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Introduction

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

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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.

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

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Introduction to Vol. 4, issue 2

In this part of twitchy world we could say that agricultural development is the key factor to stability, hence we are facing huge challenging situation of ensuring food security for ever growing population in a fragile environment and global climatic change. Responsibility of governments will grow with the population growth. Special responsibility for promoting agricultural sector and farming systems need embracing modern technologies and responsible policies.

In River Nile State, despite perceived advance with agricultural sector in term of practices and horizontal expand in cultivated area, still we are far behind our potentials. Fertile soils along rivers had been fully exploited. To increase productive areas, challenges of irrigation in this extreme arid zone, and how to grow and nourish crops in mostly alkaline and sometimes sodic soils will add to our problems of labor scarcity and shortage in finance. This situation necessitates effort to be exerted to post intermediate technology development. In Sudan we are in bad need to cut import of agricultural commodities and to increase others for export to adjust the disturbed balance of payment which could be easily achieved if we have the will. This issue, as we usually do, focuses on good, yet simple pre harvest and post-harvest production practices which could be easily applicable to our farming systems.

Editorials

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Research paper

Influence of Irrigation Interval and Plant Population Density on Sesame Growth and Yield at High Terrace Soils

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ABSTRACT

This experiment was conducted to investigate the effect of irrigation intervals and plant population density on growth and yield attributes of sesame for two successive seasons (2006/07 and 2007/08) in the Farm of the Faculty of Agriculture, Nile Valley University, Darmali, Sudan. The experiment was arranged in split-plot design with four replications. Treatments consisted of three irrigation intervals (7, 14 and 21 days), assigned to the main plots, and four plant populations (100,000, 150,000, 200,000 and 250,000 plants ha^{-1}) to the sub-plots. Parameters recorded included: leaf area index (LAI), number of branches per plant, number capsules per plant, seed yield per plant, seed yield per unit area (kg ha^{-1}), and 1000-seed weight. The results indicated that LAI after 60 days from sowing showed a significant difference among irrigation intervals and plant population density with time. The number of branches and capsules per plant increased significantly ($P \leq 0.05$) under short irrigation intervals and as plant density decreased. The heaviest 1000-seed weight (2.62 g) was obtained under 7 days irrigation interval. There was a significant interaction between irrigation intervals and plant densities on seed weight. A maximum seed yield of 450 to 463 kg ha^{-1} was obtained by plant densities of 150,000 and 200,000 plants ha^{-1}, respectively in both seasons. Therefore, it can be concluded that, irrigation of 7 days interval with density of 200,000 plants ha^{-1} and gave the highest seed yield (955 Kg ha^{-1}), so it recommended for sesame cultivation under tropical high terrace soil conditions.

Keywords: Leaf area index, capsules $plant^{-1}$, 1000- seed weight, seed yield.

تأثير فترات الري والكثافة النباتية على النمو وإنتاج السمسم في التروس العليا

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أجريت هذه التجربة لدراسة تأثير فترات الري والكثافة النباتية على النمو والحاصل ومكوناته من السمسم لموسمين متتاليين (07/2006 و08/2007) في مزرعة كلية الزراعة، جامعة وادي النيل، دار مالي، شمال السودان. وجرى ترتيب معاملات هذه التجربة في تصميم القطع المنشقة بأربعة مكررات. تتألف المعاملات من ثلاث فترات الري (7 و14 و21 يوماً)، في القطع الرئيسة، وأربعة كثافات نباتية (100000، 150000، 200000 و250000 نبات للهكتار) في القطع الفرعية. شملت القياسات: دليل مساحة الورقة وعدد الأفرع والكبسولات في النبات وحاصل البذور للنبات وفي وحدة المساحة (كجم/هكتار)، ووزن الـ 1000 بذرة. أظهرت النتائج فروق معنوية لدليل مساحة الورقة بين فترات الري والكثافة النباتية بعد 60 يوماً من الزراعة. وإلى انخفاض عدد الأفرع والكبسولات في النبات (ف <0.05) في إطالة فترات الري. وزاد عدد الأفرع والكبسولات في النبات معنوياً (0.05) كلما انخفضت الكثافة النباتية. أمكن الحصول على أثقل وزن 1000 بذرة (2.6 جرام) عند الري كل 7 أيام. هناك (ف <0.05) كان التفاعل بين فترات الري والكثافة النباتية معنوياً في وزن البذور. وأعطت الكثافة النباتية 150000 و200000 نبات/هكتار أعلى حاصل من البذور في الموسمين. توصي الدراسة بالري كل 7 أيام وبكثافة نباتية 200000 نبات /هكتار في أراضي التروس العليا.

كلمات مفتاحية: دليل مساحة الورقة، عدد الكبسولات، وزن ال 1000 بذرة وإنتاج البذور.

Introduction

Sesame (*Sesamum indicum* L.) is one of the important oilseed crops in Sudan. However, the seed yield depending upon the amount and distribution of rainfall, cultural practices and cultivars. Therefore, many factors influence plants water requirements namely, duration of growth season, climate and the humidity of soil topography (Boydak *et al.* 2007). Fazeli *et al.* (2006) concluded that leaf water potential and relative water content of the leaves decreased with the increase of water deficit. Moreover, leaf water potential was lower in the high stress. According to Boydak *et al.* (2007) the highest yields were obtained at 6 and 12 day intervals and the lowest yield obtained at 24 day intervals. In India studies of Ayyaswamy and Kulandaivelu (1992) revealed that the height of the first capsule and plant height were greatest in the 15 days interval, whereas irrigation at 20 or 30 days intervals increased the number of branches at harvest compared with 15 days interval. Ucan *et al.* (2007) concluded that, the amount of irrigation water applied significantly affected seed yield. Generally, the yield in sesame can be increased by improving mobilization of assimilations to seeds, and crop losses under deficient water can be minimized by providing irrigation during the reproductive stage (Yadav and Srivastava, 1997). Maintaining an optimum plant density plays a vital role in realizing the yield potential of the crop (Guanamurthy *et al*. 1992; Ghosh and Patra, 1994 and Caliskan *et al*. 2004). Plant density significantly influences growth and yield components. Plant height, branch number, capsule number and seed yield decreased with increasing plant density. Generally, yield parameters obtained with the increase in plant density and stand up to 222000 plants ha^{-1} considered necessary to obtain reasonably good seed yield (Subrahmaniyan and Arulmozhi, 1998 and Adebisi *et al*. 2005). With further increase in density beyond 330000 plans/ha, the number of capsules per plant and seed weight per capsule decreased significantly (Mujaya and Yerokum 2003). Recently, however Imoloame *et al*. (2007) concluded that, seed rate of 6 kg ha^{-1} produced the highest seed yield, However, 1000 – seed weight was not affected by plant density (Sarma, 1994). While, mean seed yield increased with increasing plant density (Tiwari and Namdeo, 1997; Senthilkumar *et al.* 2000). However, the optimum irrigation interval must be related to plant density. The interactive influence of irrigation interval and plant density on sesame performance has not been fully studied. The objective, of this experiment was to examine the effects of irrigation intervals and plant densities on growth, yield and yield components of sesame under irrigation.

Materials and methods

The experiment was carried out during the 2006/07, 2007/08 growing seasons, at the Faculty of Agriculture Farm, Nile Valley University, Darmali, Northern Sudan (latitude 17^{o}48 N, longitude 34^{o} 00E and altitude 346.5 meter above sea level). The soil of the experimental plots was classified as calcareous matrix strongly alkaline with low permeability to water and low in nitrogen and humus content.

The treatments were arranged in split-plot design with four replications. Three irrigation intervals (7, 14 and 21 days) were assigned to the main plots and four plant populations ($1.0x10^5$, $1.5x10^5$, $2.0x10^5$ and $2.5x10^5$ plants ha^{-1}) to the sub-plots. The Land was prepared by disc ploughed and disc harrowed, leveled and ridged at 70 cm. The plot size was 3.5×7 m^2 consisting of six ridges 7 m in length, with 70 cm spacing between ridges. Sesame cultivar Shuak was sown on the first week of July in both seasons. The crop was irrigated three times for establishment before the start of the differential watering regime. The plants were thinned at two weeks from sowing to achieve the required plant densities.

Data were collected on growth attributes leaf area index and at physiological maturity ten plants were randomly selected from harvest area for measurement, number of branches per plant, number of capsules per plant, seed yield per plant, 1000-seed weight and seed yield per unit area (kg ha^{-1}) were obtained from the center rows of each plot leaving 1 m from both ends of the plots as margins. Harvesting was done manually by cutting the crop at the soil surface bound and air dried for twenty days and converted to seed yield per unit area.

Statistical analysis was carried out using compare treatment means using MSTAT-C computer programme.

Results and discussion

Leaf area index (LAI)

Figure 1 shows the influence of irrigation intervals and plant population densities and their interaction on Leaf area index during ontogeny of sesame plants. The results showed that irrigation intervals and plant density significantly affected LAI at flowing stage and declined thereafter due to leaf senescence. Moreover, the maximum Leaf area index was attained at shorter irrigation interval and high planting density at all growth stages. The increase or decrease in LAI directly

affects plant growth. It may be due to increasing the capture of radiation within the canopy. This results is in the line with that of Subrahmaniyan and Arulmozhi, (1998) and Abusuwar and Karam Eldin (2013) on alfalfa and Rhodes grass.

Number of branches plant^{-1}

The number of branches per plant was significantly affected by irrigation intervals, plant population density and their interaction (Table. 1 and 2). The maximum number of branches per plant (1.40) was recorded when the crop was irrigated every 7 days interval. However, the number of branches per plant was significantly decreased from 1.35 to 0.67 with increase in plant density from 100,000 to 250,000 plants ha^{-1} (Table 1). Said, *et al.* (2017) reported similar results.

Number of capsules plant^{-1}

Irrigation intervals and plant densities and their interaction had significant effects on number of capsules plant^{-1} (Table 1 and 2). The maximum number of capsules plant^{-1} (27.43) was obtained when the crop was irrigated every 7 days interval and consequently decreased by long irrigation interval. The reduction in number of capsules plant^{-1} may be attributed to the effect of water stress during the reproductive phase. Yadav and Srivastava (1997) reported similar findings. However, the number of capsules per plant increased with decreasing plant population density. These results revealed that, increasing population density to 250,000 plants ha^{-1} resulted in a substantial reduction in number of capsules plant^{-1}. Mujaya and Yerokum (2003) and Adebisi *et al.* (2005) reported similar findings.

1000-seed weight (g)

The irrigation intervals had significant effects on 1000-seed weight (Table 1). 1000-seed weights were not significantly affected by plant population density. Change in plant density did not influence 1000-seed weight significantly. However, 1000-seed weight was higher at higher plant density. The interaction effect between irrigation intervals and plant densities on 1000-seed weight was significant (Table 2). Similar results were reported by Sarma (1994) and Mujaya and Yerokum (2003). Generally, increasing the number of plants per ground area increases the competition among plants for soil moisture, nutrients, light and carbon dioxide. This may explain the significant effects of irrigation intervals and the interactions.

