishrig Wad Laggai beside other dry cultivars (Sedig and Abd Alwahab, 1999).

The annual production of dates in River Nile State is estimated at about 27 thousand tons and the palm tree yield is about 30 Kg. The production is extremely low. However, it is possible for good cultivars of date palms, if provided by ideal technical packages to raise the production to about 100 kg or more (Sedig and Abd Alwahab, 1999). Most of date palm farmers in the Arab countries, where there are about 75% of the total date palm of the world, do not care much about irrigation. They believe that date palm trees can grow and bear fruits under drought and do not require irrigation. On the contrary, all the experiments and studies showed that date farming and development depend on irrigating the trees with enough water to fulfill their water requirement (Ibrahim, 2009).

Irrigation has generally proved its importance for the maintenance of regular cropping and good quality fruits of different date palm cultivars. The date palm like any other fruit tree requires enough water to compensate for the losses due to the soil surface evaporation and the transpiration from the leaves, as well as the amount that is needed during its growth and fruiting stages (Hussein and Hussein, 1983 and Gasium and Hameed, 2003). Date palms grow under desert climatic conditions and they are considered as drought resistant and salt tolerant as compared to other crops. However, it is equally important to irrigate the tree with sufficient amount of good quality water in order to produce acceptable yield and better fruit quality (Ibrahim, 2009 and Al Amoud *et al.*, 1999).

Date palm growth and yield are affected by both the magnitude of water deficit and the stage of growth subject to deficit. Insufficient water supply caused by prolonged irrigation intervals, and/or decreasing the available moisture in the soil, clearly inhibits plant growth (Scatter and Habib, 2007).

Nimir (1986) studied the effect of three irrigation intervals (10, 15 and 20 days) in combination with three irrigation water amounts (60, 75 and 90 mm per irrigation). He reported that plant height increased with short frequent and heavier irrigation. Makki and Mohamed (2005) cited that plant heights under 10 days interval were higher than those under 15 days interval. Therefore, the objective of the experiment was to study the effect of irrigation intervals on growth and yield of semi-dry date palm trees in River Nile State.

Materials and Methods

The experiments were conducted in River Nile State at "Korgus area" in the Eastern bank of the Nile and South of Abu Hamad. The region lies between latitudes 16-22^o N, longitudes 33-50^o E and generally characterized by long hot and dry summer with low relative humidity. The soil of the experimental site is clay loam near the Nile and sandy at the high terraces far from the Nile. The traditional (basin) surface irrigation system is considered the most applied irrigation system all over the River Nile State.

Irrigation treatments were 3 levels of irrigation intervals, 10 days, 20 days and 30 days. The parameters measured were annual gain in leaves number, plant height (cm), tree diameter (cm) and yield (kg/tree) for the two cultivars Mishrig Wad Laggai and Mishrig Wad Khateeb.

Tree height was measured from the terminal growing point down to the ground level by a tape. Stem diameter was determined at fixed marked points 1.3 m above ground levels.

The leaves were counted at the end of the season and at the beginning of the new season. Three leaves per tree were randomly selected after harvest in November, from the top, middle and lower parts of the tree. Small number of leaves was taken from the base, middle and terminal of the frond, mixed and dried for chemical analysis.

The design used was completely randomized block design. The data were statistically analyzed using SAS computer program.

Results and Discussion

As illustrated in Table (1), irrigation intervals showed significant effect on the number of leaves per plant for the two date palm cultivars. The largest annual gain in leaves number were obtained under 10 days irrigation interval, followed by 20 days interval, whereas the lowest annual gain in leaves number was recorded under 30 days irrigation interval in both seasons.

However, superiority of frequent irrigation over the other was reported by Saleem *et al*. (2005) who found that maximum plant height and number of leaves per plant was produced under short irrigation intervals.

Results depicted in Table (1) also showed significant effect of irrigation intervals on annual gain in plant height (cm) of the two date palm cultivars. The highest values of increment in plant height was obtained by 10 days irrigation interval, followed by the 20 days irrigation interval, and 30 days irrigation interval, for the two seasons. These results are in accordance with that obtained by Ahmed (1988) who reported a significant increase in plant height of 40 and 47% resulted from irrigation interval of 5 days compared to a long interval of 15 days.

Table 1: Mean effects of irrigation intervals on annual gain in leaves number, tree height (cm), tree diameter (cm) and on yield (kg) of the two date palm cultivars.

	Annual gain in leaves number		Annual gain in plant height (cm)		Annual gain in plant stem diameter (cm)		Yield (kg)	
Season	**05/2006**	**06/2007**	**05/2006**	**06/2007**	**05/2006**	**06/2007**	**05/2006**	**06/2007**
Irrig. Interv. 10 days	2.1 a	2.5 a	9.0 a	11.5 a	18.5 a	19.9 a	124.4 a	115.1 a
20 days	0.9 b	2.1 b	6.8 b	8.1 b	16.4 b	17.5 b	115.03 ab	97.36 ab
30 days	0.6 c	1.3 c	5.9 b	7.1 b	14.6 c	15.2 c	106.48 b	87.04 b

Means in the same column with the same letters are not significantly different at 5% level

As presented in Table (1), irrigation intervals has significant effect on plant stem diameter (cm) in both seasons. The largest increase in plant stem diameter was obtained under the 10 days irrigation interval in the two seasons, followed by the 20 days irrigation interval, whereas the smallest plant stem diameter was recorded under the 30 days irrigation interval in both seasons. The superiority of the 10 days irrigation interval might be attributed to the fact that it provides the crop with adequate crop water requirement under the prevailing environmental conditions (hot, dry and high evaporation in the region). However, these results are in conformity with the results obtained by Mohammed (2007) and Amiri and Aghazadeh (2007).

Irrigation intervals showed potent influence on the yield (kg/tree) of the two date palm cultivars (Table 1). The highest yield was obtained under 10 days irrigation interval followed by 20 days irrigation interval, whereas the lowest yield was recorded under the 30 days irrigation interval in the two seasons. Frequent irrigation would however provide the crop with adequate moisture in the surface layer where most of the tree roots exist, thus resulting in better crop nourishment and consequently yield. The yield for both cultivars under various irrigation intervals is significantly different. The results obtained are in conformity with those reported by Ahmed (1988) who mentioned that short irrigation intervals increased plant yield.

The annual gain in number of leaves prediction equation depends on irrigation intervals (Fig. 1). The precision of the equation was (R^2) 0.988. Change of irrigation intervals from 10 days to 30 days, led to a decrease of annual gain in number of leaves by 0.653. Data in Table (2) shows the indirect relationship between annual gain in number of leaves and irrigation intervals which was significantly different ($p \leq 0.05$), whereas the correlation coefficient was – 0.994.

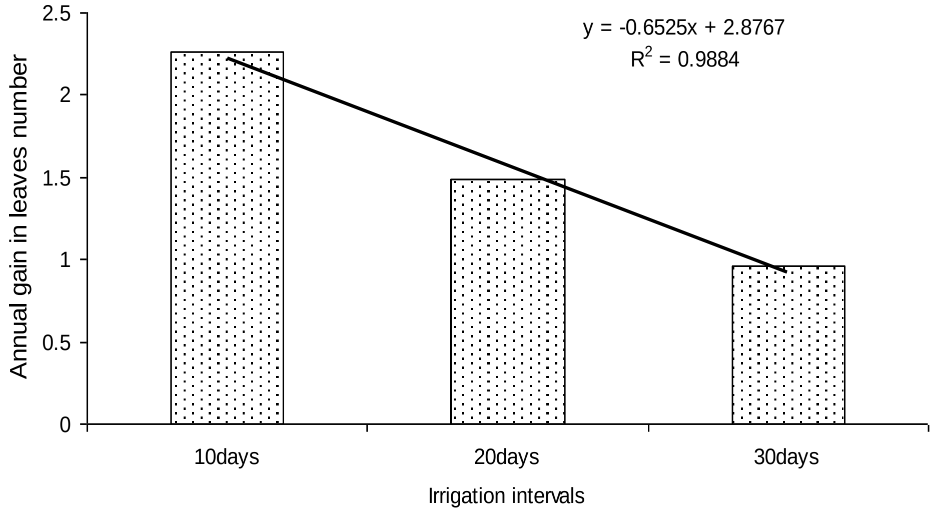

Fig. 1: Effect of irrigation intervals on annual gain in number of leaves per plant for the two date palm cultivars

Table 2: Correlations between irrigation intervals and growth parameters for two date palm cultivars

	Irrigation intervals	Number of leaves/tree	Tree height (cm)	Tree stem diameter (cm)	Tree yield (kg)
Irrigation intervals	1				
No. of leaves/tree	-0.994	1			
Tree height (cm)	-0.961	0.985	1		
Stem diameter (cm)	-0.999	0.997	0.969	1	
Yield (kg)	-0.995	0.999	0.984	0.997	1

As shown in Fig. 2. annual gain in plant height (cm) prediction equation depends on irrigation intervals. The precision of the equation was (R^2) 0.923. Change of irrigation intervals from 10 days to 30 days, led to a decrease of number of leaves by 1.9. Data in Table (2) shows the indirect relationship between annual gain in plant height (cm) and irrigation intervals with a correlation coefficient of – 0.961.

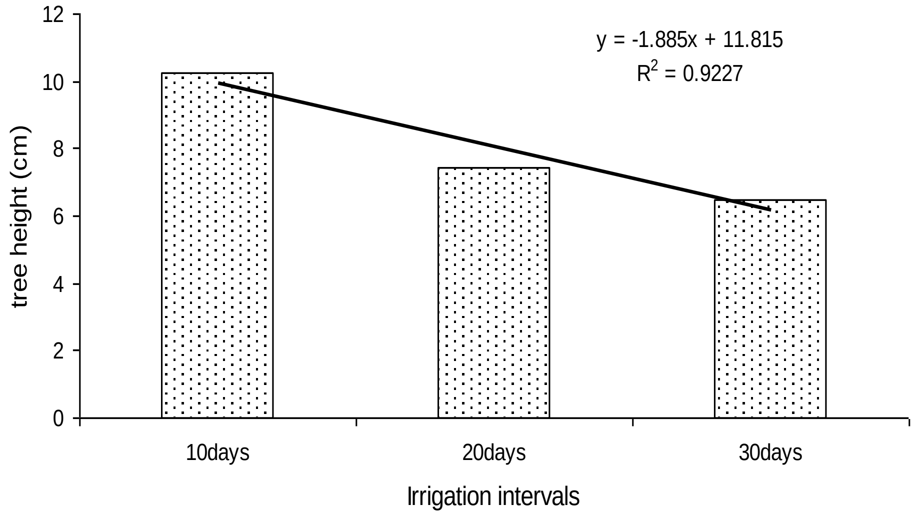

Fig. 2: Effect of irrigation intervals on annual gain in plant height for the two date palm cultivars

The annual plant stem diameter (cm) prediction equation depends on irrigation intervals (Fig. 3). The precision of the equation was (R^2) 0.999. Change of irrigation intervals from 10 days to 30 days led to a decrease of annual plant stem diameter by 2.17 cm. Data in Table (2) shows the indirect relationship between annual gain in plant stem diameter (cm) and irrigation intervals, with a correlation coefficient of – 0.999.

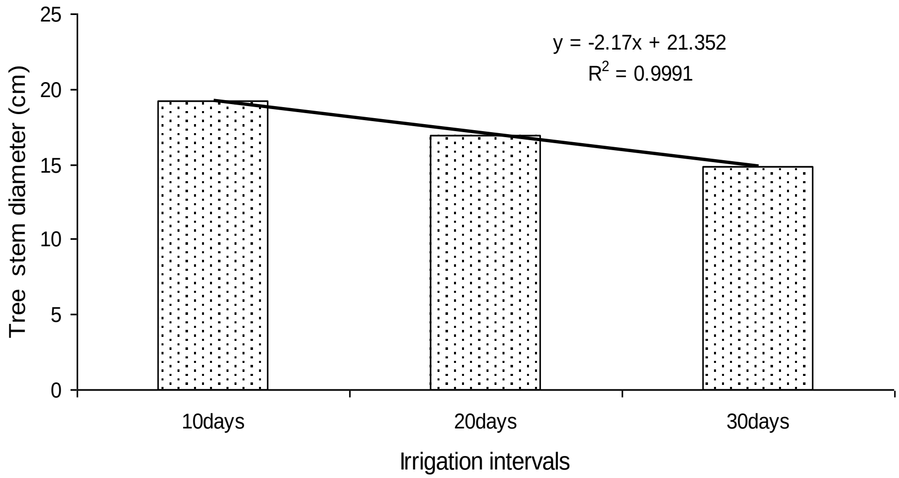

Fig. 3: Effect of irrigation intervals on annual again in plant stem diameter for the two date palm cultivars

The tree yield (kg) prediction equation depends on irrigation intervals (Fig. 4.). The precision of the equation was (R^2) 0.978. Change of irrigation intervals from 10 days to 30 days, led to a decrease of number of leaves by 11.5. Data in Table (2) shows the indirect relationship between tree yield (kg) and irrigation intervals, with a correlation coefficient of – 0.995.