Seed yield plant^{-1} (g)

Irrigation interval and the interactions significantly affected seed yield per plant at 0.05 statistical level (Table 1 and 2), but this trait was not significantly affected by population density (Table 1). The highest seed yield per plant (1.52) was produced by 7 days irrigation interval and increase in

irrigation interval from 14 to 21 days decreased it by 67%, it is likely that water deficit stress at seed setting stage resulted in the abortion in some capsules, their shedding and the decrease in seed weight per plant. Seed yield plant^{-1} reduced to 33% with increase in plant density from 100,000 to 250,000 plants ha^{-1}. Results from the present findings are in conformity with results obtained by Tomar (1992) and Jooyban and Moosavi (2011) who observed the seed yield plant^{-1} decreased with increasing plant density pressures whereas seed yield per unit area was higher at higher plant densities. This clearly indicates that the seed yield plant^{-1} at lower densities could not compensate for the loss of seed yield due less number of plants per unit area. Seed yield plant^{-1} was reduced at longer irrigation intervals. The results revealed that seed yield per plant was significantly increased with decreasing plant density. Higher seed yields per plant were recorded in the range of 100,000 – 200,000 plants ha^{-1} relative to 250,000 plants ha^{-1} is apparently as of possible lower interplant competition. Further increase in the density may affect the agronomic traits of sesame.

Seed yield (kg ha^{-1})

Seed yield of sesame was significantly affected by irrigation intervals, plant population and their interaction (Table 1 and 2). The highest seed yield (822 kg ha^{-1}) was obtained from 7 days irrigation interval which was 69 and 74% higher than that obtained from 14 and 21 days irrigation intervals, respectively (Table 1). This was related to the decreased competition between plants and the increased number of capsules per plant. This could be due to the amount of soil moisture available by irrigation which influence nutrients uptake. In addition, long irrigation intervals caused water loss by evapotranspiration. The obtained results are in agreement with Duraisamy *et al.* (1999) who mentioned that the crop suffered from moisture stress as a result of longer irrigation intervals, the stress adversely affected the growth and yield attributes and ultimately decreased the seed yield. The plant populations of 150,000 and 200,000 plants ha^{-1}produced the highest seed yield than 100,000 plants/ha. A maximum seed yield of 450 to 463 kg ha^{-1} was obtained by plant populations of 150,000 and 200,000 plants ha^{-1}, respectively. These results clearly indicated that for irrigated sesame a density of 100,000 plants ha^{-1} were sparse and hence affecting adversely the seed yield. These findings are in accordance with those of Guanamurthy *et al.* (1992). The interaction effect between irrigation intervals and plant populations was significant. These results are in agreement with those findings of Mujaya and Yerokum (2003), seed yield is directly related to the number of capsules. The results of the current study it can concluded that irrigation sesame treatment of 7

days interval grown with densities of 200,000 plants ha^{-1} is recommended for the sesame cultivation under tropical high terrace soil conditions.

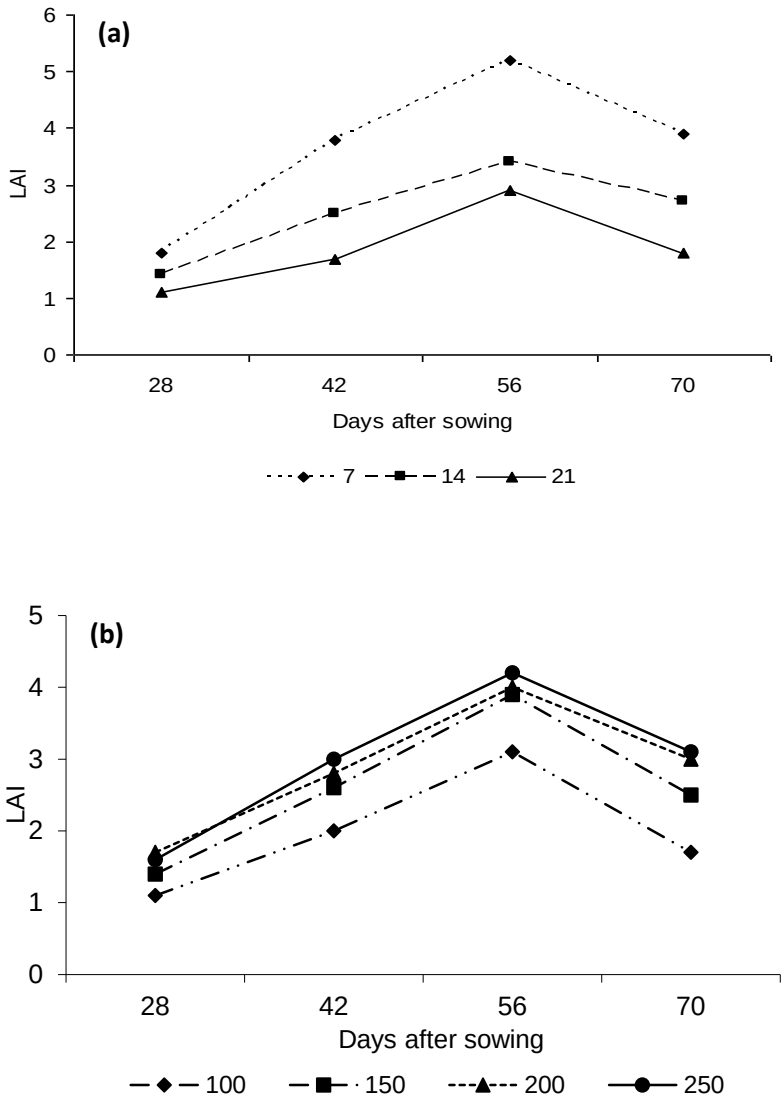

Fig.1 Leaf area index as influenced by (a) irrigation intervals (…♦…7, —■— —14 and ——21 days) and (b) plant population density (100000, 150000, 200000 and 250000 plants ha^{-1}) during 2006/07 season

Table 1. Effects of irrigation interval and plant population density on the yield and yield components of sesame (data combined for 2006 - 2007 seasons).

Treatments	No. of branches plant^{-1}	No. of capsule plant^{-1}	1000-seed weight (g)	Seed yield (plant^{-1})	Seed yield (kg ha^{-1})
Irrigation interval (days)					
7	1.40a	27.43a	2.62a	1.52a	822a
14	0.63b	13.42b	2.48a	0.69b	257b
21	0.84b	14.12b	2.08b	0.50c	214c
LSD (0.05)	0.32	2.882	0.223	0.133	23.9
Plant density (000) ha^{-1}					
100	1.35a	18.11c	2.36a	1.02a	382c
150	1.12a	20.52a	2.37a	0.95a	450a
200	0.68b	19.73b	2.41a	0.96a	463a
250	0.67b	14.90d	2.42a	0.68a	427b
LSD (0.05)	0.24	0.762	NS	NS	23.08

Means followed by the same letters in each column are not significantly different according to least significant difference (P≤0.05).

Table 2. Interactive effects of irrigation level and plant population density on the yield and yield components of sesame (data combined for 2006 - 2007 seasons).

Irrigation intervals (days)	Plant density (000) ha^{-1}	No. of branches plant^{-1}	No. of capsule plant^{-1}	1000-seed weight (g)	Seed yield (plant^{-1})	Seed yield (kg ha^{-1})
	100	2.1a	28.49ab	2.60b	1.66a	693c
	150	2.2a	31.29a	2.56b	1.58a	830b
	200	1.3c	26.64b	2.65b	1.57a	955a
	250	1.0c	23.31c	2.86a	1.28b	809b
14	100	1.8ab	11.66ef	2.43c	0.83c	237e
	150	1.6bc	14.70de	2.48b	0.64d	308d
	200	0.9c	16.83d	2.46b	0.93c	264e
	250	0.7d	10.50f	2.56b	0.37e	218f
21	100	1.3c	14.19d	2.01d	061d	216f
	150	1.2a	15.55d	2.11d	0.63d	211f
	200	0.8c	15.88d	2.08d	0.39e	171g
	250	0.6d	10.87f	2.12d	0.40e	256e
LSD (0.05)		0.37	3.099	0156	0.143	32.3

Means followed by the same letters in each column are not significantly different according to least significant difference (P≤0.05).

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Research paper

Effect of Organic and Chemical Fertilizers on Vegetative Growth and Fruit Characteristics of Banana, Grand Nain and Dwarf Cavendish Group

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ABSTRACT

Banana is one of the oldest tropical fruits cultivated by man from prehistoric times in India with great socio-economic significance, interwoven in the cultural heritage of the country. Banana fruit production in the Sudan, cover a wide spectrum of activities ranging from local utilization of fruit with self-sufficiency through small farming for local market to large plantation for export. It is one of most important fruits of Sudan. Therefore, a field experiment was conducted at two locations in Aliab, River Nile State during 2009/10 and 2010/11 seasons in split plot design with four replications. Assigned to the main plots two varieties of banana (Cavendish dwarf and Grand Nain, AAA) and to the sub –plots the fertilizer treatments arranged randomly, consisted of Urea., NPK, and combination of organic fertilizers, compost and manure. The results indicate that there were highly significant differences in pseudo stem length in the two cultivars due to fertilizer treatments especially chemical and organic fertilizers, also there were significant effect in fruit parameters (weight of bunch, finger and number of hands per bunch and finger per bunch) due to the fertilizer treatment at least in one season.

Keywords: Banana, Grand Nain, Cavendish, compost, fertilizer

تأثير التسميد العضوي والكيميائي على النمو الخضري وخصائص الثمرة للموز صنفي كافندش المتقزم والقراندنين

انتصار بابكر[1] والصادق حسن الصادق[2]

1 كلية العلوم الزراعية، جامعة دنقلا
2 كلية العلوم الزراعية، جامعة السودان للعلوم والتكنولوجيا

يعتبر الموز من أقدم المحاصيل المدارية ذات الاهمية الاقتصادية والاجتماعية المستأنسة بواسطة الانسان من عصور ما قبل التاريخ. ومتصلة في موروث البلدان. انتاج الموز في السودان يغطي طيف واسع من الانشطة من مزارع الاكتفاء للسوق المحلي الي المزارع الواسعة المنشاة للتصدير. ويعتبر واحد من المحاصيل المهمة لذلك اجريت هذه التجارب بموقعين بالعلياب، ولاية تهر النيل في موسمي 10/2009 و11/2010 بتصميم القطع المنشقة بأربعة مكررات لتشمل صنفين من الموز كافندش المتقزم والقراندنين على القطع الرئيسة والتسميد على القطع الفرعية. اوضحت النتائج فروق عالية المعنوية في طول الساق الكاذبة في الصنفين كاستجابة للتسميد بنوعيه العضوي والكيماوي كما اوضحت النتائج ايضا فروق معنوية في المؤشرات الموصفة للإثمار (وزن السباطة والاصابع وعدد الكفوف في السباطة وعدد الاصابع في الكف) كاستجابة للتسميد على الاقل في موسم واحد.