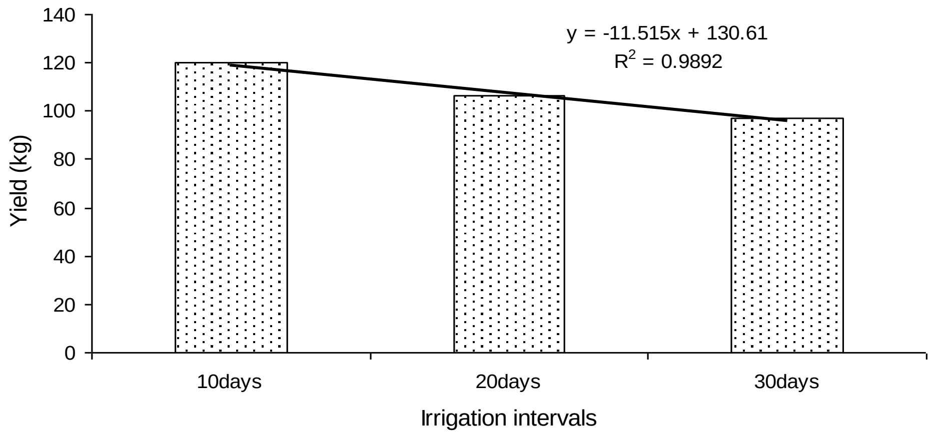

Fig. 4: Effect of irrigation intervals on plant yield for the two date palm Cultivars

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Research paper

Correlation Studies between Fertilizer, Tuber Yield and Some Yield Components for Irrigated Potato Grown on Clay Soils of River Nile State, Sudan

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ABSTRACT

Potato cultivar Diamant was grown for two consecutive seasons (2004/5 - 2005/6) at Darmali Irrigated Karu Soils (clay 42-52%) to test different correlations between fertilizer, yield and some yield components (crop-ground cover and number of stolons/plant). Twenty out of 72 experimental plot units were arranged in split plot design and considered for correlation analysis to obtain different correlation coefficients between the above mentioned traits. Results revealed that in all tested traits, correlations were positive in various degrees, however, in some of them it was not significant. Fertilizer showed highly significant and positive correlation with crop cover and yield. With regard to stolons, the relation though positive, was not significant in the two seasons. Yield-crop cover correlations were significantly positive for the two seasons, while, yield-stolon correlations were positive but only significant for season 2004/5. Crop cover-stolons correlations were not significant, though positive for the two seasons.

Keywords: *Fertilizer, potato, River Nile State, tuber yield*

الارتباط بين التسميد و الإنتاجية وبعض مكوناتها لمحصول البطاطس المروى بأراضي الكرو في ولاية نهر النيل، السودان

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كلية الزراعة جامعة وادي النيل

اجريت تجربة علي محصول البطاطس الصنف دايمونت لموسمين متتاليين (05/2004 و 06/2005) تحت الري في اراضي الكرو (نسبة الطين 42-52 %) بدارمالي لدراسة الارتباط بين التسميد والإنتاجية وبعض مكوناتها (نسبة تغطية النبات وعدد السيقان الارضية). فقط 20 من 72 وحدة تجريبية أجريت وفق تصميم القطع المنشقة هي التي استخدمت لتحليل معامل الارتباط بين التسميد والخواص المقاسة المذكورة. أثبتت النتائج أن معامل الارتباط لكل القياسات المذكورة إيجابي وفق مستويات مختلفة رغم أنه لم يكن معنوياً في بعض منها. بالنسبة للتسميد فقد أوضحت الدراسة ارتباطه العالي والمعنوي مع ألإنتاجية ونسبة تغطية النبات ولكن لعدد السيقان الأرضية فقد كانت النتيجة معنوية فقط لموسم واحد. الارتباط بين الإنتاجية ونسبة التغطية كان معنوياً للموسمين بينما كان معنوياً في موسم واحد مع عدد السيقان الأرضية. الارتباط بين نسبة التغطية والسيقان الأرضية لم يكن معنوياً رغم أنه كان إيجابياً في الموسمين.

Introduction

Most of potato grown in Sudan is occupying fertile, yet continuously cultivated revarian soils along Nile banks in Khartoum and River Nile states. In such soils symptoms of nitrogen deficiency are well known. Minerals fertilization is a common practice, hence the potato crop always exhibited noticeable tendency towards responding to fertilization, particularly with mineral nitrogen in the form of urea.

Tuber yield, crop canopy and stolon development are known to be interrelated since the work of Dyson and Watson (1971) who explained the great, small and negligible effect of N, P and K, respectively on leaf area index of cultivar King Edward. Burton (1989) indicated that the photosynthetic efficiency of the foliage depends in-part upon its content of chlorophyll, which is in turn more or less dependent to nitrogen content of the plant tissue and its effect in delaying plant senescence. Beukema and Van Der Zaag (1990) stated that shortage of nutrient supply accelerates leaf aging and suggested that there is a positive relationship between nitrogen content of the leaf and photosynthesis. They also indicated that during part of the growing season, haulm and tuber growth proceeds simultaneously showing some kind of interrelation. Vos and Oyarzum (1987) found direct correlation (r=0.91) between nitrogen content of the leaf and photosynthesis rate. However, Pyalon (1990) indicated that yield response to nitrogen is attributed to increased canopy growth. He also pointed out that; early in the season, the relationship is very clear. Using a chlorophyll meter readings, Gilello and Echeverria (2013) obtained similar results. Basu *et al.* (2002)

indicted that this relationship is a factor of a carbon partitioning coefficient (source- sink relationship). Stalin and Enzmaan (1990) stated that tuber dry matter yield at physiological maturity was positively correlated with nitrogen content of the tops and nitrogen application between 0 and 240 kg N/ha. In an experiment carried out at Shambat, Ali (1986) discovered that both nitrogen in form of urea or chicken manure has a positive effect on leaf area index and tuber yield, but she indicated that there were no significant differences due to the application of either of them on number of stolons. However, Ali and Yousif (2000) in the same condition of Shambat, indicated a positive effect of nitrogen application on number of tubers/plant. Further, similar results were obtained by Jenkins and Nelson (1992).

The objective of this study is to investigate the relationship between tuber yield and some yield components (crop cover and number of stolons/plant) and nitrogen fertilization regardless of the fertilizer form using Pearson correlation coefficient.

Materials and Methods

This study was carried out on Darmali Karu soils (clay % 42-52), in River Nile State of Sudan (longitude 34, latitude 17:48 and altitude 340 m above sea level). Potato tubers of cultivar Diamant were grown for two consecutive seasons (2004/5 and 2005/6). Twenty out of 72 total experimental plot units, laid out in split plot design, were only taken for correlation analysis. Others were excluded to avoid the interactive effect of different fertilizers. Foliar multi element fertilizer (ADB) with 8 % nitrogen in form of carbamide, ammonium and nitrate used in concentration of 30 ml/10 L of water, assigned to the main plots in 3 treatment levels (control, 2 weeks spraying and weekly spraying intervals). In the sub plots, 6 levels of urea 46 % and a combination of urea + chicken manure were applied as follows:

Level (1) 0 N/ha (control).

Level (2) 4 N/ha (180 Nitrogen kg/ha).

Level (3) 6 N/ha (270 Nitrogen kg/ha).

Level (4) 8 N/ha (360 Nitrogen kg/ha).

Level (5) 4 N/ha urea + 10 m^3 /ha chicken manure.

Level (6) 4 N/ha urea + 20 m^3 /ha chicken manure.

Chicken manure was added at planting time, while urea was added in four split doses starting 3 weeks after sowing. Treatments were replicated four times with a sub plot size of 3X3m^2, 80 cm between row and 25 cm within row spacing. Irrigation and disease and pest control were done as recommended in the north of Sudan.

The 20 samples combination analyzed using a computer statistical program SPSS were as follows:

- Four replicate readings of control treatment (without soil or foliar applied fertilizer)
- Four replicate readings of 2 weeks interval foliar applied fertilizer
- Four replicate readings of weekly foliar applied fertilizer

- Four replicate readings of the highest level of soil applied fertilizer (360 kg N/ha)
- The average of four replicate readings of 180 kg N/h +10 and 20 m^3 of chicken manure

The number of stolons were counted after 50 days from planting, while crop cover was taken using 10X10 cm quadrate after 60 days from planting.

Results and Discussion

Tables (1 and 2) show correlations between fertilizer, yield in ton/ha, % crop cover and stolon number/plant in the two seasons. Fertilizer showed highly significant (p= 0.000) and positive correlation with % crop cover and yield (0.708, 0.718 in the first season and 0.855, 0.708 in the second season, respectively). However, in the two seasons correlation between fertilizer and number of stolons/plant, though positive, was not significant. The relation between yield and crop-cover was significant and positively correlated for the two seasons (0.686 in the first season and 0.664 in the second season). Regarding the correlation coefficient between stolons and yield, results showed positive relation in the two seasons, however, it was only significant in the first season (0.523). The results obtained with regard to the effect of fertilizer on crop cover and yield were in line with that obtained by Ali (1986), Vos and Oyarzum (1987) and Stalin and Enzmaan (1990) while results obtained with regard to the number of stolons/plant were similar to those obtained by Ali (1986) and Jenkins and Nelson (1992). It also do not contradict with what was mentioned by Ali and Yousif (2000) but don’t agree completely with them hence, Ali and Yousif indicated the relationship at physiological ripening (complete tubers) while this study and that of Ali (1986) and Jenkins and Nelson (1992) referred to the relationship at early stages of growth. It is obvious that, greater number of stolons does not necessarily mean greater number of tubers at harvest, hence, Beukema and Van Der Zaag (1990) indicated only about 50 % or less develop into tubers. However, the work of Ali and Yousif stated clearly that development of tubers from stolons is largely enhanced by fertilization. Results obtained regarding correlation between stolons and yield (0.523 in the first season and 0.333 in the second season) can also justify the above-mentioned findings. Greater crop cover means greater light reception which can in turn enhance photosynthetic efficiency of potato. But at the same time, it could be concluded that; other factors also can control stolons' number such as planting depth and hilling together with environmental and genetic factors.

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Table 1: Correlation between fertilizer, tuber yield and some yield components on irrigated potato in Darmali, Sudan -season 2004/05

Character		Crop cover	Yield	Stolons
Fertilizer	Pearson correlation	0.78**	0.72**	0.23
	Sig. level	0.000	0.000	0.24
Crop cover	Pearson correlation		0.69**	0.38
	Sig. level		0.001	0.10
Yield	Pearson correlation			0.52*
	Sig. level			0.02

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
N= 20

Table 2: Correlation between fertilizer, yield and some yield components on irrigated potato in Darmali, Sudan -season 2005/06

Character		**Crop cover**	**Yield**	**Stolons**
Fertilizer	Pearson correlation	0.86**	0.71**	0.28
	Sig. level	0.00	0.00	0.23
Crop cover	Pearson correlation		0.66**	0.44
	Sig. level		0.001	0.05
Yield	Pearson correlation			0.33
	Sig. level			0.15

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

N= 20

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Research paper

Efficiency and Economic Feasibility of Manual and Chemical Weed Control in Faba Bean

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ABSTRACT

The performance of hand weeding was compared with that of a tank mix of herbicides imazythapyr (Pursuit) and pendimethalin (Stomp) applied as pre-emergence treatment for weeds control in faba bean (*Vicia faba*) in the River Nile State for two successive seasons (2005/06-2006/07). Hand weeding was undertaken once at 4 weeks after sowing and twice at 4 and 6 weeks after sowing. Pursuit in tank mix with Stomp was applied at the recommended rate. There was a variation in efficiency of hand weeding and herbicides application, the mean of the total weeding efficiency of hand weeding at 4 and 4+6 weeks after sowing and pre-emergence herbicides was 75.4, 78.6 and 87.1%, respectively. The yield of the treated plots out yield the weedy plot. The net benefit from hand weeding was less than from using herbicides.

Keywords: *Herbicides, faba bean, weed control*

الكفاءة والجدوى الاقتصادية لمكافحة الحشائش يدوياً وكيمائياً فى الفول المصرى

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تمت هذه الدراسة لمقارنة مكافحة الحشائش يدوياً وباستخدام مبيدات قبل النمو (بيرسوت+أستمب) في الفول المصري بولاية نهر النيل خلال موسمين متتاليين (2004/05-2005/06). تم إجراء المكافحة يدوياً مرة بعد اربعة اسابيع ومرتان بعد أربعة وسته أسابيع من الرية الاولى، أما مبيدات ما قبل الزراعة فقد تم خلطها في الرشاشه حسب الجرعة الموصى بها ورشها فبل الريه الاولى. أظهرت النتائج المتحصل عليها أن هناك تباين فى كفاءة المكافحة اليدوية والمبيدات، حيث كان متوسط الكفاءة خلال الموسمين للمكافحة يدوياً بعد 4 اسابيع و4+6 أسابيع واستعمال المبيدات هي 75.4، 78.6 و 87.1 % على التوالي. وأعطت الاحواض التى تمت بها المكافحة إنتاجية أعلى من التي تركت دون مكافحة الحشائش. من الناحية الاقتصادية كان العائد من المكافحة اليدوية أقل خلال الموسمين.

Introduction

Agriculture represents the main occupation in Sudan. More than 80 % of the population is engaged in agricultural production. Contribution of agriculture to the national economy is estimated to be 40 %. In the River Nile State, irrigated agriculture extends along the River Nile banks. Farm holdings range between 0.5-2 ha. The main field crops grown in winter season are the legume crops and wheat. Faba bean (*Vicia faba*) is one of the main state's cash crops and occupies an area of 20000 to 35000 ha (Mohamed *et al*., 2014). Average faba bean yield is about 1.8t/ha. Weeds compete with the crop for water, nutrients, light and space. Weeds differ in the damage that they cause to crops and this is governed by their growth habit, vigor, seed production, regenerative capacities and time of germination. Since the beginnings of agriculture, growers have had to compete with weeds for crop products grown for human use and consumption. The total global potential loss due to weeds infestation accounts for 45% (Mohamed *et al*., 2014), thus weed control is indispensable in every crop production system.

The faba bean crop is very sensitive to competition from both broad-leaved and grassy weeds (Wilson and Cussan, 1970, 1972; Glasgow *et al*., 1976; Lawson and Wiseman, 1978 and Brink and Belay, 2006). Annual weeds are considered to be one of the limiting factors to faba bean growth and yield (Kukula *et al*., 1983). The extent to which crop yield is reduced by weeds depends not only on crop, the environment and on the weed species and density, but also on the period for which weeds are allowed to compete freely with the crop (Dawson, 1970). The critical period at which there is a severe competition of weeds with the crop is in the range of 4 to 6 weeks from the sowing date (Mohamed, 1996 and Kavurmaci *et al*., 2010), therefore, good weed control is an essential part of the successful cultivation (Hebblethwaite, 1983).

Hand weeding is common around the world, and it is estimated that 50-70% of the world's farmers control weeds with this method (Hill, 1982 and Wicks *et al*., 1995). Farmers rely on family members especially women and children for weeding and often use weeds for animal feeding or even as human food. Commercial farmers with larger land holdings use more hired labor. The oldest form of weeding is the removal and pulling by hand, gradually, techniques have been improved with the use of implements adapted to do this job, using array of hand tools developed for local conditions; crops and weed present. Manual weeding by casual labor have been used for weed control in different crops in Sudan, however, hand weeding is still the most common method practiced by the farmers, and represents 85% of the practices in usage for weed control in the northern Sudan, while chemical represents only 6% (Hashim and Abdalla, 2005).

During the past four decades, large number of herbicides has been introduced as weed killers in many countries of the world. However, this change benefited mainly the industrialized countries, where agriculture was already highly mechanized and the level and value of output were able to bear the cost of these products. In developing countries, many reasons faltering the progress to use these chemicals, from which, small farmers have no access to the necessary equipment; herbicides are relatively expensive products; prices paid to farmers produces are still low; fear of adoption of herbicides will tend to exacerbate unemployment and the danger of wrong dose-rates to some plant products especially in illiterate societies.

Mohamed (1996) indicated that unrestricted weed growth and delayed weeding reduced faba bean yield by 80%. Several experiments were undertaken on efficiency and economic feasibility of chemical weed control in faba bean in northern Sudan. The herbicides imazythapyr and it's tank-mixers with pendimethalin or oxyfluoren were recommended for controlling weed (Mohamed *et al.*, 2004).

The present investigation was undertaken to compare performance of efficiency and economic feasibility of hand weeding and imazethapyr/ pendimethalin tank for weeds in faba bean in the River Nile State.

Materials and Methods

The performance of the hand weeding using a hoes with 9 cm cutting width and 65 cm wood handle was compared with that of a combination of imazythapyr at 0.05 kg a.i.ha^{-1}, pendimethalin at 1.2 kg a.i.ha^{-1}, applied after planting and before first irrigation in faba bean (*Vicia faba*) in the River Nile State for two successive seasons (2005/06-2006/07). Hand weeding (HW) was carried out at 4 weeks and a 4+6 weeks after first irrigation.

The plot size for each treatment was 2.4x7m. A randomized complete block design with four replications was used. A quadrant of 60x60cm was placed between ridges before and after weeding the plots by hand weeding, and on weedy and herbicides treated plots to count the weeds to assess weeding efficiency. Weed control was assessed as a percentage of total weeds at 6 weeks after sowing on weedy plots to the removed or killed weeds after weeding operation for each treatment. Crop samples of 2 ridges by 2 m long were cut; manually threshed and cleaned to assess yield. At harvest of each plot, at the same time a weed sample from $1m^2$ area for each plot under the experiment was collected and dried on direct sun for one week, then weighed.

Economic analysis was performed using MSTAT-C computer program to assess the costs of the weeding methods under test. Hand weeding cost was calculated according to the work rate of a 6 hours workday and 10 SDG/day labour wage, work rate was calculated from the time consumed to apply each treatment to every plot with measured area, while the herbicide cost including the chemicals price of 59.5 and 95.2 SDG ha^{-1} for imazythapyr and pendimethalin, respectively, and 35.7 SDG ha^{-1} for the labour for spraying. Yield selling of 1.2 SDG kg^{-1} was the market price after harvest.

Results and Discussion

From weed counting on all plots, there was no variation in the treated and weedy plots concerning weed/m^2, with about 144 and 140 in treated and weedy plot, respectively in the first season and 131 and 130 in second season of the experiment, taking into account a fair ground to treatments, with the dominant species *Beta vulgaris, Sinapis arvensis, Portulaca oleracea, Sorghum sudanensis* (wild sorghum), where grasses represent

57%. There were variations among hand weeding at 4WAS, 4+6WAS and herbicides application in the weeding efficiency. Mean of the two seasons to control grasses and broad-leaved weeds at 4 weeks after sowing by toryia was 88.1, 70%, respectively, where at 4+6 weeks after sowing was 83.2, 74.5%, respectively, and for imazythapyr and pendimethalin was 92, 85%, respectively. The mean of the total efficiency of hand weeding at 4, 4+6 weeks after sowing and herbicides was 75.5, 78.8 and 88.6%, respectively (Table1).

Table (2) shows the mean of yield of the hand weeding and herbicides compared to weedy plot. Comparison of means ranked the yield of herbicides and 4+6 WAS hand weeding first, 4WAS hand weeding second, and weedy in the last. Economic analysis showed that the net benefit from hand weeding in the two seasons was less than using herbicides (Table 3). Marginal analysis revealed just how the net benefit from every treatment increases as the amount of cost increases, where any treatments fall below the curve was not feasible, as shown in Fig.1 and 2.

A study on faba been by Mohamed *et al*. (2004), assessing the same two herbicides with the same doses through three consecutive seasons, obtained an average efficiency of 82.5% for three years which is nearly the same as in this study. The effectiveness of herbicides depends on soil type and in the weed flora, thus far, there is a wide variation in these two factors in River Nile State.

Conclusion

The recommended herbicides for faba bean is pre-emergence, farmers behavior to control weeds after their presence, and the manual weeding is done normally by farm owner or volunteer for animals feed, when consider these the hand weeding it may become feasible, and still represent one of practices for weed control in faba bean in River Nile State.

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Table 1: Efficiency of manual and chemical weed control in faba bean in the River Nile State

Season / Treatment	2005-06					2006-07					Mean weed Control (%)		
	Grass/m²	Brd.L/m²	Weed control (%)			Grass/m²	Brd.L/m²	Weed control (%)					
			Grass	Brd.L	Mean			Grass	Brd.L	Mean	Grass	Brd.L	Total
4WAS HW	63	87	85	76	81	97	37	77	64	70	81	70	75
4+6WAS HW	68	73	89	76	83	89	34	77	73	75	83	74	79
Pursuit+Stomp	80	61	87	92	89	96	41	98	78	88	92	85	89
Weedy	65	75				92	38						
SE	*4.2 ns*	*5.6 ns*	*1.1 ns*	*1.5***	*1.1***	*3.4ns*	*2.7ns*	*1.5***	*1.5***	*0.75***			
C.V. (%)	*15.1*	*13.3*	*2.6*	*3.7*	*2.6*	*7.3*	*14.2*	*3.5*	*4.1*	*1.9*			

WAS = weeks after sowing HW= hand weeding Brd.L= broad leaved

*and** = indicate significant at 5% and 1% level, respectively.

Table 2: Effects of control method on weeds number and dry weight and faba bean yield in the River Nile state

Season	2005-06				2006-07			
Treatment	Plants/m^2	Weeds/m^2	Wdwt (g/m^2)	Yield (kg/ha)	Plants/m^2	Weeds/m^2	Biomass (kg/ha)	Yield (kg/ha)
4WAS HW	30	150	190.3	1550^c	28	134	10832	5046^b
4+6WAS HW	28	141	195.8	1783^b	26	123	12083	6008^a
Pre- m.herbicides	28	141	150.0	1924^a	20	137	12083	6056^a
Weedy	26	140	280.5	1041^d	27	135	10872	4341^c

WAS= weeks after sowing HW= hand weeding Wdwt= weeds dry weight
Means in the same column with the same letters are not significantly different at 5% level

Table 3: Marginal analysis for the hand weeding compared to herbicides treatment

Treatment	Value of output (SDG/ha)	Weeding cost (SDG/ha)	Threshing cost (SDG/ha)	Net benefit (SDG/ha)	MNB⌖ (SDG/ha)	MRR^ψ (%)
			2005-06			
Herbicides	2308.8	204.7	54.6	2049.5	831.4	364.3*
4+6 HW	2139.6	296.5	53.5	1789.6		
4 HW	1860	213.8	47.9	1598.3		
Weedy	1249	0	31.1	1218	0.0	0.0
			2006-07			
Herbicides	7267.2	204.7	183.5	6879.0	1136.6	1507.4*
4+6 HW	7209.6	348.0	180.2	6681.4		
4 HW	6055.2	155.0	166.8	5733.4	669.7	379.9*
Weedy	5209.2	0	136.5	5072.7	0.0	0.0

⌖ Marginal net benefit   * marginal variable cost   ψ marginal rate of retuen   ♦ index of variability

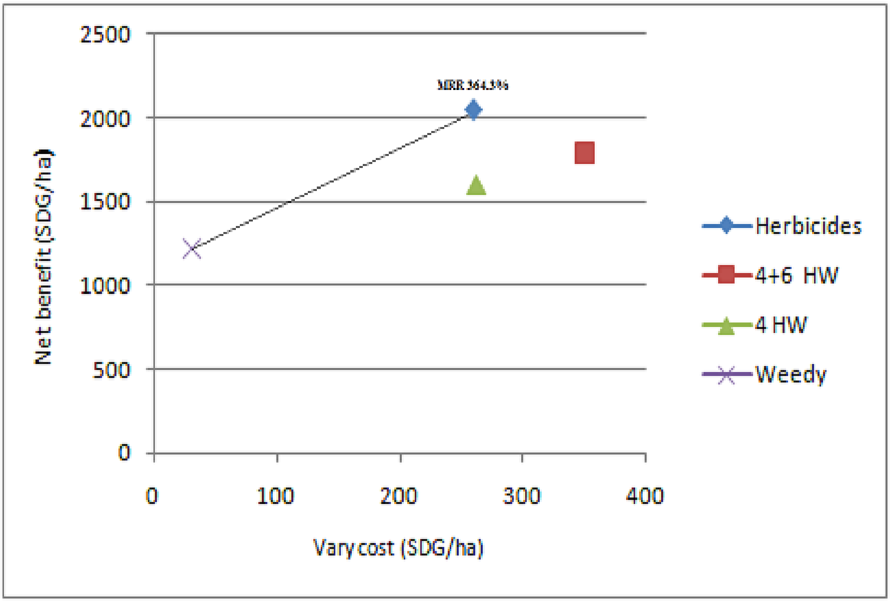

Fig. 1. Net benefit of using hand weeding and herbicides control for season 2005-06

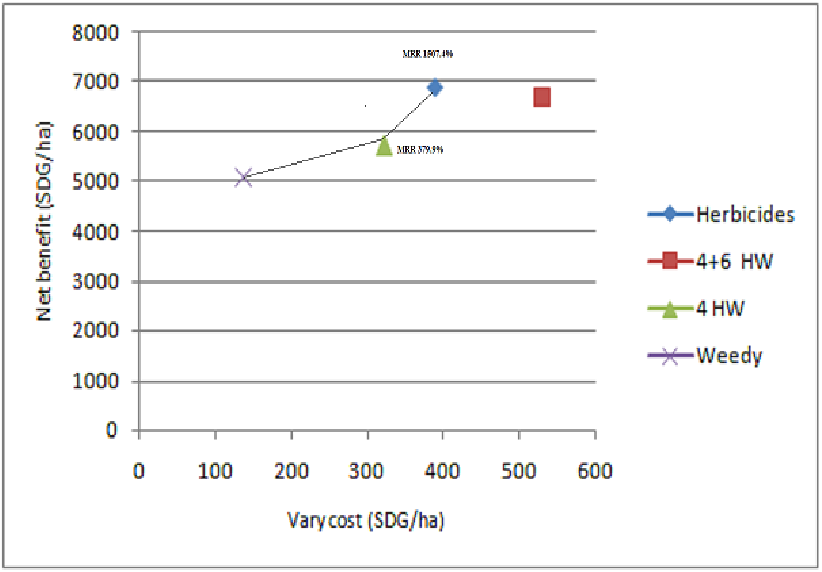

Fig. 2: Net benefit of using hand weeding and herbicides control for season 2006-07

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Research paper

Yield and Quality Evaluation of Six Local Onion (*Allium cepa* L.) Varieties

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ABSTRACT

Research was carried out at Hudeiba Research Station Experimental Farm, in the River Nile State, during seasons 2003/04 – 2004/05 to evaluate bulb yield and quality of six local varieties, open pollinated onion namely; Saggai (an improved cultivar with pink red skin colour); Kamleen (with yellow skin colour); El-Hillo (with white skin colour); Abufrewa (with deep red skin colour); Wadhamid (with yellow skin colour) and Zeidab (with red skin colour). Results showed a considerable variation in vegetative growth among the six varieties, where Kamleen and Wadhamid produced more foliage and earliness in bulbing than others. Kamleen gave the highest total and marketable yield, while Zeidab gave the lowest yield in the two seasons. Saggai, Kamleen and El-Hilo varieties showed less splitting, doubling and premature bolting. Wadhamid, Abufrewa and Zeidab gave the lowest values in quality characters. However, Abufrewa matured earlier, while cultivar Saggai matured late.