كلمات مفتاحية: الموز، القراندنين، كافندش المتقزم، الكمبوست، السماد

Introduction

The word "banana" is a general term embracing a number of species or hybrids in the genus Musa of the family Musaceae, most edible-fruited banana, usually seed less. It belongs to the species *M-acuminata*. Banana can be divided into two main groups. Dessert bananas which constitutes 43% of world production (Anon., 19920 and the fruits of this group are chiefly eaten raw when ripe, as a dessert fruit. They are sugary and easily digestible. The most important example of this group are fruits from cultivars of the common Cavendish group. The second group of bananas which account for the other 57% of world production are the cooking banana (Anon, 1992). The experiment was done with two cultivars of Cavendish group, dwarf and giant Cavendish. Dwarf is the smallest or short and better adapted to a cool climate than any other cultivar. "Giant Cavendish" compared to dwarf is slightly taller and its French name is "Grand Nain (Samson, 1980). Grand Nain is an outstanding banana variety growing from 6 to 8 feet tall and solid green in color. It is very attractive for its landscaping potential and good wind resistance.

The 'Grand Nain' produces very large heads of delicious fruit. Bunches may weight up to 150 Lb. This is a commercial variety that you buy in the grocery store. The full sized fruit ripen rapidly. The fruits of this group are chiefly eaten raw when ripe, as a dessert. Banana fruit production in the Sudan covers a wide spectrum of activities ranging from local utilization of fruit with self-sufficiency through small farming for local market to large plantations for export. The organic manure which is made from compost provides the ingredients necessary for the crop as well as nitrogen, phosphorus, potash etc., which improves the important functions of the organic, chemical and physical characteristics of the soil. The soil fertility increases and it becomes soft and porous. Humidity is also maintained. In Sudan commercial banana production is for local market. The cultivation is concentrated on alluvial Delta of Gash River in Kassala State. The central production in Khartoum State is restricted to Wad Ramli Suburb, in River Nile State, and in the Blue Nile State, South of Sennar. In Kassala there is reduction in acreage. This reduction was mainly attributed to scarcity of irrigation water and to poor husbandry practice (Shomo, 1974 and Osman *et al*., 2015). There are many problems hindering the production of banana such as nematode infestation, scarcity of suckers and the dependence on one variety, in addition to the lack of knowledge about the cultural practices, and absence of detailed agricultural operations, such as, planting methods, variety, spacing, and pruning, ripening and marketing programs of the crop. Therefore, to stimulate banana crop production and make it commercially feasible, considerable research should be geared towards investigating, recognizing and solving the problems facing

banana industry in the country. Fertilization is an important and limiting factor for growth and productivity of banana plants which remove large amounts of nutrients from the soil, it is well known that banana needs large amounts of fertilizers especially nitrogen. So, the major problems facing banana growers are the high costs of excessive manufactured fertilizers. Besides, these chemical fertilizers are considered as air, soil and water polluting agents during their production and utilization. Consequently, it has drawn the attention of researchers and banana growers to use the organic fertilizers, which are safe for human, animal and environment, as a partial substitute for mineral source. Thus, it is preferred to use these natural fertilizers to avoid pollution and to reduce the costs of chemical fertilizers. In this experiment, application of two type of fertilizers, organic manure (cow and chicken compost) and chemical fertilizer (urea +NPK), and their combination was used. The objective of this study is to investigate the effect of organic manure and chemical fertilizers on growth and yield of two banana cultivars namely, dwarf Cavendish and Grand Nain, and determining the best dose of fertilizers that influence the yield and fruit characteristics like total bunch weight, middle-hand weight and number of fingers per middle-hand, of Grand Nain Dwarf Cavendish banana.

Materials and Methods

The study was carried out at Alliab area in the River Nile State, Sudan (lat. 17°,30′; long. 33°,15′), during the period from June to September 2009/10 and 2010/11. The climate of the area is desert with summer rain and warm winter (Van Der Kevie, 1976). The soil samples from the experimental site were analyzed for physical and chemical characters according to the standard procedures. The experiment was carried out as split plot design based on randomized complete block design (RCBD) with four replications, total of 18 treatments including, in the main plots, the two varieties of Cavendish Dwarf and Grand Nain [AAA], and in the sub –plots, the fertilizer treatments, arranged randomly.

Planting materials are suckers of banana cultivar ‘Dwarf Cavendish and Grand Nain’ four months old, sword type. The suckers of Dwarf Cavendish were selected from banana plantation in Shendie Locality. The Grand Nain from tissue culture lab in Medani Research Station. The sub plots consisted of Urea, 400g/plant/yr., NPK, 200 g/plant/yr. and the organic fertilizers, compost (10) kg/plant/yr, manure 5 kg/plant/yr. In this experiment growth parameters of the plant crop and

first ratoon crop were measured and recorded. They include plant height (cm), pseudo stem girth (cm) and number of leaves.

Weight of bunch (kg), Weight of hand/ Bunch (kg), and Weight of finger/ hand (kg), were recorded in addition to No. of hand/ bunch and No. of finger/ hand, as yield parameters.

The bunches were weighed using spring balance to determinate the weight of fingers, then the weight of all hands in a bunch was divided by the total number of fingers in that bunch.

Results and Discussion

Generally, the results in the two seasons indicated that there was high significant difference between the two cultivars, Grand Nain and Dwarf Cavendish through all parameters, plant high, pseudo stem girth and number of functional leaves. Significant increase (p=,0.05) in weight of bunch, number of hands/bunch, number of fingers/bunch, and weight of hands/bunch were recorded due to fertilizer treatments especially manure, (M+U), Compost + Urea (C+U) and urea alone, (table 1and 2). Also there was significant difference between the two varieties. The best growth (height, girth of pseudo stem and number of leaves) and bunch yield were observed following application of 200gN/plant in 4 split doses (2, 4,6 and 8 months after planting). This result is supported by many workers like, Singh and Suryanaryana (1999) who studied the response of application of 200 or 250 g N/plant in 4 split doses. Irizarry and Rico (1989) studied the effects on growth and yield of banana CV "Dwarf Cavendish". They found that Williams's cultivar had significantly higher vegetative growth than Dwarf Cavendish.

Results indicated that the effect of urea on Grand Nain is more than on Dwarf Cavendish in all parameters. This seems to agree with Gangwar and Niranjan (1990) who studied the effect of inorganic fertilizers and FYM on the rain-fed fodder sorghum. They found that addition of FYM+50% recommended doses of inorganic fertilizer resulted in significantly higher plant height, dry weight, and fresh weight and increased the uptake of N, P and K compared with the control.

Results in Table (3) and (4) indicated significant effect of fertilizer on bunch, finger weight, finger number/ hand and hand number/ bunch in both seasons. However, the differences between varieties in all studied parameters, were only significant in season 20010/11. Results were in line with Singh and Suryanaryana (1999) and Munica *et al.* (1978) who recorded highest bunch weight and fruit yield by 200g N and 300g N per plant. Akyeambong and Hitamana (1979) found that the best growth and bunch yield followed application of 200g/plant. Butler (1960) reported that

substantial increase in mean weight of bunch and total production per ha were mainly obtained by application of nitrogen –containing compounds especially when those applied in small quantities. The treatments were manure (M+U), Compost + Urea (C+U) and Urea affected bunch weight and number of finger per hand compared to control are shown in figure (1) and (2). Comparing the two cultivars, Grand Nain responded to fertilization better than Dwarf Cavendish on all parameters. As indicated by Abdel Monieum *et al*. (2008), application of fertilizer combinations influenced the reproductive characteristics of Grand Nain. The best results with regard to quality of fruit were obtained from plants received 50% compost plus 50% out of recommended rate of N mineral source. Bakheit (1994) also reported that application of organic manure resulted in higher leaf NPK contents of both banana and the first ratoon crop.

The results indicated that application of organic manure only was not enough for banana plant growth and yield, so the chemical fertilizers are important in the soil in the Sudan. This agrees with Dawoud *et al*. (1999) who studied the response of dwarf Cavendish banana to nitrogen fertilization on heavy clay soils.

Table (1): Effect of fertilizers (organic +N fertilizer) and two varieties on vegetative growth in plant crop of banana, season (2009/10).

Treatments	Plant high	Plant Girth	No. leaves
U	113,9^{bc}	60.5^{c}	14.3^{a}
NPK	122^{bc}	54.8^{c}	13.6^{a}
M	135^{bc}	59.8^{c}	12.1^{a}
C	177.6^{b}	65.9^{c}	10.9^{a}
M+U	180.3^{b}	83.9^{b}	11.1^{a}
M+NPK	190^{a}	89.6^{b}	13.^{a}4
C+U	180^{b}	100.3^{a}	14.3^{a}
C+NPK	176.3^{b}	88.4^{b}	12.5^{a}
C_0	21.5^{d}	42.6^{d}	9.1^{a}
LSD	61.04	10.57	41.9^{a}
CV%	39.61	14.66	7.59
SE±	21.46	3.71	14.74

Means in columns followed by the same letter (s) are not significantly different at P≤ 0.05, according to Duncan's Multiple Range Test

Key: M: manure, U: urea, C: compost, C_0: control

Table (2): Effect of fertilizer (organic and N applications on vegetative growth in plant crop of two cultivars, season (2010/11) in Ratoon crop

Treatments	Plant high	Plant Girth	No. leaves
U	152.6^{de}	68.3^{cd}	13.4^{bcd}
NPK	132.9^{e}	61.0^{d}	13.9^{abcd}
M	144.9^{de}	57.8^{cd}	13.6^{abcd}
C	168.8^{cd}	62.6^{c}	13.1^{cd}
M+U	184.8^{bc}	74.3^{b}	14.4^{abc}
M+NPK	190.5^{bc}	76.9^{b}	14.9^{abc}
C+U	224.0^{a}	87.0^{a}	15.8^{a}
C+NPK	203.4^{ab}	77.6^{b}	15.1^{ab}
C0	96.0^{f}	43.1^{e}	12.0^{d}
LSD	27.64	8.17	1.73
SE±	9.72	2.87	0.61
CV%	16.53	10.33	12.37

Means in columns followed by the same letter (s) are not significantly different at P≤ 0.05 according to Duncan's Multiple Range Test

Key: M (manure), U (urea), and C (compost).