Keywords: *Cultivar, onion, Sudan, yield*

تقويم الإنتاجية والخواص النوعية لستة اصناف من البصل في السودان

محمد احمد الطيب[1] و جعفر محمد الحسن[2]

[1] محطة بحوث الحديبة- هيئة البحوث الزراعية

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أجريت هذه الدراسة بمحطة البحوث الزراعية بالحديبة بولاية نهر النيل في موسمي 04/2003 و 05/2004 لدراسة وتقويم خصائص ستة من اصناف البصل السودانية مفتوحة التلقيح وهى سقاى محسن (احمر اللون) كاملين (اصفر اللون)، الحلو (ابيض اللون)، ابو فريوة (باللون الاحمر الداكن)، ود حامد (اصفر اللون)، وزيداب (احمر اللون). اوضحت النتائج وجود اختلافات في النمو الخضرى بين الاصناف حيث اعطت الاصناف كاملين وود حامد نمو خضرى قوى وتبكير في الابصال واعطى الصنف كاملين اعلى انتاجية كلية وانتاجية ابصال قابلة للتسويق بينما اعطى الصنف زيداب اقل انتاجية في الموسمين. اعطت الاصناف المجازة (سقاى محسن، كاملين والحلو) اقل النسب للابصال المزدوجة والمزهرة مبكرا (البنبون)، مقارنة مع الاصناف غير المجازة (ابوفريوة، ودحامد وزيداب). النتائج اوضحت ان الصنف ابوفريوة صنف مبكر النضج وسقاى صنف متأخر النضج.

Introduction

Onion (*Allium cepa L.*) is the most important of the bulb crops and is one of the most important vegetable crops grown in most parts of the world. Onion is probably a native of Asia. It belongs to the family Alliaceae, genus Allium.

Onions have relatively high nutritive value, being rich in vitamins moderate in carbohydrates, calcium and riboflavin. Its extract has antibacterial properties. Also the shoot system of onion is rich in a number of vitamins.

Onion is the leading vegetable crop in Sudan. It is eaten fresh, pickled, dry or cooked. Onion is planted annually as a winter crop. Estimation of total production of onion in Sudan is one million tons from 84,000 hectares (Mohamed Ali, 2009) and the River Nile State produces 162,648 tons from 11,340 hectares (27,000 feddans) (Mohamed *et al*., 2003). Sudanese onion cultivars are good in quality characters (total soluble solids, dry matter, etc...) (Nourai, 2003).

The present study was conducted to test and compare the yield and quality characters of six different local released and promising onion cultivars.

Materials and Methods

Six local Sudanese cultivars of onion (*Allium cepa* L.) namely; Saggai (an improved cultivar with pink red skin colour), kamleen (with yellow skin colour), El-Hilo – Nassi (with white skin colour), Abufrewa (with deep red skin colour), Wadhamid (with yellow skin colour) and Zeidab (with red skin colour) were tested for yield and quality. The experiment was carried out during seasons 2003/4 and 2004/5, at Hudeiba Research Station (Lat. 17° 34’ N, Long. 33° 56’ E, Elev. 350 m above sea level) in the River Nile State. The soil of the experimental site is thick loamy with pH 7.8 - 8.4.

The source of seeds was the Agricultural Research Corporation. The seeds were sown during the first week of October in the nursery and transplanted to the field after 60 days. A randomized complete block design with six replications was used. Seedlings were planted on both sides of the ridge of 60 cm width at 10 cm spacing between plants. Irrigation was applied at 8 days interval and stopped 15 days before harvesting. Manual weeding was practiced. Fertilization and insects control were applied as recommended.

Parameters to be measured were: number of leaves per plant, blubbing ratio (Bulb diameter/ neck diameter), average bulb dry weight in grams, total yield (t/ha), marketable yield (t/ha), days to maturity, total soluble solids (TSS) and dry matter content (%).

Analysis of variance was carried out for each experiment separately with mean separation for comparison among means (LSD) at 5 % level of significance following Gomez and Gomez, (1984).

Results

Number of leaves/plant

Differences in number of leaves/plant among the cultivars were significant (P=05). The number of leaves increased with the plant development in both seasons (Table 1). Kamleen and Wadhamid produced the highest number of leaves/plant and Zeidab gave the lowest number in both seasons.

Bulbing ratio

Significant differences among the six cultivars in bulbing ratio in the two seasons were observed. The cultivar Kamleen produced the highest bulbing ratio and cultivar Zeidab gave the lowest bulbing ratio (Table1).

Average bulbs fresh weight (g)

Analysis of variance showed significant differences among the six cultivars for bulb fresh weight in the two seasons. The highest bulb fresh weight was obtained by Wadhamid in the first season (174.3 g) and Kamleen in the second season (186.4 g). The lowest bulb fresh weight (151.1 g) was produced by the cultivar Zeidab (Table 1).

Average bulbs dry weight (g)

Table (1) shows significant differences among the six onion cultivars in the two seasons regarding bulb dry weight. Cultivar Kamleen produced the highest bulb dry weight in both seasons 23, 36 and 25, 62 (g), respectively, while the lowest bulb dry weight of 18.31 (g) in the first season and 20.79 (g) in the second season, was produced by cultivar Zeidab.

Total yield (t/ha)

Differences in the yield among the six cultivars were significant in both seasons (Table 1). Cultivar Kamleen produced the highest total yield followed by Wadhamid, El- Hilo and Saggai. While Abufrewa and Zeidab produced the lowest yield in both seasons.

Marketable yield (t/ha)

Table (1) showed significant differences among the cultivars in marketable yield. Kamleen cultivar produced the highest marketable yield of 13.28 and 15.71 t/ha in the first and second seasons, respectively, followed by El- Hilo and Saggai, while Wadhamid, Abufrewa and Zeidab cultivars produced lower marketable yield in both seasons.

Days to maturity

As presented in Table (3), cultivar Abufrewa matured early (after 134.3 days in the first season and 140.3 days in the second season) and Saggai matured late (after 172.2 days in the first season and 165,7 days in the second season).

Quality characters

Total soluble solids (TSS)

Differences among the six cultivars in TSS were significant in both seasons (Table 2). In the first growing season, Kamleen gave the highest TSS of 17.43 %, while in the second El-Hilo recorded the highest TSS of 17.78 %.

Meanwhile, the lowest TSS was obtained by Cultivar Zeidab (14.18%) in the first season and Wadhamid (15.07 %) in the second season.

Dry matter content (%)

Differences among six cultivars in dry matter content were not significant (Table 2). In both seasons Kamleen gave the highest dry matter content (15.73 % in the first season and 16.40 % in the second season), while the lowest dry mater was recorded by Wadhamid (13.95 %) in the first season and Abufrewa (13.88 %) in the second season.

Percentage of doubles and splits

Significant differences among the six cultivars were obtained regarding doubles and splits in the two seasons (Table 2). The cultivars Zeidab and Wadhamid produced the highest percentage of doubles and splits of 13.22 % and 15.77 % in the first and second seasons, respectively. On the other hand, cultivar Kamleen produced the lowest percent (7.83 %) in the first season and Saggai (9.83 %) in the second season.

Percentage of premature bolting

Table (2) shows that the differences among the six cultivars in premature bolting were significant in both seasons. Cultivar Zeidab produced the highest percentage of premature bolting of 9.83 % in the first season and 17.08 % in the second season while cultivar El-Hilo produced the lowest premature bolting in the second season (8.55 %).

Discussion

The six onion cultivars under study varied considerably in their growth components including the number of leaves/plant, bulbing ratio, bulb fresh weight (g) and bulb dry weight (g). Cultivars differed in their yield that may be due to the fact that those cultivars differ in their genetic makeup which interacts differently with the prevailing environmental conditions as temperature, humidity and soil type. Such conclusion was indicated by Brewster (2008), who stated that successful onion bulb production depends mainly upon selection of cultivars. Cultivar Kamleen gave the highest number of leaves in both seasons, while cultivar Zeidab gave the lowest number of leaves. The number and size of leaves corresponds with high yields. These findings agreed with that of Gough *et al*. (2010) who reported that leaves production appears to be genetically controlled. Kamleen and Wadhamid showed a high percentage of bulbing ratios. The results accord with the findings of Mettananda and Fordham (1997) who reported that bulbing in onion is primarily controlled by photoperiod. They also showed that cultivars differ in their response to the length of the photoperiod. Differences among the six cultivars in premature bolting, in which Kamleen, Saggai and El-Hilo showed lowest percentage of bolting, while, cultivars Wadhamid, Abufrewa and Zeidab showed the highest percentage of bolting, was discussed earlier and related to different factors. Abdalla and El-Hassan (1977) reported that temperature from July to October in Sudan tend to promote leaves production resulting in large plants which are more susceptible to premature bolting when exposed to low temperature of the winter season. Brewster (2008) indicated that cultivars vary considerably in their tendency to bolt.

The total soluble solids of the six local onion cultivars studied in both seasons differed ranging between 14.18 % and 17.78 %. The dry matter content ranged between 13.88 % and 16.40 %. High total soluble solids and dry matter content which is positively correlated with good keeping quality, was indicated by Randle (1992) who observed that cultivars vary in dry matter from 3.03 to 20 %. Also Yoo *et al.* (2006), Simon (1995), Bedford (1999) and Sand Chope *et al.* (2007) reported that the accumulation of organo-sulphur compounds in onions depends upon many factors, the most important of which are sulpher-based fertilization, the environment and the genotype of the cultivars.

There were significant differences among the cultivars in percent doubling and splitting in both seasons. This is in an agreement with the finding of Ahmed (1984), who reported that the percentage of splitting differs from one cultivar to another.