Table (3): F-values of the yield for the treatments and their interactions in main plant crop (2009/10)

Sources	Weight of bunch	Weight of hand/ Bunch/kg	Weight of finger/ hand (kg)	No of hand/ Bunch	No of finger/ Hand
Fertilizer	4.12**	1.47^{ns}	1.29*	2.59*	2.12*
Varieties	1.28^{ns}	0.94^{ns}	0.09^{ns}	2.14^{ns}	0.49
Fertilizer x variety	0.93	1.47^{ns}	0.66^{ns}	0.20^{ns}	2.49*
Cv%	34.51	43.66	22.88	21.66	17.56

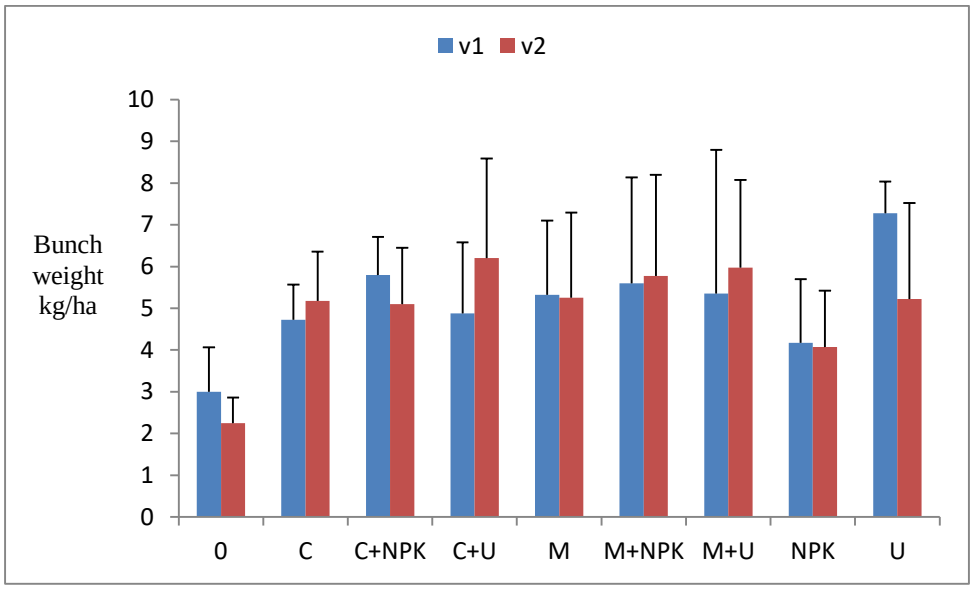
Means in columns followed by the same letter (s) are not significantly different at P≤ 0.05 according to Duncan's Multiple Range Test.

Key: fertilizer (organic+N fertilizer), varieties (Grand Nain and Dwarf Cavendish)
*, **, ***: significant at 0.05, 0.01and 0.001 probability levels, respectively
^{ns} :Not significant at probability ≤ 0.05

Table (4): F-value of yield and yield components for the treatments and their interactions of Plant crop in seasons (2010/11)

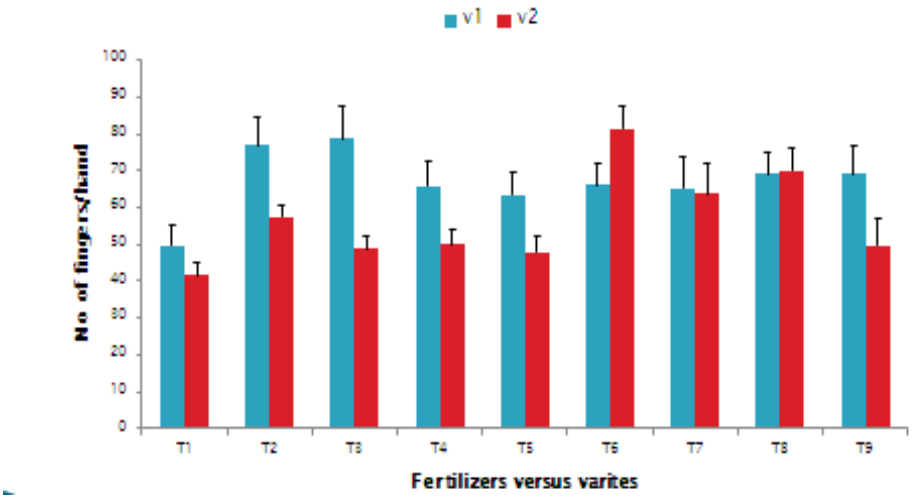
Sources of Variation	Weight of bunch	Weight of hand/ Bunch/kg	Weight of finger/ hand (kg)	No of hand/ Bunch	No of finger/ Hand
F	0.62^{***}	1.48^{ns}	1.81^{*}	3.72^{**}	2.06^{*}
V	0.17^{***}	0.002^{***}	0.041^{***}	2.21	18.44^{**}
FXV	1.11	1.35^{ns}	1.31^{ns}	1.23	1.81^{*}
CV%	43.83	29.89	17.28	18.47	16.89

*, **, *** significant at 0.05, 0.01and 0.001 probability levels, respectively
Ns: Not significant at probability ≤ 0.05
Key: F= fertilizers (organic and N applications), V: varieties Grand Nain and Dwarf Cavendish.



Key: V1, Grand Nain.V2, Dwarf Cavendish, T1-T9, fertilizer treatment

Fig.1: Bunch weight kg/ha for plant crop



Key: V1, Grand Nain.V2, Dwarf Cavendish, T1-T9, fertilizer treatment

Fig. 2: Number of fingers/hand

Conclusion and Recommendations

The best fertilizer program for better growth and yield of banana is application of organic fertilizer (compost and manure) with urea or NPK. The increase in fertilizer dose significantly increased the plant height, pseudo stem girth and leaf production in plant crop and first Ratoon crop. The highest values of yield components were significantly greater in weight of bunch, hand and fingers and in the average number of hands and fingers per bunch and fingers per hand. There were highly significant differences between the two cultivars. However, Grand Nain is the best in vegetative growth\ also had highest values of yield components.

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Research paper

Economic Evaluation of Improved Faba Bean Yield on Farmers' Fields in Central Darfur State-Sudan

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ABSTRACT

Faba bean is a traditional crop in Central Darfur state. It is the major food crop where it produced as an irrigated winter crop. The crop is also produced as rainfed crop in the plains of the highlands of Jebel Marra and the alluvial plains along the borders with Tchad and Central Africa. This study is an attempt to identify the economic performance of faba bean on farmers yield. The study was conducted in Zalingei locality of central Darfur state during 2017/18 cropping season. Partial crop budget was applied to know cost benefit analysis. Result revealed that productivity of faba bean was found to be 2.5, 2.2 and 1.7 ton per hectare in improved Shendi, Basabeer and local super, respectively. Results also revealed that improved genotypes exceed the local super by 47% and 29% by improved Shendi, Basabeer respectively. Partial crop budget result showed that The highest net returns was obtained by improved Shendi (SDG 43,335) followed with improved Basabeer (SDG 34,950) while the lowest net returns recorded by local super with SDG 30,362. In contrast the highest SDG cost was given by improved Basabeer (17,070) and the lowest obtained by local super (SDG 16,328). Study noted that the net return of local super was lower than that of improved genotype by 43 and 15% for Shendi and Basabeer, respectively. Result also showed that the cost benefit ratio is varied from 1.9 to 2.1 to 2.6. The study recommended agronomic research needed specially in crop water requirement and pests and diseases control for minimizing the production costs and maximizing the economic yield.

Keywords: Faba bean, economic, productivity, partial budget, cost-benefit rate

تقييم الاداء الاقتصادي لإنتاجية الفول المصري المحسن بحقول المزارعين بولاية وسط دارفور، السودان

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2 هيئة البحوث الزراعية، محطة ابحاث الحديبة، ولاية نهر النيل، السودان

المستخلص

الفول المصري من المحاصيل التقليدية التي تزرع في ولاية وسط دارفور حيث يتم إنتاجه بالري شتاء كما ينتج خريفياً في سهول جبل مرة والسهول الطميه على طول الحدود مع دولتي شاد وأفريقيا الوسطى. تعتبر هذه الدراسة محاولة للتعرف على الأداء الاقتصادي للفول المصري المحسن وأثره على غلة المزارعين. اجريت هذه الدراسة بمحلية زالنجى للموسم الزراعي الشتوي 18/2017. كما تم استخدام الميزانية الجزئية لتحليل العائدات والتكاليف. أظهرت النتائج أن إنتاجية الفول المصري (طن/هكتار) هي 2.5، 2.2، و1.7 لكل من شندى، بسابير والبلدي السيوبر، على التوالي. كما أظهرت النتائج أيضاً أن إنتاجية المحاصيل ذات الصفات الوراثية المحسنة تجاوزت الصنف البلدي السيوبر بنسب 47 %، و29 % لكل من شندى وبسابير على التوالي. أوضحت نتائج الميزانية الجزئية أن أعلى عائدات تم الحصول عليها بواسطة الصنف المحسن شندى (43,335 جنيه)، بسابير محسن (34,950 جنيه) بينما الصنف البلدي سيوبر أعطى أقل عائدات (30,362 جنيه). على النقيض نجد أن الصنف بسابير أعطى أعلى تكلفة (17,070 جنيه) بينما الصنف البلدي السيوبر أعطى اقل تكلفة (16,328 جنيه). أشارت الدراسة إلى أن عائدات الصنف البلدي السيوبر أقل من عائدات الأصناف المحسنة لكل من شندى وبسابير بنسب 43 و15 % على التوالي. كما أوضحت النتائج وجود اختلافات في معدل التكاليف للعائدات بمقدار 1.9، 2.1، و2.6 لكل من البلدي، بسابير وشندى، على التوالي. أوصت الدراسة بإجراء مزيد من البحوث في الاحتياجات المائية للمحصول وطرق مكافحة الآفات والإمراض بغرض تقليل تكاليف الإنتاج وتعظيم الإنتاج الاقتصادي.

كلمات مفتاحية: الفول المصري، اقتصاد، انتاجية، الميزانية الجزئية، نسبة التكلفة للمنفعة

Introduction

Grain legumes are an important component of agricultural and food systems in practically all over the world, and serve to complement the cereal crops in several aspects. First in terms of human nutrition, legumes supply a higher percent of protein while cereals are the primary source of calories. The amino acid profile of legume protein tends to complement that of cereals, adding lysine to the diet while cereals had better source of sulfur containing amino acids. Furthermore, legumes are better source of minerals, presenting two or more times the levels found in most cereals. Within the group of legumes having edible seeds, faba bean is the most important. It is originated in the Near east and is one of the earliest domesticated legumes after chickpea and pea. Ethiopia is considered as the secondary center of diversity and one of the nine major agro-geographical production regions of faba bean. China is the leading producing countries followed by Ethiopia (FAO, 2009). At present faba bean is the third most important cool-season food legume in the world. Moreover, it can improve soil fertility through fixing atmospheric nitrogen and provides large cash for producers and foreign exchange for the producing countries (Bekele, 2016).

Faba bean is the most important legume in Sudan; it constitutes the main dish on the breakfast and dinner tables for large sector of population, and consumed by all income groups. The average per capita consumption was found to be 2.25 kg/month in the urban area. Faba bean production is concentrated in the North of Sudan; production takes place under farming system of small private pump schemes and some larger public schemes. It is considered among the most important annually produced crops with respect to its share in area and farm income in the River Nile State (Siddig *et al.*, 2007).

Faba bean in central Darfur state, in general, is faced by low crop productivity, lack of improved seeds, pests and diseases, marketing problems, lack of extension and credit services and climate change consequences. To alleviate the problem, improved varieties accompanied with technical packages were introduced in the study area for enhancing crop productivity and improving farmers' livelihoods security.

Productivity is commonly defined as a ratio between the output volume and the volume of inputs. In other words, it measures how efficiently production inputs, such as labour and capital, are being used in an economy to produce a given level of output (Krugman, 1994).

Dewett and Singh (1966) suggested, that the concept of productivity is based not only on the single relationship between output and input, but rather on the differences between two or more relationships i.e., differences in the same agricultural region or sub-region as between successive periods (in time), and between similar agricultural regions in different countries or regions during the same period (in space). It may also be possible to make comparisons between the trends of productivity for different products, between different regions of the national economy or between the agricultural regions and the national economy as a whole.

Partial budgeting is a management tool that can compare the costs and returns that are affected by a potential change in a business. It is especially useful in evaluating budgets that involve small, specific, and limited changes within a business by helping to determine the profitability of that change (Breima and Khalifa, 2016).

The overall objective of the study is to know the economic performance of improved seeds in the study area. More specifically the study concentrated on: Assessing the yield performance of faba beans against local check. Furthermore, study aims to know the extent of which improved faba bean can be introduced as leguminous and notorious crops in the study area.

Research Methodology

Zalingei locality lies between Latitudes 14 – 12^0 N and longitudes 23 – 22^0 E. Research on faba bean was carried out in association with faba bean breeding section at Hudeiba research station. Two improved Faba Beans (Shendi & Basabeer) were planted against one local check (Super bolded seed). Seeds were planted on one side of ridge 70 cm wide at plant spacing of 20 cm with two seeds per hole. The gross plot area for each genotype was 4200 m^2. 100 kilogram of urea was applied into two doses. Clustered Random sampling technique was used to collect farmer production and costing information. Both productivity coefficient and partial crop budget were endorsed in analysis and evaluation.

The formula for assessing productivity coefficient would be read according to Krugman (1994) as:

$$\frac{Y}{Y_n} : \frac{T}{T_n}$$

Where:

Y = Total yield of respective crop in the unit area

Y_n = total yield of the crop at the national level

T = Total crop area of unit

T_n = Total crop area at the national level

Results and Discussion

Crop Productivity

The productivity of faba bean was found to be 2.5, 2.2 and 1.7 ton per hectare for Shendi, Basabeer and local Super, respectively. Results also revealed that improved genotypes exceed local super by 47% and 29% (Table 1). This results highlight that improved faba bean has good potential to be used as cash and food crop in the study area. These results agreed with what had been claimed by Abusarra (1996).

Results of partial crop budget was presented in Table (2). Yield from on farm experiment was adjusted downwards by 20% to reflect the difference between the experimental yield and the yield that farmers expected from the same treatment. The highest net returns were obtained by improved Shendi (SDG 43,335) followed by Basabeer (SDG 34,950) while the lowest net returns recorded by local super with SDG 30,362. In contrast the highest SDG cost was given by improved Basabeer (17,070) and the lowest realized by local super (SDG 16,328). Study indicated that the net return of local super was lower than that of improved genotype by 43 and 15% for Shendi and Basabeer, respectively. Result also showed that the cost-benefit ratio is varied from 1.9 to 2.1 to 2.6. This give evidence that faba bean is financially profitable and acceptable to be grown in the area of the study. This result was in line with Chanza, and Hoffmann (2016) in the concept that farmers usually gain benefit from the use of improved legume technologies.

Conclusion

The study concluded that there was increase in faba bean productivity and this attributed to improved genotypes. The overall performance of improved faba bean is financially worthy and indicating their profitability in the study area. Minimizing the production costs and maximizing the economic yield, as study recommended, could be achieved by conducting research needed in crop water requirement and pests and diseases control.

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This work is sponsored by Agricultural Research Corporation, Ministry of Forestry and Irrigation. The financial support of research technology transfers and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) through the award of postgraduate scholarship to Mr. Elnour is really appreciated.

Table (1): Faba bean yield performance of improved genotypes compared to local Check in Zalingi locality (2017/18)

Entry	Area (m^2)	Yield (kg)	Yield (ton/ha)	Yield increase %
improved Shendi	4200	1050	2.5	47
improved Basabeer	4200	910	2.2	29
local (Super bolded)	4200	700	1.7	-

Source: Author, 2017

Table (2): Partial crop budget for improved genotypes compared to local Check of faba bean of in Zalingi locality (2017/18)

operation costs	SDG/ha		
	Shendi	**Basabeer**	**local Super**
1. Costs			
land preparation	2857	2857	2381
Planting	1190	1310	852
Seeds	2380	2380	2857
seed dressing	238	238	238
Weeding	2619	2619	2619
pest control	476	952	476
Fertilization	1905	1905	1905
Irrigation	3571	3571	3571
Harvesting	1429	1238	1429
Total variable costs	**16,665**	**17,070**	**16,328**
2. Returns			
yield (kg/ha)	2500	2167	1667
Adjusted yield (kg/ha)	2000	1734	1334
price (SDG/kg)	30	30	35
gross field benefits	60,000	52,020	46,690
Net returns (2 - 1)	**43,335**	**34,950**	**30,362**
cost benefit ratio	**2.6**	**2.1**	**1.9**

Source: Author, 2017

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Research paper

Onion (*Allium cepa* L.) Bulb Storage in Improved Shaded and Aerated Store in River Nile State, Sudan

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ABSTRACT

This study aimed to evaluate the storability of onion in improved shaded and aerated store in condition of River Nile State, Sudan. Dry onion of cultivar Red Baftaim collected from cultivation sites at Aliab during June 2018 and differentiated into small (50-100 g) and large size (100-280 g) bulbs. Storage started after two weeks curing, under straw shade, in three different sides of the store (North-eastern, the centre and South-western). Keeping material used were jute sacks, plastic boxes, plastic nets, baskets and the fifth part was left without containing material. Ten Kilograms of bulbs were weighed in the beginning of the storage period by early July to determine loss in weight of whole sample after 3 months as first experimentation. In the second experimentation five bulbs in each container were marked, their weight was registered every month to detect periodic trend for weight loss in each keeping material. Results revealed that bulbs kept in jute sacks showed the least sloping change in weight. All other containing material showed higher losses but in an inconsistent trend. While, bulbs stored in plastic boxes showed the highest rotting ratio. The storage side in the store showed no significant differences in trends and final evaluation of percentage losses. The last storing month showed sharper slope of bulb weight loss compared to the starting and the subsequent month, mainly in large size onions. Bulb sprouting was not observed in containers as well as on bulbs without containers.

Keywords: Onion, storability, improved store, keeping materials

تخزين البصل في مخزن مسقوف محسن ومفتوح للتهوية بولاية نهر النيل، السودان

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كلية الزراعة جامعة وادي النيل

هدفت هذه الدراسة لتقييم قابلية التخزين لصنف البصل المزروع بافطيم احمر تحت مخزن محسن تحت ظروف ولاية نهر النيل السودان. عينات الابصال تم جمعها من منطقة العالياب. وتم فرزها الي ابصال صغيرة (50-100 جرام) وكبيرة (100- 280 جرام). تم تخزين البصل بعد ان خضع لمعالجة لمدة اسبوعين في الحقل تحت ظل من القصب في يونيو 2018 في ثلاث مناطق في المخزن هي الشمال الشرقي ووسط المخزن والجنوب الغربي. حاويات التخزين التي استخدمت هي جوالات الخيش والصناديق البلاستيكية وشباك البلاستيك والمقاطف وترك الجزء الخامس ليخزن دون حاوية. تم تخزين عشرة كيلوجرامات من البصل في بداية التجربة وتم وزنها في نهاية التجربة لتقدير الفقد في الوزن بعد ثلاثة أشهر. كما تم ترقيم عدد خمس ابصال في كل حاوية وفي الجزء المخزون دون حاوية لتقييم التغير في الوزن. اوضحت النتائج ان جولات الخيش هي الاقل في الفقد الدوري وفي الوزن كما ان البصل المخزن في صناديق البلاستيك سجل النسبة الأعلى في تعفن الابصال. ولم تكن النتائج معنوية لا في الوزن النهائي ولا الشهري بين الجوانب المختلفة في المخزن كما ان الشهر الاخير سجل منحي كبير للفقد في وزن الابصال مقارنة مع الشهر الاول والثاني خاصة في الابصال الكبيرة. لم يلاحظ نموء للأبصال طوال مدة التخزين

كلمات مفتاحية: البصل، قابلية الخزن، مخزن محسن، حاويات التخزين

Introduction

Onion (*Allium cepa L.*) is one of the most important vegetable crops. It is grown commercially in nearly all parts of the world. Onion belongs to the family *Alliaceae*, genus *Allium* comprising about 500 species widely distributed in the northern temperate regions. Botanically it is a monocotyledonous cross- pollinated with 16 basic chromosomes number (2N). In Sudan it is considered as cool season vegetable crop. Onion has great economic importance due to its medicinal and nutritional values since ancient times and with worldwide production of storage (dry) onion as estimated in 2010 by 74.3 million tones. UK, Japan and Gulf countries are net importers, while leading exporters include India, Argentina, The Netherland, Spain, Mexico and Turkey (Brewister, 2008).

Northern states of Sudan are considered the best regions for onion production by virtue of having relatively cool, dry and long winter season which favors onion bulbing compared to other part of the country. The total area under the crop as estimated by Mohamedali in 2009 as 84000 hectares. Since then, onion production increased substantially specially in River Nile state. In the last years reports of the regional Ministry of Agriculture indicated that the River Nile state alone is now producing one million ton of bulb onion.

Red Baftaim cultivar dominates production at least in River Nile state due to its high productivity compared to other cultivars and the preferred cocking qualities that encouraged producers to expand its areas. However, it retained somewhat lower keeping qualities.

Major causes of onion losses during storage are; deterioration and loss of moisture, decomposition and loss of weight by respiration, onion rotting, contamination, onion sprouting and sun burn under direct sun condition. Storing requirement for onion is bound by the above mentioned problems. The crop requires two storing conditions; regarding temperature, relative humidity, light and storage atmosphere. Regarding temperature, two ranges are required (0-2 or 25-30) ^{0}C. Regarding humidity; most studies indicated that a store atmosphere of about 65–75% RH is required (Benkeblia *et al*., 2003; FAO, 2003; Banuu *et al*., 2014).

Warade *et al*. (1997) investigated the effect of different recommendations on storability of onion bulbs for six months under modified storage structure with bottom and central ventilation and observed that the modified storage structure had reduced losses 32 percent as compared to the conventional method (52%).

Like in similar conditions, most Sudanese onion producers bring onion directly to the market after harvest as the crop losses is great in traditional storing conditions. Proper storage facilities are very few and considered costly by farmers. The present storage capacities are inadequate and most of the available units has no trained personal. Marketing of the entire stock within one or two month of harvest usually pull prices to be very low then after, the rise in prices is rapid and sometimes elevated extraordinary when it is out of farmer hands, leading to frustration among producers as well as consumers. Hot and dry summer conditions at harvest and unexpected rains and flooding usually worsen farmer ability for proper traditional storage (Musa *et al*., 1973; Musa, 1999; Ahmed *et al*., 2015).

To improve the situation, the regional ministry of agriculture and the Japanese Agency for International Cooperation in their (CADAPIS) project desired to change this situation by establishing appropriate storage structures for onion with minimal cost to farmers, together with small dehydration units. Successful implementation was carried out at Aliab Agricultural scheme. The aim of this study is to evaluate the storability of onion in improved shaded and aerated Store.