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Table 1: Growth and yield performance of six local onion varieties during 2003/04 – 2004/0

Season	2003/04						2004/05					
Cultivars	**Leaves/ plant**	**Bulbing rate (%)**	**Fresh weight (g)**	**Dry weight (g)**	**Total yield (t/ha)**	**Mar/ yield (t/ha)**	**Leaves/ plant**	**Bulbing rate (%)**	**Fresh weight (g)**	**Dry weight (g)**	**Total yield (t/ha)**	**Mar/ yield (t/ha)**
Saggai	13	1.87	163.2	21.86	17.75	9.28	13	1.89	174.5	22.70	20.47	11.47
Kamleen	14	1.86	172.6	23.36	22.40	13.28	14	1.94	186.4	25.62	23.35	15.71
El-Hilo	13	1.93	158.6	18.63	19.35	12.78	13	1.84	165.7	25.24	19.94	13.85
Abufrewa	13	1.93	144.3	18.88	15.26	7.78	13	1.84	162.5	21.13	17.10	9.47
Wadhamid	14	1.91	174.3	21.45	19.66	5.55	14	1.91	183.1	28.04	21.87	9.57
Zeidab	12	1.86	151.1	18.31	14.16	5.47	12	1.77	162.2	20.79	14.95	7.50
C.V. (%)	**6.72**	**3.01**	**5.27**	**10.27**	**12.46**	**18.20**	**6.72**	**4.12**	**7.22**	**12.88**	**10.20**	**20.91**
LSD	**1.0**	**0.07**	**10.07**	**2.51**	**1.13**	**0.84**	**1.0**	**0.09**	**14.51**	**3.66**	**1.00**	**1.18**

Table 2: Quality evaluation of six local onion varieties during 2003/04 – 2004/05

	2003/4				2004/5				
Cultivars	**TSS %**	**Dry mat %**	**Doub %**	**Bolt %**	**TSS %**	**Dry mat %**	**Doub %**	**Bolt %**	**Rott %**
Saggai	15.88	15.12	9.08	8.69	16.12	14.9	9.83	9.08	3.47
Kamleen	17.45	15.73	7.83	6.90	17.20	16.4	9.85	8.55	2.67
El-Hilo	16.85	15.68	10.75	4.98	17.78	13.9	14.87	9.03	2.72
Abufrewa	15.17	15.35	11.17	9.62	15.75	13.8	13.17	14.17	2.70
Wadhami	14.27	13.95	13.14	7.48	15.07	15.3	15.77	13.57	5.52
Zeidab	14.18	14.17	13.22	9.83	15.62	14.7	15.15	17.08	4.40
C.V. (%)	**7.22**	**9.24**	**14.34**	**15.55**	**8.60**	**13.3**	**13.4**	**18.52**	**31.02**
LSD	**1.34**	**1.65**	**1.85**	**1.46**	**1.66**	**2.37**	**2.08**	**2.62**	**1.32**

Table 3: Days to maturity of six local onion varieties during 2003/04 – 2004/05

Variety	Season 2003/04	Season 2004/05
Saggai	172.0	165.7
Kamleen	162.2	158.0
Nassi	155.0	164.3
Abufrewa	134.3	140.3
Wadhamid	162.0	160.3
Zeidab	161.0	155.7
SE±	***4.52***	***5.11***
C.V (%)	***21.8***	***23.9***

Table 4: Temperature data during experimental period (2003– 2005)

Month	Season 2003/04 (ºC)	Season 2004/05 (ºC)
October	39.2	41.7
November	39.0	40.6
December	37.1	33.5
January	35.9	34.2
February	40.3	37.3
March	42.0	38.7
April	41.7	41.5
May	46.6	44.3

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Research paper

The Performance of Nine Common Bean (*Phaseolus vulgaris* L.) Genotypes under Three Sowing Dates, in River Nile State

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ABSTRACT

The performance of nine common bean genotypes (*Phaseolus vulgaris* L.) was investigated under sowing dates. The field experiments were conducted during winter season of 2003/04 and 2005/06 in Hudeiba Research Station Experimental Farm, Eddamer, River Nile State. The objective of the study is to identify the most tolerant genotypes to heat stress. Nine genotypes of different seed sizes; small seeded (Basabeer, DB 190-74-1 and UBR(92)25-2), medium seeded (Giza-3, Bellenber-1 and COWU-3-94-9) and large seeded (Ibarya, Turki-2 and S/Hashim/98), were tested at three sowing dates; early (SD1, 1st Oct.), optimum (SD2, 30 Oct.) and late (SD3, 30 Nov.). A split- plot design with three replications was used to execute the experiments; sowing dates were assigned to the main plots and genotypes to the subplots. Results showed that sowing date treatments significantly affected the reproductive traits of common bean genotypes. The highest values of yield under stress (early planting to yield under non-stress (YSD1/YSD2) conditions were obtained with the small (59 %) and medium (82 %) seeded genotypes. However, the highest values of yield under stress (late planting) to yield under non-stress (YSD3/YSD2) were obtained with the large (53 %) and the medium (56 %) seeded genotypes. The highest value of geometric mean productivity (1591 kg) was obtained with the genotype Giza 3. The highest values of geometric mean productivity at SD1 (1842 kg and 1734 kg) and SD3 (1338 kg and 1530 kg) were obtained by Basabeer and Giza3 genotypes, respectively. The genotypes Basabeer and Giza3 are adapted to favorable conditions. Bellenber-1 is the most tolerant under heat stress conditions at both early and terminal heat stress and can be used in breeding program.

Keywords: *Common bean, genotypes, heat stress, sowing dates, Sudan.*

استجابة تسعة سلالات من الفاصوليا لثلاثة مواعيد للزراعة تحت ظروف ولاية نهر النيل

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تسعة من سلالات الفاصوليا تم تجريبها في ثلاثة مواعيد مختلفة للزراعة خلال فصل الشتاء في موسمي 04/2003 و 06/2005 بمزرعة محطة بحوث الحديبة بالدامر. وتهدف الدراسة لمعرفة اكثر الاصناف مقاومة لظروف الاجهاد الحرارى وصنفت الاصناف لصغيرة الحبة ومتوسطة الحبة وكبيرة الحبة. وقد اختبر اداؤها في ثلاثة مواعيد للزراعة: مبكرة في الاول من اكتوبر ومثالية في الثلاثين من اكتوبر ومتأخرة في الثلاثين من نوفمبر. استخدم تصميم القطع المنشقة بثلاثة مكررات لتنفيذ هذه التجربة بتوزيع مواعيد الزراعة على القطاعات (الاحواض) الرئيسة والسلالات المختلفة على القطاعات (الاحواض) الفرعية. اثبتت التجربة تأثير مواعيد الزراعة على القراءات المختلفة معنوياً. اعلى قيمة للإنتاجية تحت الاجهاد الناتج عن الزراعة المبكرة مقسومة على الانتاجية دون اجهاد حرارى (المواعيد المثلى) نتجت عن السلالات صغيرة الحبة (59 %) ومتوسطة الحبة (82 %). كما وأن اعلى قيمة للإنتاجية تحت الاجهاد الحرارى الناتج عن الزراعة المتأخرة مقسومة على الاخرى (دون اجهاد حرارى) نتجت عن السلالات كبيرة الحبة (53 %) ومتوسطة الحبة (65 %). السلالة جيزة 3 احرزت القيمة الاعلى للمتوسط الهندسي للإنتاجية (159 كجم). كما احرزت السلالات بسابير وجيزة3 القيمة الاعلى للمتوسط الهندسي للإنتاجية (1842 و1734 كجم للزراعة المبكرة و1338 و1530 كجم للزراعة المتأخرة) على التوالي. اثبتت السلالات بسابير وجيزة3 موائمة للظروف المثالية للإنتاج بينما السلالة بنلر 1 كانت الاكثر موائمة لظروف الاجهاد الحرارى لكل من الزراعات المبكرة والمتأخرة على السواء وبالتالي فيمكن اخضاعها لبرامج تربية.

Introduction

In Sudan, common bean (*Phaseolus vulgaris* L.) is normally cultivated under residual soil moisture in basins and islands after recession of the Nile flood. In addition, appreciable areas are also grown under irrigation. Average areas grown with this crop in recent years reached 15000 ha with an average productivity ranging between 0.5 and 1 ton/ha. However, this yield level is much less than the yield potential of this crop. The major producing areas of common bean in the north of Sudan are Shendi and Berber, where more than 90% of the crop is produced. The common bean is grown during the winter season which is characterized by having warm and short and sometimes even hot spells. Heat and drought are considered as the main limiting factors of bean production in east, central and southern Africa causing losses of more than 395000 tons each year. Moisture and heat stress, in conjunction with biotic stresses especially diseases and pests, act as main factors responsible for low productivity of common bean. These multiple constraints often act concurrently with considerably negative effects on the quantity and quality of crop production (Amede *et al.*, 2001). The rate of temperature change, and the duration and degree of high temperatures, all contribute to the intensity of heat stress. Therefore, the objective of this study is to identify the most tolerant bean genotypes to early and terminal heat stresses.

Materials and Methods

The experiment was carried out during the three consecutive winter seasons (2003/04 and 2005/06) at Hudeiba Research Station farm, River Nile State, Sudan. The crop of the experiment in season 2004/05 showed symptoms of diseases and complete sudden loss was occurred. The soil of the experimental site was classified as Karima series, with about 47 % clay, 11 % silt and 42 % sand. Maximum and minimum temperatures for the two seasons (2003/04 and 2005/06) are shown in Figure (1, A and B). The genotypes and sowing dates were arranged in split-plot design with three replications. Nine genotypes were used in this study and grouped according to their seed size (small<24 g/100 seed: Basabeer, DB 190-74-1 and UBR (92) 25-2), medium (25-35 g/100 seed: Giza-3, Bellenber-1 and COWU-3-94-9) and large (>39g/100 seed: Ibarya, Turki-2 and S/Hashim/98). To study the effect of temperature on the above-mentioned nine common bean genotypes, three sowing dates were used: early planting (SD1, 1st October), optimum or recommended planting date (SD2, 30 October) and late planting (SD3, 30 November). Sowing dates were randomly assigned to the main plots and genotypes to the subplots. The sub-plot size was 1.2 m x 6 m, consisted of two rows. Sowing was on both sides of the ridge at a rate of two seeds per hole with intra row spacing of 20 cm between holes. Crops were kept weed-free by hand hoeing every week in all experimental plots. Data were collected from five random plants taken from each row per sub-plot. Number of pods per plant, number of seeds per pod, 100-seed weight (g) and seed yield (kg/ha) was determined for each sub-plot.

Heat susceptibility index of Fisher and Maurer (1978) was determined for each genotype, based on data of seed yield:

HSI= (YSDn-YSDs)/ (YSDn (1- YSDs /YSDn)

Where:

YSDs and YSDn = mean yields of all genotypes evaluated under SD1, SD3 (Stress) and SD2 (recommended sowing date), respectively.

(YSDn-YSDs) = relative yield reduction due to stress.

1 - YSds/YSdn = heat intensity index (relative yield reduction over all genotypes in the environment).

Values of HSI < 1 denote below average heat susceptibility (= above average heat tolerance), an average reaction is defined by HSI = 1, and values of HSI>1 describe above heat susceptibly (= below average heat tolerance).

Geometric mean of productivity (GMP) is measured as square root of yield under stress to yield under non-stress conditions as described by Fernandez (1993):

$$GMP = (YSDs \times YSDn)^{0.5}$$

Results and Discussion

Results presented in Tables 1, 2 and 3 showed that number of pods per plant were reduced at the early sowing (SD1) which may be reasonably explained by the relatively high temperatures prevailing during fertilization and pod setting stage. The genotypes Basabeer and Giza3 were not affected by the early sowing as they produced similar seed weights to that of the optimum one. Sensitivity of the reproductive stages in common bean to temperatures has been reported by Weaver *et al.*, 1985, Monterroso and Wien, 1990 and Konsens *et al.*, 1991. Stages sensitive to high temperatures include flower bud formation, flowering, pollen formation and function, fertilization, and pod and seed set. Konsens *et al.* (1991) indicated that heat- induced abscission of flower buds before anthesis could be due to decreased carbohydrates level or translocation constraints. It appears that pollen grains are more sensitive to high temperatures than female reproductive structures (Dickson and Botteger, 1984 and Monterroso and Wien, 1990). Furthermore, Paulsen (1974) stated that high temperatures are particularly detrimental, because they affect crops directly by impairing physiological processes and indirectly by altering plant-water relations.

In this study, most of the genotypes gave heavier seed weights at the optimum sowing date (SD2). The small seeded genotype (Basabeer) and the medium one (Giza3) were not affected by the early sowing date, SD1. However, the large seeded genotypes were not consistent in their response to sowing date. Davis *et al.* (1991) suggested that, in breeding programs, heat-acclimatization potential may be the more important as a selection criterion for improving crop performance in high-temperature environments. They reported that seed weight was controlled by a large number of genes, with both additive and dominance effects.

Seed yield of all genotypes was significantly reduced (Table 4) at SD1 and SD3 by 18.2-82.1% and 44.8-68.1% for the two seasons, respectively. This finding was similar to that reported by Berry and Bjorkman (1980), who stated that early sowing dates from 2 to 23 September resulted in very low seed yield (360 kg/ha) of common bean because fewer plants survived. However, Konsens *et al.* (1991) concluded that heat stress, especially during reproductive development, causes severe yield reductions in common bean. Meanwhile, Subbarao *et al*. (1995) have reported that exposure to less extreme temperatures during critical reproductive stages can directly affect seed yield.

Estimates of relative yields YSD1/YSD2, YSD3/YSD2, stress susceptibility index (SSI) and geometric mean productivity (GMP) at early (SD1) and late (SD3) sowing dates were given in Table (5). Higher values of YSD1/YSD2 were obtained by the small seeded genotypes; Basabeer (82%), DB190-74-1(55%), UBR (92)25-2 (59%) and the medium seed size, Giza3 (64%). The lower values were obtained by the three large seeded genotypes and the medium ones Bellenber-1 and COWU-3-94-9 (20, 18, 32, 37 and 25 %, respectively). At the late sowing date (SD3), the higher values were obtained by the large seeded genotypes: Ibarya (53%), S/Hashim/98 (52%) and the medium ones; COWU-3-94-9 (56%) and Bellenber-1(55%). The three small seeded genotypes: Basabeer, DB190-74-1 and UBR (92)25-2 gave heat tolerance values ranging from 32 to 43%. The stress susceptibility index under the early sowing date (SD1) for most genotypes was above average drought susceptibility index. The lowest values; 0.33, 0.65 and 0.74 were obtained by the small seeded genotypes; Basabeer, Giza3 and UBR (92)25-2, respectively. At the late sowing date (SD3), the small seeded genotypes showed high values of susceptibility index, however, the rest genotypes gave values ranging from 0.86 to 0.98.

The highest values of geometric mean productivity at the early sowing were obtained by Basabeer (1842 kg/ha) and Giza3 (1734 kg/ha.), however, the lowest values were attained by genotypes; Ibarya (617 kg/ha), COWU-3-94-9 (726 kg/ha) and Turki-2 (856 kg/ha). At the late sowing (SD3), the highest values were recorded for Giza3 (1530 kg/ha.), Basabeer (1338 kg/ha) and Turki-1(1412 kg/ha). The two small seeded genotypes; UBR (92)25-2 and DB190-74-1 gave the lowest geometric mean productivity.

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Table1: Interaction effects of seasons, genotypes and sowing dates on reproductive traits of common bean

Season	Genotype	Trait											
		No. of Pods /plant			No. of Seeds /Pod			100-seed wt.(g)			Seed Yield (kg/ha)		
		SD1	SD2	SD3	SD1	SD2	SD3	SD1	SD2	SD3	SD1	SD2	SD3
2003/4	Basabeer	18.0	21.0	18.0	3.0	4.0	3.0	23.3	23.0	19.0	1545	2034	887
	DB190-74-1	12.0	15.0	13.0	4.0	3.0	2.0	21.0	18.0	16.0	683	1388	717
	UBR(92)25-2	12.0	14.0	12.0	4.0	4.0	3.0	14.0	16.0	15.0	540	1165	460
	Giza 3	18.0	20.0	18.0	3.0	5.0	3.0	29.0	29.0	24.0	1081	2296	1286
	Bellenber-1	9.0	15.0	13.0	3.0	4.0	3.0	25.0	31.0	24.0	392	1854	1110
	COWU-3-94-9	11.0	12.0	13.0	3.0	3.0	3.0	28.0	32.0	26.0	300	1458	956
	Ibarya	9.0	12.0	12.0	2.0	3.0	2.0	36.0	42.0	42.0	114	1322	1052
	Turki-2	12.0	17.0	15.0	3.0	3.0	2.0	32.0	36.0	33.0	149	2047	1061
	S/Hashim/98	10.0	13.0	13.0	3.0	4.0	2.0	29.0	41.0	35.0	204	1424	944
Mean		12.0	15.0	15.0	3.0	4.0	3.0	26.1	29.6	26.1	549	1665	941

2005/6	Basabeer	20.0	27.0	19.0	2.0	4.0	3.0	22.0	21.0	18.2	1786	2039	872
	DB190-74-1	14.0	18.0	10.0	3.0	3.0	3.0	20.0	22.0	14.0	810	131	217
	UBR(92)25-2	13.0	16.0	36.0	4.0	4.0	3.0	18.0	20.0	12.0	872	1219	300
	Giza 3	23.0	24.0	18.0	4.0	4.0	4.0	27.0	27.0	22.0	1700	2028	879
	Bellenber-1	17.0	15.0	15.0	3.0	4.0	3.0	28.0	29.0	23.0	888	1578	772
	COWU-3-94-9	12.7	14.0	14.0	3.0	3.0	3.0	30.0	29.0	22.1	427	1442	654
	Ibarya	11.0	15.0	10.0	3.0	3.0	2.0	41.0	46.0	26.8	431	1446	426
	Turki-2	14.0	28.0	17.0	2.0	4.0	2.0	38.0	34.0	27.6	576	1992	913
	S/Hashim/98	16.0	19.0	14.0	3.0	3.0	2.0	39.0	32.0	28.1	726	1476	568
Mean		16.0	19.0	17.0	3.0	4.0	3.0	29.3	28.7	21.6	913	1614	622
S.E ±			0.79			0.3			0.11***			50.0***	
C.V%			14.0			23.3			8.3			17.6	

SD1= 1st October, SD2=30 October, (optimum or recommended planting date), SD3=30 November

Table 2: Main effects of nine common bean genotypes on the reproductive traits.

	Traits			
Genotypes	**No. of pods/plant**	**No. of seeds/pod**	**100-seed weight(g)**	**Seed yield Kg/ha**
Basabeer	20.0 a	3.1 a b c	20.9 e	1527 a
DB 190-74-1	13.4 b c	3.0 b c d	18.6 f	854 c d
UBR (92)25-2	17.1 a b	3.6 a b	15.8 g	760 d
Giza 3	19.9 a	3.8 a	26.3 d	1535 a
Bellenber –1	14.3 b c	3.3 a b c	26.8 c d	1099 b
COWU -3-94-9	13.1 b c	2.9 b c d	27.8 c	873 c d
Ibarya	12.1 c	2.3 d	38.8 a	799 c d
Turki–2	17.1 a b	2.9 b c d	33.2 b	1123 b
S/Hashim/98	14.7 b c	2.8 c d	34.0 b	890 c
Mean	15.7	3.1	26.9	1051
S.E ±	1.52	0.24	0.53	43.50
C.V %	41.0d	32.9	8.3	17.6

Means in the same column followed by the same letters are not significantly different at 0.05 probability level using Duncan, s Multiple Range Test (DMRT)

Table 3: Reproductive traits of the nine common bean genotypes evaluated under three sowing dates, averaged over seasons 2003/04 and 2005/06.

Treatments	No of Pods/plant	No of Seeds/pod	100-seed wt.(g)	Seed yield (kg/ha)
SD1	14.0	3.0	27.7	731
SD2	17.0	4.0	29.2	1639
SD3	16.0	3.0	23.8	781
Mean	**14.0**	**3.0**	**26.9**	**717**
S.E±	**1.1**	**0.4**	**0.2**	**70.7**
Significant Level	*****	**n.s**	*****	******

SD1= I[st] October, SD2=30 October, (optimum or recommended planting date), SD3=30 November.
*and**=indicate significant at 5% and 1% level, respectively.

Table 4: Percent reduction in seed yield in nine common bean genotypes, under three sowing dates (SD1, SD2 and SD3), averaged over 2003/4 and 2005/6 seasons.

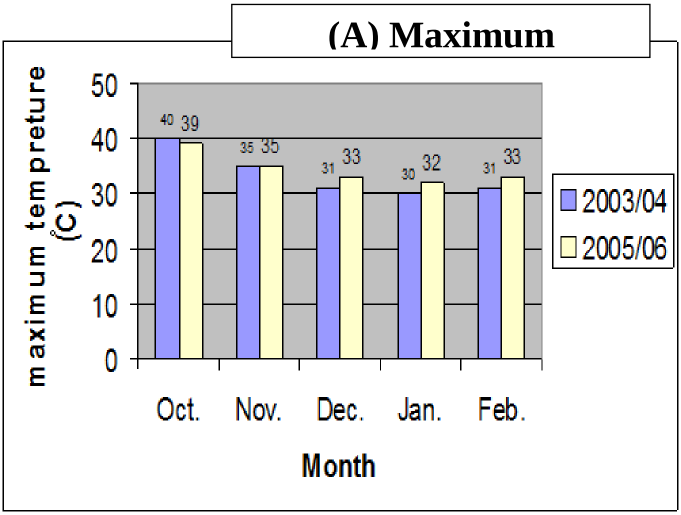
Genotype	SD2	SD1	Reduction (%)	SD3	Reduction (%)
Basabeer	2036	1666	18.2	880	56.5
DB 190-74-1	1347	747	44.5	467	65.3
UBR(92)25-2	1192	707	40.7	380	68.1
Giza-3	2162	1359	37.1	1083	49.9
Bellenber-1	1716	640	62.7	941	45.3
COWU-3-94-9	1450	364	74.9	805	44.8
Ibarya	1384	273	80.3	739	46.6
Turki-2	2020	362	82.1	987	62.6
S/Hashim/98	1450	465	67.9	755	47.9
Mean	**1665**	**731**	**56.1**	**782**	**53.1**

SD1= 1^{st} October, SD2=30 October (optimum or recommended planting date), SD3=30 November

Table 5: Means of heat tolerance parameters in nine common bean genotypes over three sowing dates in two seasons (2003/4 and 2005/6).

Genotype	Optimum YSD2	Early YSD1	Late YSD3	YSD1/YSD2 (%)	YSD3/YSD2 (%)	SSI (SD1)	SSI (SD3)	GMP (SD1)	GMP (SD3)
Basabeer	2037	1666	880	82.0	42.0	0.33	1.1	1842	1338
DB 190-74-1	1349	747	467	55.0	35.0	0.81	1.2	1004	794
UBR(92)25-2	1192	706	380	59.0	32.0	0.74	1.3	917	673
Giza-3	2162	1391	1083	64.0	50.0	0.65	0.96	1734	1530
Bellenber-1	1716	640	941	37.0	55.0	1.1	0.87	1048	1271
COWU-3-94-9	1450	364	805	25.0	56.0	1.4	0.86	726	1080
Ibarya	1384	276	739	20.0	53.0	1.5	0.90	617	1011
Turki-2	2020	362	987	18.0	49.0	1.5	0.98	856	1412
S/Hashim/98	1450	465	756	32.0	52.0	1.2	0.92	1032	1047
Mean	1640	735	782	-	-	-	-	-	-

Optimum, Early and Late sowing days; SD1, SD2 and SD3, respectively.
YSD1, YSD2 and YSD3= seed yield at sowing date SD1, SD2 and SD3, respectively.
SSI = Stress susceptibility index.
GMP = Geometric mean of productivity.



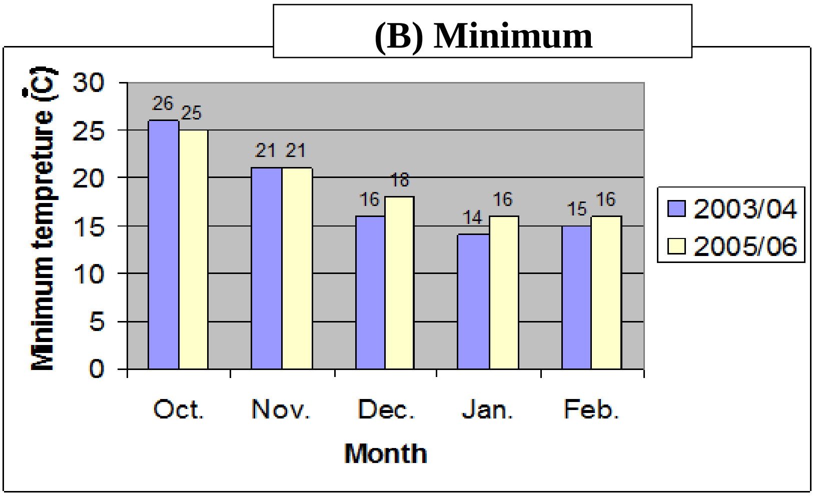


Fig. 1 (A and B): Means of maximum and minimum temperatures for two seasons (2003\04) and (2005/06).

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Research paper

Evaluation of the Life Cycle of Two Wild Plant Species; Senna (*Cassia italica Mill.*) and Handal (*Citrullus colocynthis L.*)

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ABSTRACT

The present study was carried out in Wadi Abu Salam (63 Km. east of Berber, River Nile State, Sudan), during 2004/5 and 2005/6 seasons. The life cycle of two major desert plant species, Senna (*Cassia italica*) and Handal (*Citrullus colocynthis*), were studied. For the purpose of this study, Wadi Abu Salam area is divided into three sections; upper, middle and lower. The life cycle of Senna plant was 121 and 112 days in the first and second seasons, respectively. Handal plant completed its life cycle in 137days in both seasons. The plant height of Senna was 82cm in both seasons. For Handal, the plant length was 77 and 107cm. in the first and second season, respectively.

Keywords: *Cassia, Citrullus, colocynthis, Handal, Italica, Senna*

تقويم دورة حياة نباتي السنامكة والحنظل الصحراويين

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أجريت هذه الدراسة خلال موسمي (05/2004) و(06/2005) في وادي أبو سلم علي بعد 63 كم شرق بربر، ولاية نهر النيل، السودان، علي نوعين من النباتات الصحراوية هما السنامكة *Cassia italica* والحنظل *Citrllus colyonthsis*. الهدف من هذه الدراسة وصف وتحليل وفهم ميكانيكية دورة حياة كلا النوعين من إنبات البذرة حتى وضع البذور. قسم الوادي (لغرض هذا البحث) إلي ثلاثة أقسام: علوي، أوسط وأسفل. أكمل نبات السنامكة دورة حياته في 121 و 112 يوم في الموسم الأول و الثاني علي التوالي، ونبات الحنظل في 137 يوم في كلا الموسمين. أعطت نباتات السنامكة ارتفاع بلغ 82 سم في الموسمين, ونبات الحنظل بلغ طوله 77 و 107 سم في الموسم الأول و الثاني علي التوالي.

Introduction

One group of plants belong to exerophytic species can grow in deserts in low places where water is found. They are natural graze for animals especially in rainy season. Other are unpalatable for animals and drought tolerant. These plants complete their life-cycle in the next season. The plants provide vegetation cover, minimizing drought hazards, desertification and erosion. In Sudan, more than 40% of the area is desert or semi-desert, receiving less than 90 mm of annual rainfall (Noordwijk, 1984). The Northern region lies approximately between latitudes $17^0 – 22^0$ N and longitudes $25^0 – 36^0$ E. The remaining area, away from the Nile, is classified as desert (Anon, 1987). This region is characterized by its desert climate with hot summers and warm winters.