Material and Methods

Onion bulbs samples (of cultivar Red Baftaim) were collected from cultivation sites at *Aliab* during June 2018. The bulbs were obtained after two weeks curing under straw shading in ambient environmental conditions in farmer field. Bulbs were differentiated into small (50-100 g) and large size (100-280 g) bulbs to be stored in three different sides of the store, North-eastern, the centre and South-western. The store (15x30m) is shaded with insulated iron sheets left by steel shafts and bordered by 1.3 cement wall. Bulb storage was conducted on shelf raised by one meter from the store flooring (Plate.1 and 2). Keeping material used were jute sacks, plastic boxes, plastic nets, baskets and the fifth part was left without containing material. Ten Kilograms of bulbs were weighed in the beginning of the storage period by early July to determine loss in weight of whole sample after 3 months as first experimentation. In the second experimentation five bulbs in each container were marked, their weight was registered every month to detect periodic trend for weight loss in each keeping material. In this sample, rotten bulbs were registered as percentage compared to initial sample number. Monthly average temperatures and relative humidity are illustrated as metrological climate indicators for the region (Table 1 and Fig. 1). The first experiment was arranged in a randomized block design, while, the other was arranged as split plot. Probability and LSD were presented as derived by computer statistical package SAS.

Plate (1) Store from outside

Plate (2) Store from inside

Table (1): Aliab weather temperatures in centigrade

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Temperature	23	25	27	32	35	35	33	33	35	32	27	24
Avg. Max Temperature	31	33	36	41	43	43	41	40	42	40	36	32
Avg. Min Temperature	15	16	18	23	27	27	27	26	27	25	21	16

Source: https/www.weather atlas.com/en/Sudan/Atbara climate

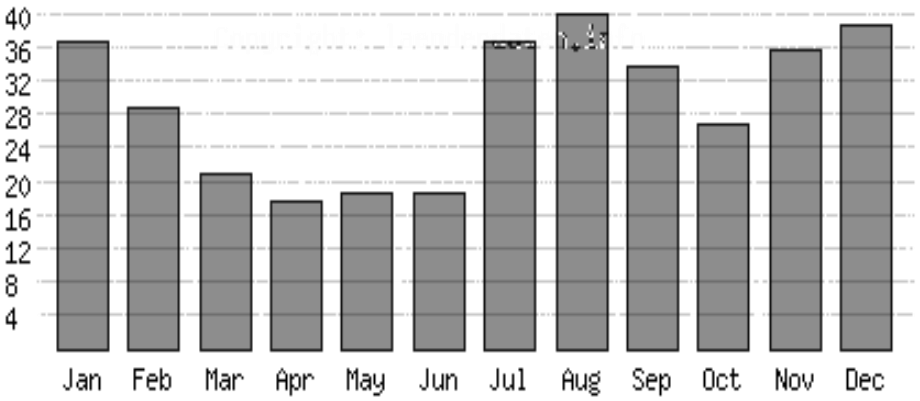

Fig. (1): Relative humidity (%) during the year in Aliab region
(Source: https/www.weather atlas.com/en/Sudan/Atbara climate)

Results

As indicted in table (2) Jute sacks resulted in the least significant percentage loss in weight in both large and small size bulbs (28.0 and 19.3 % respectively) followed by plastic nets and storing onion in plastic nets or without keeping material. While plastic box resulted in the highest percentage weight loss (62.7 and 63.3 % in large and small bulbs respectively).

Table (2): Percentage loss in weight per container after 90 days

Keeping material		**Jute sacks**	**Plastic net**	**Plastic box**	**Basket**	**Without**
Percentage loss in weight	**Large size bulbs**	28.0	33.3	62.7	50.3	32.7
	Small size bulbs	19.3	33.3	63.3	44	37.3
	Average	23.7	33.3	63	47.2	35
CV %	26.65					
P	***					
LSD bulb size	25.57					
LSD container	13.22					

LSD: least significant difference at stated confidence level (*=95% ** = 99% *** > 99%)

Regarding trend for individual bulb deterioration, as reflected in table 3A and 3B, significant differences between containers with regard to detected periodical loss in weight on both large and small bulbs observed. Bulbs kept in jute sacks showed the least sloping change in weight. All other containing material showed higher losses but in an inconsistent trend. While, bulbs stored in plastic boxes showed the highest rotting ratio (Table 4**)**. No single sprout was observed over bulbs in all

containers as well as on bulbs without containers. The storage side in the store showed no significant differences in trends and final evaluation of percentage losses. The last storing month showed sharper slope of bulb weight loss compared to the starting and the subsequent month, principally in large size onions.

Table (3A): Large size onion loss in weight through time (g)

Container type	Loss in weight (g)				
	Side	**Starting**	**After 30 days**	**After 60 days**	**After 90 days**
Without	North east	178.8	154	148	83
	Centre	144.6	136	133.2	76
	South west	183.2	182	149	71
	Mean	**168.87**	**157.33**	**143.40**	**76.67**
Basket	North east	180.8	174	134.4	98.2
	Centre	164.4	156.6	140.2	57.5
	South west	140.6	138	132	88.6
	Mean	**161.93**	**156.20**	**135.53**	**81.45**
Jute sack	North east	182.6	172.8	162.6	144.6
	Centre	178	171.2	170.2	158
	South west	162.2	156	154.4	142.3
	Mean	**174.27**	**166.67**	**162.40**	**148.29**
Plastic net	North east	109.4	105	100.8	80.75
	Centre	165.8	147	138.8	81
	South west	123.6	117.6	117.2	113
	Mean	**132.93**	**123.20**	**118.93**	**91.58**
Plastic box	North east	125.8	119.6	113	97.6
	Centre	119.6	115.2	104.2	57.3
	South west	189	167.8	146.8	131
	Mean	**144.8**	**134.20**	**121.33**	**92.28**
P side			NS	NS	NS
P container			**	***	***
P interaction			NS	NS	NS
LSD container			26.08	21.61	33.18

LSD: least significant difference at stated confidence level (*=95% ** = 99% *** > 99%)

Table (3B) Small size onion loss in weight through time (g)

Container type	Side	Bulb weight (g)			
		Starting	After 30 days	After 60 days	After 90 days
Without	North east	77.6	79	58.6	32.4
	Centre	78	67	49	34
	South west	73.8	62.4	59	26
	Mean	**76.47**	**69.47**	**55.53**	**30.8**
Basket	North east	92	88.2	76.4	71
	Centre	90.4	85.2	72.2	45.7
	South west	88.4	85.4	83	70.2
	Mean	**90.27**	**86.27**	**77.2**	**62.32**
Jute sack	North east	67.8	63.8	60.8	59.2
	Centre	78.4	77	73.8	68.5
	South west	66.8	63.8	62.6	61.2
	Mean	**71**	**68.2**	**65.73**	**62.97**
Plastic net	North east	79.8	62.2	58	36
	Centre	83.6	73.2	70.2	65
	South west	68.4	65.4	61.2	53.6
	Mean	**77.27**	**66.93**	**63.13**	**51.53**
Plastic box	North east	88.6	84.6	76.4	51.6
	Centre	106.4	93.2	86	76.6
	South west	62.6	59.8	53	37.5
	Mean	**85.87**	**79.2**	**71.8**	**55.23**
P side			NS	NS	NS
P container			*	NS	*
P interaction			NS	NS	NS
LSD container			14.29		20.85

LSD: least significant difference at stated confidence level (*=95% ** = 99% *** > 99%)

Table (4): Percentage of rotting bulbs in each batch (20 bulbs per split treatment)

Container type	Side	After 30 days		After 60 days		After 90 days	
		Small bulbs	Large bulbs	Small bulbs	Large bulbs	Small bulbs	Large bulbs
Without	North east	0	0	0	5	5	5
	Centre	0	0	0	0	0	5
	South west	0	0	0	0	0	5
Basket	North east	0	0	5	0	10	5
	Centre	0	0	0	0	5	5
	South west	0	0	0	0	5	5
Jute sack	North east	0	0	0	0	0	0
	Centre	0	0	0	0	5	0
	South west	0	0	0	0	0	0
Plastic net	North east	0	0	10	0	10	0
	Centre	0	0	0	0	0	5
	South west	0	0	0	0	0	0
Plastic box	North east	0	0	10	0	15	5
	Centre	0	0	0	0	0	5
	South west	0	0	0	0	0	0

Discussion

Although not like perishable crop, onion is a semi-perishable crop with relatively high moisture content. The storability is relatively low. Hence, 30-50% postharvest losses were reported during short term storage under room conditions. As reported by Musa *et al*. (1973) very high percentage (>50%) of losses is expected in long term storage (more than 5 months) under condition of Sudan.

Perfect bulb storage depends on acquaintance with the scientific facts about bulb dormancy and the pathology of diseases of stored bulbs. Excessive water loss from bulbs and microbial infection of the inner fleshy scales usually hindered by the dry intact skin of the onion bulb. It also prevents postharvest injuries. During the maturation of bulbs the outer scales lose water and form thin, dry skins that wrap the bulb, as stated by Brewister (2008). In this concern, attractive and intact skins are essential for high-quality onions preservation. Therefore, knowledge of how to produce and maintain sound and attractive skins is important for the onion to be kept in good condition for longer periods. Controlling factors of pre-harvest and post-harvest operations will yield best storage results. In the store, high relative humidity will reduce moisture loss but at high temperatures will increase product rotting and may induce sprouting. Intermediate temperatures (5-20) in presence of humidity will enhance sprouting. Low humidity usually preferred to reduce fungal growth and rotting, but will enhance shriveling and water loss. According to this background, factors are complicatedly interrelated.

In this study bulbs were kept under shade at high summer temperatures and 20-40% RH. Observation revealed that water loss and shriveling with individual bulb were more prominent in bulbs stored without containing material due to lower % RH, in the vicinity of the individual bulb, than always bulb need to preserve its protective skin. Onion skins usually adsorb and evaporates water from the surroundings atmosphere till reach equilibrium with the water vapour pressure in their adjacent environment. Skin water content depends primarily on RH of the surrounding vicinity and, on temperature at a given RH. However, increasing humidity in the bulb atmosphere to 65–70% RH is sufficient for hygroscopic equilibrium irrespective of temperature to keep reasonable skin flexibility and avoids dampness to extent of encouraging microbial rotting. Although kept in good ventilation, bulbs stored without keeping materials performed more loss of weight compared to other kept in containers. Water loss might be more excessive leading to continuous scale removal under low RH as at this condition skins seems to be less flexible and tend to torn apart. Such interpretation was explained by Brewister (2008) and Sabaragamuwa *et al*. (2011). On the other hand, containers can keep more humidity around bulb surroundings, however, this condition seemed to enhance rotting and decay as stated by Swee-Sauk *et al*. (2002), this was clearly manifested on bulbs kept in plastic boxes. The ability of jute as cellulose fiber to attract humidity and keep bulb surrounding somewhat humid and somewhat ventilated may favored it over other containing materials under this type of stores.

Conclusion:

Compared to other bagging materials, under the improved shaded and aerated store, the jute sacks showed the least losses and the least sloping change in bulb weight during short storage period (3-4 months). Onion bulb losses in such conditions usually caused by desiccation and /or rotting rather than bulb sprouting.