Senna (*Cassia italica*) and Handal (*Citrullus colocynthsis*) are annual herbs and grow at the beginning of rainy seasons. Handal is a creeping annual plant that grows under the same conditions as Senna. Both species were used in many medicinal applications. Senna is used for digestive system and rheumatism diseases, while Handal is used for skin diseases for animals. Furthermore, Handal is a good source of tar oil that is used in tanneries. These plants, although they grow irregular and neglected in their origins, now received more attention worldwide and became as exportable crops. They are usually collected in a very primitive way. They began to disappear from many districts in Sudan as a result of frequent droughts in addition to other factors such as fires and cultivation in rain fed valleys.

The ecology of wadi Abu Salam was studied as a representative of many wadies in the Northern Region of Sudan. Running through the Nubian Desert, the wadi receives sporadic low rainfall. The soils of the wadi are generally classified as Entisols, formed in situ by colluviums and alluvium and are mainly affected by wind erosion due to the low vegetation cover (Mohamed, 1989). Cloudily-Thompson (1965) concluded that, this type of sandy desert usually occurs where sand is relatively scarce and the wind direction is constant. Different groups of nomads, semi-nomads and seasonal cultivators use the wadi. Herbs and grasses compose 75% of wadi Abu Salam vegetation, many of which are palatable and of high nutritive value. Often they support the indigenous animal population for a considerable part of the year. The main sources of income are the sale of livestock and/or agricultural crops to satisfy the essential requirements (Mohamed, 1989).

Due to overgrazing and continuous cultivation, combined with prolonged drought, the vegetation cover of the wadi was greatly reduced. This led to many problems, the most dangerous of which are soil erosion in cultivated areas and sand encroachment over different places.

Senna plant can stand high temperatures during the different stages of growth. Therefore, it gives higher yields in warm climates than in temperate and semi- temperate climates. It grows extensively when planted in highlands in Equatorial or semi- Equatorial areas. In addition, it may be possible to grow it in all agricultural areas if the soil is well aerated, fertile, well filled and rich in organic matter (Haikal and Omer, 1993). However, if

Senna plants are exposed to short periods of snow or cold spell, its branches will dry out (Abu Zeid, 1986; A. A. A. D., 1988; Haikal and Omer, 1993; EL Djoy, 1996).

Senna is more favorable in sandy soils, with high organic matter and in light alluvium and heavy clay to obtain a high yield of glycosides (Saber, 1961). Fairbairn and Shrestha (1967) concluded that the total content of anthraquinones glycosides is high 65 days after planting and decreases when the plant reaches 150–160 days, which is the time for fruit formation. The Senna growing in hot and dry climate in Sudan produces higher quantities of glycosides (2.7%) compared to those growing widely in districts with similar climate- hot and relatively humid- in Southern Egypt and Eastern Desert (2.3%).

Handal (*Citrullus colocynthis)* occurs in many places in Middle East, from the north to the hot desert, in sandy soil and wadies. It flowers between May and August (Feinbrum – Dothan, 1978). It grows intensively in very hot and low humidity places in arid and semi arid environments, which are characterized by low rainfall especially in summer season when the temperatures are high and with longer light periods. It grows best in light soils especially in sandy and loamy soils and believed to tolerate high salty and alkaline conditions as well as infertile and poor soils (Abu zeid, 1986).

Handal regenerates by seeds in early summer and grows well in sandy soils and therefore it is easily spread to desert areas. Fruits ripen in October – November (Haikal and Omer, 1993 and ELDjoy, 1996). When fruits ripen, its color becomes yellow and the skin thick. Leaves become yellowish and dry. The fruits are then collected and dried in a shady place or under the sun. In other cases it could be possible to cut the fruit into small pieces and put them in spreaders to dry up, it may also be possible to dry the fruits artificially inside ovens with temperatures ranging between 40 and 50 °C (Abu zeid, 1998; Haikal and Omer, 1993 and EL Djoy, 1996). Darwish *et al*. (1974) stated that sun drying or in the shade is preferable than the artificial drying especially when the fruits are cut to small pieces.

The objectives of this study is to describe, analyze and understand mechanisms and processes involved in the life cycle of each species from seed germination up to seed setting.

Materials and Methods:

The experiments were carried out during the seasons 2004/5 and 2005/6 on Abu Salam Wadi (valley), Berber, River Nile State, Northern Sudan (Latitude 17˚ 22´ N, Longitude 25˚ 36´ E).

Wadi Abu Salam is geographically divided into eleven parts using a GPS (GARMIN, GPS, and 12 XL. Personal Navigator, 1998 GARMIN Corporation). Table (1) showed the parts name and locations and the distance from Nile bank. The wadi is divided into three equally sections (Upper, Middle and Lower). Each section extends 21Km. The eleven parts are grouped according to the ecological similarity.

The upper section covers the area from Jebal Abu Salam to Umm Rueit and, composed of four parts. The middle section, from EL Kubsit to

Umm Simera, composed of four parts and the lower includes the last three parts, Umm Sarih, Dabal, and EL Ku.

Data collection

Life cycle analysis

Random plant samples in upper, middle and lower sections of the wadi were used. The life cycle of each plant was followed through laps of time from emergence, first 2-4 leaves, first flowering, first fruits setting, second flowering, first seeds formation and 2^{nd} fruits setting and 2^{nd} seeds formation. The above stages were observed through regular visits at ten days intervals, to chart and date the plants progress.

Statistical analysis:

Data were subjected to probability analysis (MSTAT- C program, 1991) to calculate regression and Dunken Multiple Range Test.

Results and Discussion:

Life cycle of Senna:

The development of Senna plant at different growth stages and duration to senescence of plant life cycle for seasons 2004/05 and 2005/06 are shown in Fig. (1, a and b) The life cycle of Senna plant in the first season, where the rainfall covered only the middle section of the wadi, can be summarized in the following: 15 days between the emergence and first 2-4 leaves stage; 48 days through first flowering stage and the complete life- cycle is about 121 days. In the second season rain fall covered the three sections of the wadi, yet Senna plants were absent in the lower section and the plant completed its life cycle in 109 to 116 days at the upper and middle sections, respectively. The life- cycle of Senna plant was significantly longer in the middle section in the 1st season and in the upper and middle sections in the 2nd season (Table 2).

Life cycle of Handal

The development of Handal plant during different growth stages and the duration for each growing stage to senescence of its life cycle for both seasons is shown in Fig. (2, a and b) In the first season, rainy showers covered the middle section only. The life cycle of Handal as followed in this section was completed in 137 days. In the second season, where the rain covered the three sections of the wadi, the plant completed its life cycle in 120, 142 and 156 days in the upper, middle and lower sections, respectively. There was a significant difference ($P < 0.05$) between Handal plant life cycle in the three sections. The mean life cycle of Handal plant in the three sections of Wadi Abu Salam for the two seasons are shown in Table (2). The longer period of Handal life cycle in the lower section of the wadi could be attributed to the higher levels of moisture in this section compared to other sections, especially at 30- 60 cm. depth which represents the limits of the layer that hold the plant roots spreads. In addition to that, the sandy top layer of the soil at 0 - 30 cm depth in this section made the spread of roots easier. The fact that Senna and Handal plants are seasonal desert plant and that they complete their life cycle during the rainy season and spread their seeds waiting for the next rainy season, were confirmed by results obtained by EL- Gazali *et al.* (1994).

Height of Senna

Height of Senna plant during 2004/5 and 2005/6 seasons is shown in Fig. (3, a and b). In the 1st season the mean plant height of Senna reached 82 cm. The plant growth accelerated at the vegetative growth period before the flowering stage and reached a height of 60 cm. At the final stages of growth, the increment in plant height slowed down as a result of transferring photosynthesis products to satisfy the need of flowering and fruit development and the decrease in soil moisture content. During the 2nd season, the Senna plant reached a mean height of 71and 90cm. at upper and middle sections, respectively. However, the mean plant height for the two seasons was 82cm. The mean height of Senna plants were significantly different ($P>0.05$) (Table 3). These results generally agree with the findings of Grieve (1984), Wickere (1984) and EL Amin (1990) who generally reported Senna plant height as 16- 60 cm. However, Abu Zeid (1986), A.A.A.D (1988), Haikal and Omer (1993) and EL Djoy (1996) found that the Senna plant height ranged between 50-200 cm.

Length of Handal

Length of Handal plant during 2004/5 and 2005/6 seasons is shown in Fig. (4, a and b). During the 1st season, the average Handal plant length reached 112 cm. The plant length development increased during the vegetative period before first flowering, with an increment of 77 cm. while during late development stages, the increment in plant length decreased. This could be attributed to transfer of assimilate supply towards production of fruits and seeds and to the depletion of soil moisture content during this stage. The results during 2005/6 season showed that, the mean lengths of Handal plants were 86, 109 and 126 cm. for upper, middle and lower sections, respectively. The difference in plants length in the two seasons and in the three sections of the wadi was found highly significant (P>0.01) (Table 3).

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Table 1: **Wadi Abu Salam sections names, GPS and distance from Nile Bank.**

	No	**Site Name**	**GPS**	**D. From Nile bank /km**
Upper	1	EL Musgur	N 18,00', 103" E 34,28,659"	63.60
	2	EL Yuet	N 18,03', 410" E 34,19', 637"	54.70
	3	ELSalobit	N 18,20', 718" E 34,19', 625"	51.70
	4	Umm Rueit	N 18,20', 718" E 34,19', 626"	47.50
Middle	5	EL Kubsit	N 18,01', 680" E 34,17', 694"	42.80
	6	EL Lilueit	N 18,03', 042" E 34,16', 006"	37.20
	7	Umm Beid	N 18,02', 962" E 34,13', 223"	33.60
	8	Umm Simeira	N 18,50', 800" E 34,11', 906"	28.50
Lower	9	Umm Sarih	N 18,06', 176" E 34,08', 902"	22.70
	10	Dabal	N 18,06', 457" E 34,05', 364"	20.70
	11	EL Ku	N 18,07', 738" E 34,04', 272"	18.20

Table 2: Life cycle (days) of Senna and Handal plants in different sections of wadi Abu Salam during two seasons

Season / Section	2004/05		2005/06	
	Senna	**Handal**	**Senna**	**Handal**
Upper	0.00 b	109 a	0.00 b	120 b
Middle	121.0 a	116 a	137.0 a	142.0 a
Lower	0.00 b	0.00 b	0.0 0 a	156.0 a

Means within the same column having the same letter are not significantly different at P = 0 .05 according to Duncan's Multiple Range Test.

Table 3: The height of Senna plant and plant length of Handal (cm) in different sections of wadi Abu Salam during two seasons

Season / Section	2004/05		2005/06	
	Senna	**Handal**	**Senna**	**Handal**
Upper	0.00 b	71.0 a	0.00 b	86.0 a
Middle	82.0 a	90.0 b	112.0 a	109.0 b
Lower	0.00 b	0.00 c	0.00 b	126.0 b

Means within the same column having the same letter are not significantly different at P = 0 .05 according to Duncan's Multiple Range Test.