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Research paper

Effect of Sowing Methods on Growth, Yield and Yield Components of Groundnut (*Arachis hypogaea* L.) Varieties at Dongola-Sudan

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ABSTRACT

This study was conducted at the demonstration farm of Dongola Research Station, Northern state, Sudan during 2016 and 2017, to assess the effect of sowing methods namely; flat and ridges on the performance of five released varieties of groundnut under the environment of Arid-soil and Surface irrigation system. The experimental design was arranged as split- plot in randomized complete block design with three replications. Five released groundnut varieties (Sodari, Madani, Kiriz, Tozi and Ahmadi) were used and assigned to the main plots and the two sowing methods (Flat and Ridge) were assigned to the sub plots. The hole to hole and ridge to ridge (or row to row) spacing were 30 cm and 60 cm, respectively, with plot size 3 x 3 m. In both seasons, sowing date was 24th July. The results for growth attributes of this study revealed that sowing methods significantly affected main stem diameter in the first season and days to 50% flowering in the second season. On the other hand, non-significant differences were indicated for plant height (cm), days to maturity and biomass/plant. The results of Yield and yield components indicated significant differences in 100-seed weight in both seasons, number of branch/plant and seed yield (kg/ha) in the first season and seed yield/plant in the second season. However, this result indicated a non-significant differences in number of pods/plant, number of pods/branch, pod yield/plant, pod yield (kg/ha) and number of seeds/pod in both seasons.

Keywords: groundnut, sowing method, varieties

تأثير طريقة الزراعة على الانتاجية ومكوناتها لبعض اصناف الفول السوداني بدنقلا، السودان

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مستخلص

أجريت هذه التجربة في مزرعة محطة البحوث الزراعية في شمال السودان بدنقلا خلال موسم 2016 و2017 لدراسة تأثير طريقة الزراعة بالسرابات والزراعة في الأرض المسطحة على نمو وانتاجية خمس أصناف من محصول الفول السوداني (سودري، مدني، كرز، توزي واحمدي). تم استخدام تصميم القطاعات العشوائية الكاملة وفق تنظيم القطع المنشقة بثلاث مكررات وكانت مسافات الزراعة بين النباتات 30سم وبين السرابات 60 سم وكان تاريخ الزراعة يوم 7/24 في الموسمين. أظهرت النتائج التي تم الحصول عليها لصفات النمو ان هنالك فروقات معنوية في سمك الساق الرئيسي وفى مواعيد الازهار في الموسم الأول وفروقات غير معنوية في طول النبات وتاريخ النضج والوزن الحيوي للنبات. اما النتائج المتحصل عليها لصفات الإنتاجية أظهرت فروقات معنوية في وزن ال 100 حبة في الموسمين وفى عدد الفروع للنبات وفى إنتاجية البذور بالكيلوجرام للهكتار وانتاجية البذور للنبات وفروقات غير معنوية في عدد القرون للنبات وعدد القرون في الفرع وعدد البذور في القرن وانتاجية القرون للنبات وانتاجية القرون بالكيلوجرام للهكتار في الموسمين.

كلمات مفتاحية: الفول السوداني، طريقة الزراعة، الاصناف

Introduction

Sudan, cultivated about 1900000 hectares of groundnut and produced 1200000 metric tons with an average yield of 632 kg/ha (FAO, 2006). In Sudan, the crop is grown under irrigation in the central clay plains and in the rain fed areas in the sandy soils of Western Sudan. About 80% of the area and two third of the national production came from the traditional rain fed sector of western Sudan. In North Kordofan, groundnut comes after sorghum in area under cultivation. Barberton, Sodiri and Gubiesh cultivars are widely grown and were characterized by early maturity.

Wakweya and Meleta (2016) revealed that sowing method significantly affected plant height, number of pods/ plant, biomass and seed yield (kg/ha). The seed yield gained by row sowing method was 20.2% higher than broadcast sowing method. the highest plant height (16.43 cm), pods/plant (22.4) and biomass. Seed yield of 11272.1 and 5297.9 kg/ha were recorded by row planting method as compared to broadcast planting. Dalley *et al*. (2004) reported that wide-row treatments recorded relatively larger biomass than the narrow-row treatments probably due to lesser competition for growth resources compared to narrow-row treatments. The low biomass recorded by some narrow row treatments could be compensated-for by the additional plants/m^2, resulting in significantly large biomass yield compared to wider-row spacing. Yilmaz (1999) reported that, the highest yield was obtained with 60 x15 cm spacing and the lowest yield was obtained with the widest spacing of 50 ×20 cm. Baldwin *et al.* (1998) reported a significant increase in yield of 381 kg/ha and total sound mature kernel (TSMK) with the twin-row spacing over the conventional row pattern when averaged across four runner cultivars and locations. Troedson *et al*. (1989) concluded that planting method has a significant effect on better resource utilization like water, nitrogen and phosphorus economy, energy savings and overcoming problems of soil compaction. Moreover, absorption of photosynthetically active radiations has also been found to be influenced by planting methods (Lal *et al*., 1991). Kaushik and Chaubey (2000) observed that pod yield of peanut was significantly affected by row spacing. The pod yield of 30 cm inter-row spacing was significantly higher than that of 45 cm inter row spacing. Kadiroglu (2012) reported significant higher yield in twin row planting compared to single row planting pattern. Ahmed *et al.* (2007) and Konlan *et al*. (2013) also reported that pod yield was 16.0% higher in narrow-row plantings than traditional wide-row crop. Kadiroglu (2012) found out that pod yield was 22% higher in twin-row plantings compared to traditional single-row ground nuts.

The present study was designed to evaluate the effect of two sowing methods on the performance of five released cultivars of ground nut under the environment of Arid-soil and Surface irrigation system at Dongola, Northern Sudan.

Materials and methods

This study was conducted at the Demonstration Farm, Dongola Research Station, Northern State, Sudan. Dongola lies between latitudes16 º:22′ N and longitudes 20 º:32′ E. The experiment was conducted during seasons of 2016 and 2017.

Two sowing methods namely; flat and ridges using five released cultivars of ground nut *Arachis hypogaea* L were evaluated. The experimental design was arranged in split- plot in randomized complete block design with three replications. Five released groundnut varieties (Sodari, Madani, Kiriz, Tozi and Ahmadi) were used and assigned to the main plots and the two sowing methods (Flat and Ridge) were assigned to the sub plots. The hole to hole and ridge to ridge (or row to row) spacing were 30 cm and 60 cm, respectively with plot size 3 x 3 m. In both seasons, sowing date was 24th July. The irrigation was applied at an interval of 8- 10 days in both seasons and no fertilizer was applied. Weeding was carried out twice by hand. For data collection, five randomly selected plant per plot were sampled, in both seasons to study the following parameters: plant height (cm), days to 50% flowering, days to maturity, main stem diameter (cm), biomass(g), number of reproductive branches/ plant, number of pods/ plant, number of pods/ branch, number of seeds/pod, 100-seed weight, pod yield/plant, seed yield/plant, pod yield (kg/ha) and seed yield (kg/ha).

Statistical analysis:

The collected data were subjected to standard procedures of statistical analysis as follows:

The procedure described Gomez and Gomez (1984) was used to estimate the individual and combined analysis of variance. Individual analysis of variance was carried out each season separately; then combined analysis of variance was done for those characters in which the mean squares of error (b) were homogenous.

Mean separation:

Duncan's multiple range test (DMRT) at 0.05 level of significance was performed, according to Gomez and Gomez (1984), as follows:

Step one: all the treatment means were ranked in decreasing order.

Step two: the adequate standard error of the differences (Sd) was computed according to the following equations:

a) For means over all varieties:

$Sd_1 = \sqrt{2[(b-1) E_b + E_a]/rb}$

b) For means over the two sowing methods:

$Sđ_2 = \sqrt{(2E_a)/rb}$

Where:

E_a and E_b = mean squares of error (a) and error (b), respectively.

r and b = numbers of replications and sub-plots, respectively.

Step three: values of the shortest significant range at 0.05 level were calculated as:

$R_p = [(r_p). (Sđ)]/\sqrt{2}$ for p = 2, 3, …,t

Where:

R_p = the (t-1) value.

t = the total number of treatment means under comparison.

p = the distance in rank between the pairs of treatment means to be compared.

r_p = the tabular values of significant studentized ranges at 0.05 level.

Step four: all treatment means, which did not differ significantly from each other, were then identified and grouped together.

Step five: alphabet notations were then used to indicate the non- significant difference between any two treatment means.

Coefficient of variation:

Coefficient of variation (CV) for each character, in both seasons, was determined using the following formula:

$CV\ a = (\sqrt{E_a} \chi\ 100)/ G$

$CV_b = (\sqrt{E_b} \chi\ 100)/ G$

Where:

E_a and E_b = the mean squares of error (a) and error (b), respectively .

G = overall mean of the character

Results and Discussion

Growth attributes:

The result of this study indicated significant differences in the analysis of variance between the two sowing methods (ridges and flat) in main stem diameter in the first season and days to 50% flowering in the second season. On the other hand, non-significant differences were indicated in both seasons for plant height (cm), days to maturity and biomass/plant. Similar findings for plant height was reported by Khalil *et al*. (1993) and Abdalla *et al*. (2000). However, this contradicted the funding of Wakweya and Meleta (2016) who indicated significant differences in plant height. In the first season, the earliest sowing methods reached 50 % flowering in 47 days with flat sowing and the latest (48 days) with ridge sowing (Table 1). Whereas, in the second season both sowing methods reached 50 % flowering in 48 days (Table 2). In both seasons, the higher main stem diameter was recorded with ridge sowing (4.213 and 4.483cm) and the lower main stem diameter (4.147 and 4.400 cm) with flat sowing. (Table 1 and 2).

Yield and yield components:

The analysis of variance indicated significant differences with 100-seed weight in both seasons, seed yield (kg/ha) in the first season and number of branches/plant and seed yield/plant in the second season. Similar findings for seed yield (kg/ha) was reported by Wakweya and Meleta (2016). These results are in parallel with the conclusion of Trodson *et al*. (1989) who stated that planting method has a significant effect on resource utilization like water, nitrogen and phosphorus economy, energy savings and soil compaction. Moreover, Lal *et al*. (1991) concluded that absorption of photosynthetically active radiations has also been found to be influenced by planting methods. On the other hand, this result indicated a non-significant difference in number of pods/plant, number of pods/branch, number of seed/pod, pod yield/plant, pod yield (kg/ha) and number of seeds/pod in both seasons. In the first season, the higher 100-seed weight (53.876 g) was recorded by the flat sowing and the lower (49.000 g) by ridge sowing (Table 1). However, in the second season the higher 100-seed weight (51.689 g) was recorded by the ridge sowing and the lower (45.139 g) by flat sowing (Table 2). In both seasons, the higher seed yield (151.660 and 166.331 kg/ha) was recorded by ridge sowing and the lower seed yield (149.940 and 140.381 kg/ha) by flat sowing (Table 1 and 2).

The combined analysis indicated insignificant differences for all studied characters. In addition, the sowing method x variety interaction was insignificant for all characters reflecting a similar response of the five varieties to the two sowing methods (Table 3).