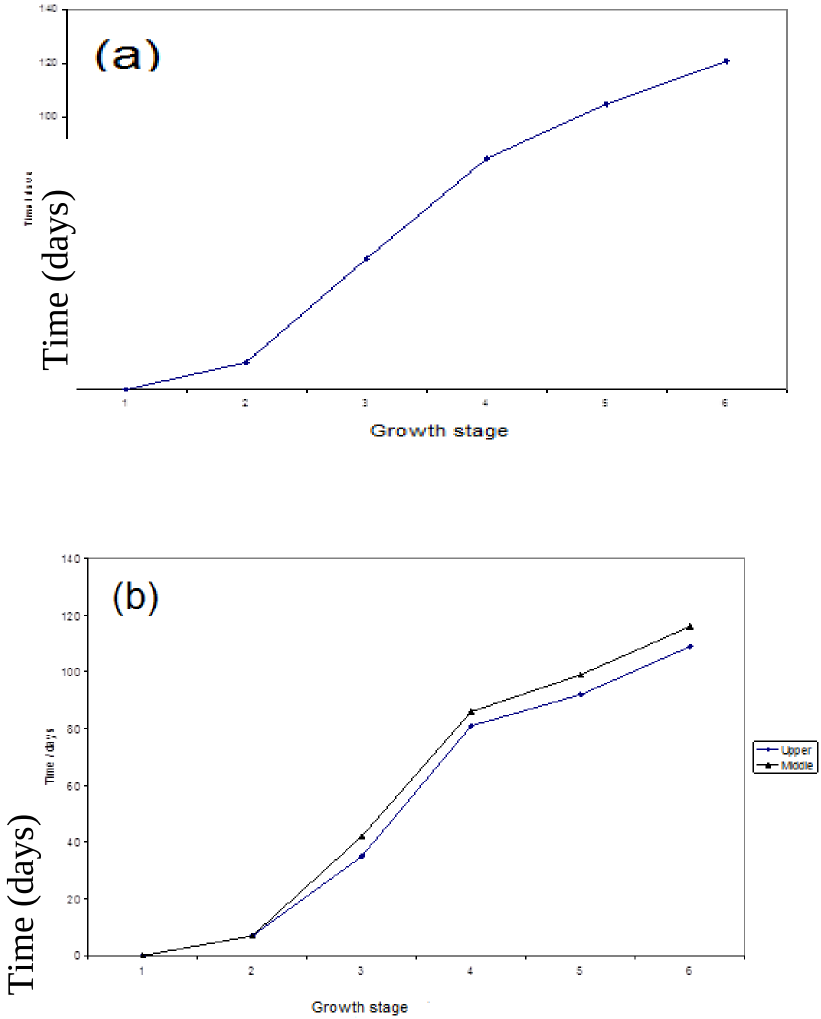
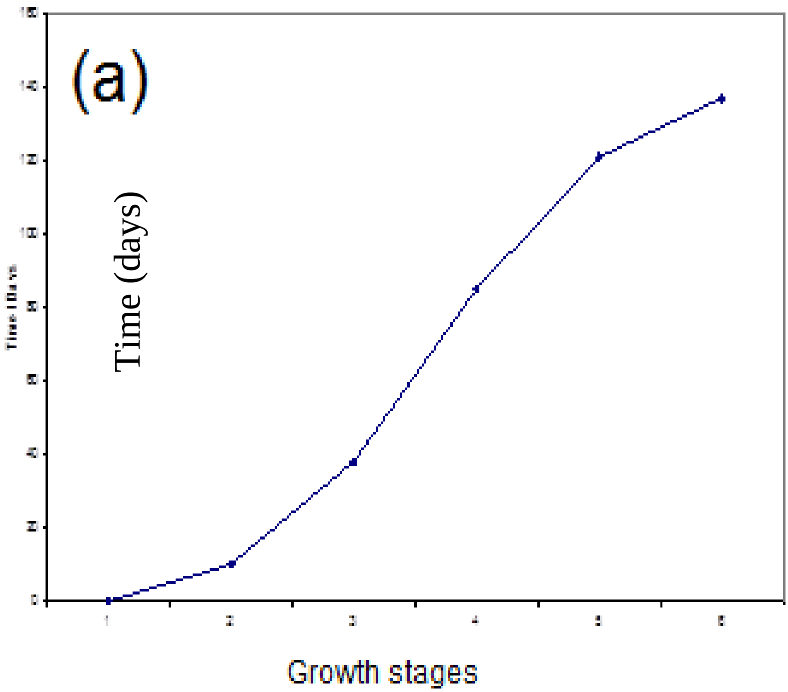


Fig. 1: The life cycle of Senna plant (days) during two seasons: (a) Season 2004/5 (b) Season 2005/6 at different wadi sections (Upper, Middle, Lower) and different growth stages (1- emergence, 2- first 2 -4 leaves, 3- first flowering, 4- first fruits setting and 2nd flowering, 5- first seeds formation and 2nd fruits setting and 6- 2nd seeds formation).


(a)
Time (days)
Growth stages

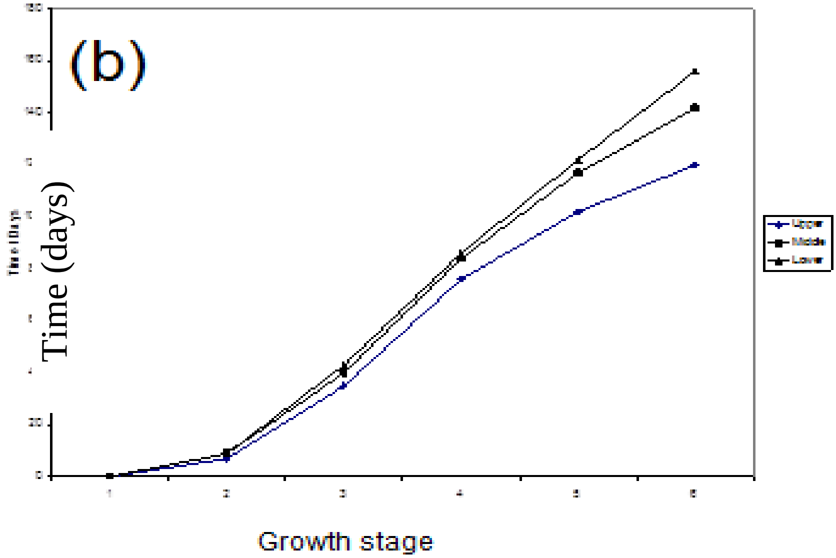
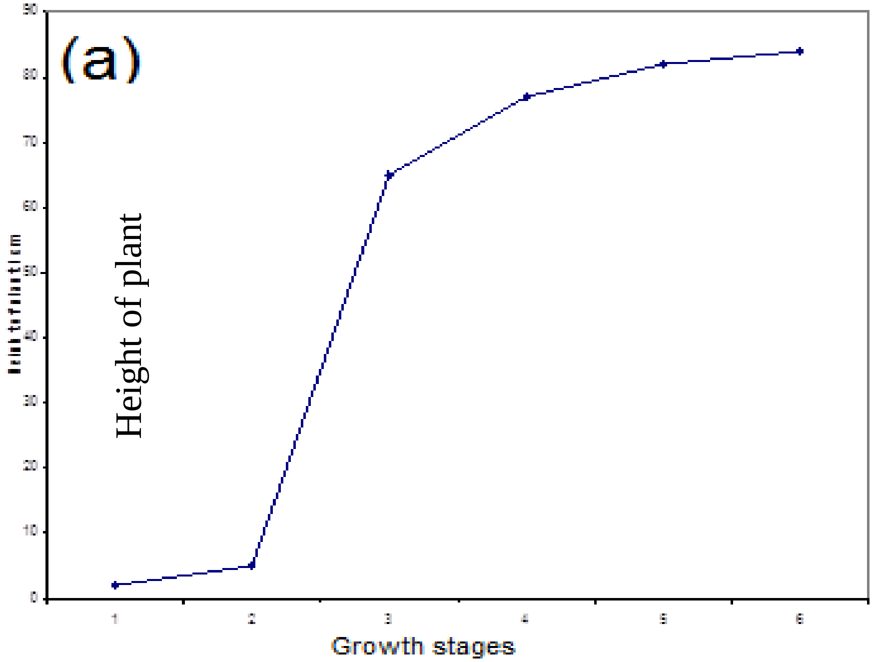


Fig. 2: **The life cycle of Handal plant (days) during two seasons: (a) Season 2004/5 (b) Season 2005/6 at different Wadi sections (Upper, Middle, Lower) and different growth stages (1- emergence, 2-first 2 -4 leaves, 3-first flowering, 4-first fruits setting and 2nd flowering, 5- first seeds formation and 2^nd^ fruits setting and 6- 2^nd^ seeds formation.)**


(a)
Height of plant
Growth stages
0
10
20
30
40
50
60
70
80
90
1
2
3
4
5
6

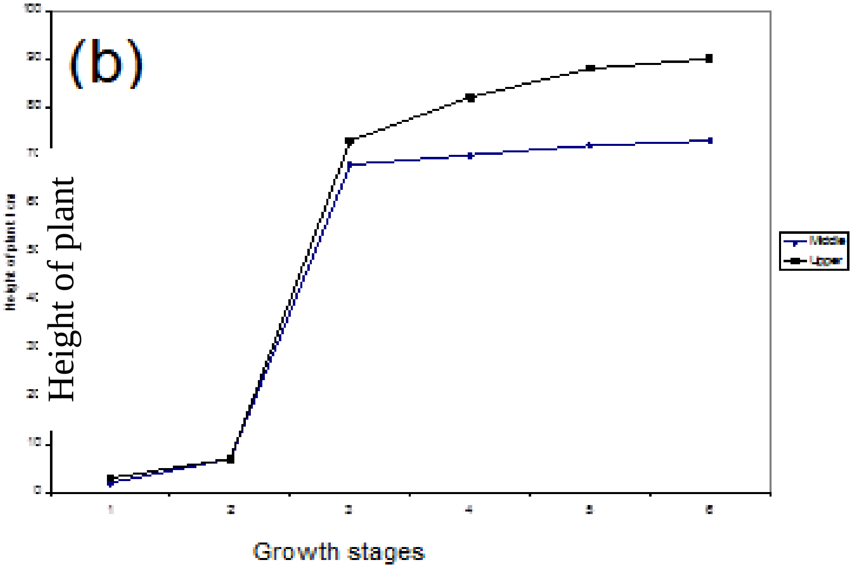
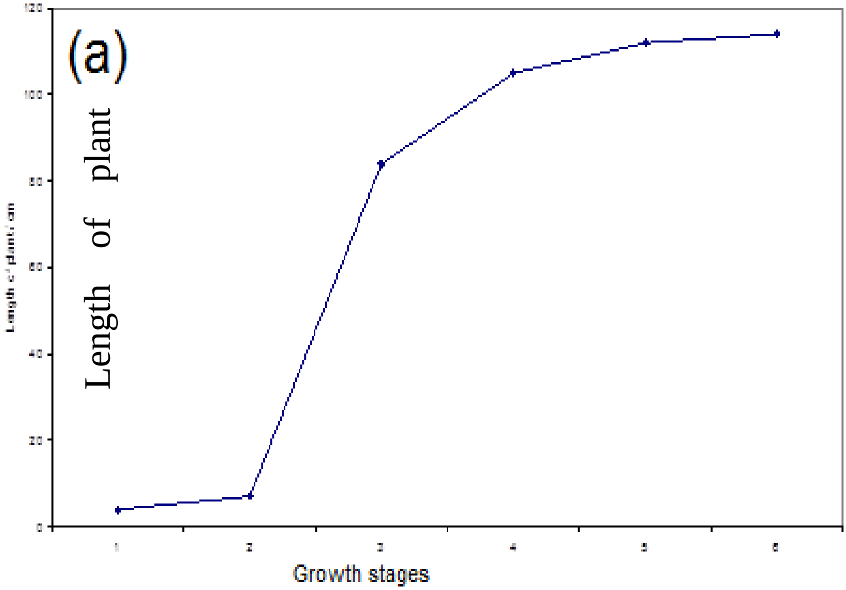


Fig. 3: **Height of Senna plant (cm) during two seasons: (a) Season 2004/5 (b) Season 2005/6 at different Wadi sections (Upper, Middle, Lower) and different growth stages (1- Emergence, 2- First 2 -4 Leaves, 3- First Flowering, 4- First Fruits Setting and 2nd Flowering, 5- First Seeds Formation and 2nd Fruits Setting and 6- 2nd Seeds Formation.**


(a)
Length of plant
Growth stages
0
20
40
60
80
100
120
1
2
3
4
5
6

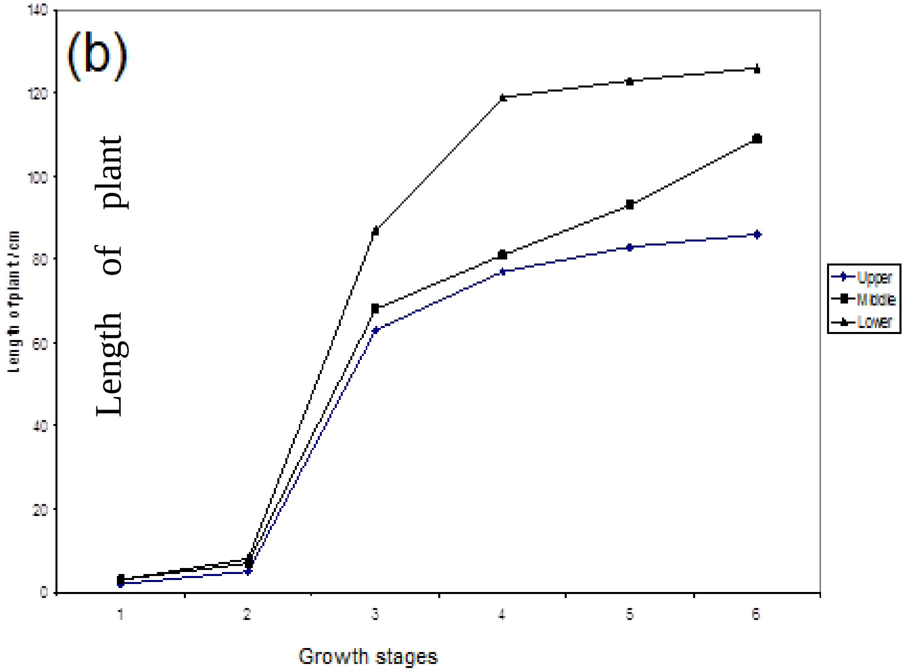


Fig. 4: Length of Handal plant (cm) during two seasons: (a) Season 2004/5 (b) Season 2005/6 at different wadi sections (Upper, Middle, Lower) and different growth stages (1- emergence, 2- first 2-4 leaves, 3- first flowering, 4-first fruits setting and 2nd flowering, 5- first seeds formation and 2nd fruits setting and 6- 2nd seeds formation)