Table (1): Means of different characters of groundnut as affected by sowing methods in season 2016

Sowing method	Ridge	Flat
Plant height (cm)	14.867	13.933
Days to 50% flowering	48.067	47.867
Days to maturity	143.467	143.467
No. of branches/plant	8.933	8.800
No. of pods/plant	38.867	34.733
No. of pods/branch	6.267	6.133
No. of seeds/pod	2.00	2.00
100 seed weight (g)	49.000a	53.867b
Biomass/plant (kg)	0.107	0.109
Seed and husk yield/plant (g)	32.280	29.067
Seed yield/plant (g)	17.053	15.573
Seed and husk yield (Kg/ha)	246.840	256.107
Seed yield (Kg/ha)	151.660b	149.940a
Maim stem diameter (mm)	4.213b	4.147a

Table (2): Means of different characters of ground nut as affected by sowing methods in season 2017

Sowing method	Ridge	Flat
Plant height (cm)	13.780	13.196
Days to 50% flowering	48.133a	48.400b
Days to maturity	139.667	139.667
No. of branches/plant	5.133b	4.600a
No. of pods/plant	23.133	20.733
No. of pods/branch	4.467	3.867
No. of seeds/pod	2.00	2.00
100 seed weight (g)	51.689b	45.139a
Biomass/plant	0.111	0.108
Seed and husk yield/plant	68.333	52.333
Seed yield/plant	36.627b	26.321a
Seed and husk yield (Kg/ha)	324.440	283.840
Seed yield (Kg/ha)	166.331	140.381
Maim stem diameter	4.483	4.400

Table (3): The combined analysis of variance for the different characters for five groundnut varieties and two sowing methods evaluated in seasons 2016/2017

Character	Mean Squire		
	Season 2016/2017		
	SM × S (d.f = 4)	V × SM × S (d.f = 4)	Error (d.f = 20)
Plant height (cm)	0.398	4.045	2.187
Days to 50% flowering	0.058	0.275	0.217
Days to maturity	0.000	0.000	0.000
Main stem diameter (mm)	0.390	0.425	0.323
Number of branch/plant	1.333	1.767	1.317
Number of pods/plant	35.358	12.558	57.700
Number of pods/branch	2.017	0.817	3.117
Number of seeds/pod	0.000	0.000	0.000
100 seed weight (g)	119.333	6.062	52.974
Biomass/plant (kg)	0.004	0.003	0.017
Pod yield/plant	146.481	239.931	296.385
Seed yield/plant (g)	301.647	97.329	192.152
Pod yield (Kg/ha)	262803.023	168501.833	171919.959
Seed yield (Kg/ha)	2460.704	572.887	52989.26

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Research paper

Effect of Ambient Temperature and Relative Humidity on Foraging Activity of Termite *Microtermes thoracalis* (*Isoptera: Macrotermitinae*) in Sinnar State, Sudan

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ABSTRACT

A field study was carried out at two experimental sites in Sinnar State during April- July 2014, to assess the effect of relative humidity and temperature on the foraging activities of termite species belonging to the Genus Microtermes in tree canopy and open areas. The first site was located at the eastern bank of the Blue Nile River (Elsuki locality- Hilatsaeed) while the second site was located at the western bank of the Blue Nile River (Abuhujar locality- Sairo). Randomized Complete Block Design with four replicates was used to perform this study. Treatments in each site are executed in an area of four plots 10×10 meter. Ten wood baits were placed horizontally along rows of 2 meters, giving a total of 400 baits per two treatments. The baits were then examined for termite damage at two weekly intervals and the number of attacked baits was expressed as percentage. The collected data was subjected to statistical analysis using Statistical Analysis System computer package. The results showed that there were fairly marked differences in the levels of infested wood baits laid in trees canopy compared to levels of infested wood baits laid in open-areas. The termites foraging activity in tree canopy is greater than that in open areas. It is worth mentioning that infestation of wood baits by termites increased as temperature decreased and relative humidity increased.

Keywords: Termites, foraging activity, *Microtermes spp*., Isoptera

تأثير درجة الحرارة والرطوبة النسبية على نشاط الأرضة *Microtermes spp.* (Isoptera, Microtermitinae) في البحث عن الغذاء، ولاية سنار، السودان

فتح الرحمن ابراهيم الصديق

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أجريت دراسة حقلية في موقعين مختلفين من ولاية سنار في الفترة من إبريل 2014 إلى يوليو 2014 بهدف تقييم تأثير الحرارة والرطوبة النسبية التي تسود في السترة الشجرية والمساحات المكشوفة على نشاط البحث عن الغذاء بواسطة الارضة من جنس مايكروتيرم (Microtermes). كان الموقع الاول في الضفة الشرقية للنيل الازرق (محلية السوكي- حلة سعيد) بينما جاء الموقع الثاني في الضفة الغربية (محلية أبوحجار – سيرو). تم تنفيذ التجربة بتصميم القطاعات العشوائية الكاملة بأربعة مكررات. تم تكرار التجربة في كل موقع في قطع (Plots) تبعد الواحدة عن الاخرى بمقدار 2 متر. تم وضع 10 طعوم خشبية أفقياً على كل خط بحيث تبتعد الواحدة عن الاخرى بمقدار متر معطياً جملة 400 طعم في كل موقع. تم أخذ القراءات كل أسبوعين وتم حساب عدد الطعوم المصابة كنسبة مئوية من العدد الكلي. أخضعت التجربة للتحليل الإحصائي بواسطة برنامج (SAS). أوضحت الدراسة وجود فرق معنوي بين إصابة الطعوم الخشبية الموضوعة تحت السترة الشجرية (المظلة) في البستان مقارنة مع نسبة الإصابة في الطعوم الخشبية الموضوعة في المساحات المكشوفة في موقعي الدراسة حيث ازداد نشاط الارضة تحت السترة الشجرية عنه في المساحات المكشوفة. أظهرت الدراسة أيضاً أن رحلات جمع الغذاء تنشط مع انخفاض درجة الحرارة وارتفاع الرطـوبة النسبية.

كلمات مفتاحية: الارضة، النشاط الغذائي، متساوية الاجنحة

Introduction

Termites, a common name for numerous species of insects, comprising the order Isoptera, a Latin term referring to the fact that adult termites have two pairs of wings that look very much alike. The infra order name is derived from the Greek words iso (equal) and Petra (winged), which refers to the nearly equal size of the fore- and hind-wings (Bignell et al., 2010).

Termites feed mainly on wood and other materials containing cellulose. This Termite predilection to feeding on wood has always put them in conflict with man. Sudan is a vast country with a total area of about 2.5 million square kilometer. The country is populated by approximately 30.5 million (El shafie, 2001). Eighty percent of the work force is engaged in agriculture and is living in the country side. The Sudan is climatically and geographically very divers, containing deserts, semi-deserts, shrubby and woody savanna lands. The Sudan termite fauna also reflects this topological and climatologically diversity. Some Sudan termites are destructive feeders and can cause damage to agricultural crops and homes. Several published studies provide valuable overview of termites as pests of crops in Sudan (Schumtterer, 1969; Kambal, 1975; Wood and Kambal,1984; Abd El Nour, 1985; El Bakri,1986; Tiben *et al*.,1990).

Both the worker and soldier castes lack wings and therefore never fly, so termites are predominantly reliant upon their legs to move around (Bignell et al., 2010). Workers do not forage unprotected and are rarely found out in the open. They rely on sheeting and runways to protect them from predators (Both the worker and soldier castes lack wings and therefore never fly so termites are predominantly reliant upon their legs to move around (Bignell et al., 2010). Foraging workers use semiochemicals to communicate with each other (Costa-Leonardo *et al*., 2013). In one species, *Nasutitermescostalis*, there are three phases in a foraging expedition: first, soldiers scout an area. When they find a food source, they communicate to other soldiers and a small force of workers starts to emerge. In the second phase, workers appear in large numbers at the site. The third phase is marked by a decrease in the number of soldiers and an increase in the number of workers. The most efficient forager is able to build over non-woody material, to forage over long distances and have efficient defensive castes (Costa-Leonardo *et al*., 2013).

Daily and seasonal factors affect termite activity, distribution and population dynamics. Moisture is the major factor closely linked to temperature that affects termite activity. Changes in environmental conditions cause changes in termite behavior. The special structure of colonies

depends on environmental conditions. Some termites are more tolerant to environmental factors, this can depend on the size or degree of sclerotization of the cuticle as well as on adaptations linked to their normal habitat (Cornelius and Osbrink, 2010). The termite's activity is associated with the temperature. It is high during the spring and summer. However, an increase in temperature, even in the winter months, can cause an increase in activity (Lewis *et al.*, 2011). Activity is also lowest during the morning, and peaking in the late afternoon. As the termites become more active, they have an increase in the release of CO_2 (Shelton, 2001). Turner (2001) mentioned that termites require relative humidity around 70 % to 80 %. However, the nest mean temperature is 26.16°C ± 4.18°C in winter and 31.73°C ± 2.94 in summer. Temperature and relative humidity (RH) play a vital role in influencing foraging behavior of desiccation prone termites (Bignell et al., 2010). No previous studies were undertaken to determine the best combination of temperature and RH for foraging of termite in Sudan.

The objective of the presents study is to assess the influence of temperature and relative humidity which prevail in trees canopy and in open areas on foraging activity of the termite (*Microtermisthoracalis*) in two different locations in Sinnar State.

Materials and Methods

The study area

This study was conducted in two different sites during the period from April 2014 to July 2014 in Sinnar State. The first site was Siro (Abuhujar locality) orchard situated at western bank of the Blue Nile River (Latitude 12.49° North, Longitude 33.59° East and Altitude 429 meters above sea level). The second site was at Hilat Saeed (Suki locality) orchard situated at the eastern bank of the Blue Nile River (Latitude13.15° North, Longitude 33.94° East, and Altitude 436 meters above sea level). The soil of the research site is predominately loamy soil composed of loam, sand and organic matter. The climate of the region is described as tropical savanna where annual rainfalls range from 350 to 450 mm (SMAD, 2015). The mean maximum and minimum monthly temperature range from 40.9° C in April to 33.2°C in July and from 25.4°C in April to 23°C in July, respectively.

Experiment and sampling

An area of 25 m × 25 m was marked out in Abuhujar and in Elsoki. In each site plant leaves, twigs and other organic matters were cleaned to avoid competition with the experimental baits in the

attraction of termites. The area was subsequently divided into four equal size plots each measuring 10 m × 10 m with a 3 m between each two adjacent plots. In each plot 10 parallel rows, 1 m a part was measured, ten wood baits were laid horizontally along each row at 1 m spacing, thus making 100 baits on each of four replicate plots total 400 baits per treatment (under shade and /or open spaces). The ten wooden baits along each row were examined for termite damage at 2-weeks intervals. Attacked baits were replaced by new baits on each monitoring occasion. The number of attacked baits was expressed as percentage of the initial number.

Statistical Analysis

The data collected were subjected to arcsine transformation and analysis was carried out using (SAS/ STAT, 2003) method of analysis. Means were compared according to Duncan's Multiple Range Test (DMRT). Results of analysis were presented as Means.

Results and Discussion

Foraging activity in various termite species is influenced by an array of biotic and abiotic factors. Of the abiotic factors, RH and temperature, play a vital role in affecting foraging behavior that ultimately determines their survival (Potter, 2001). The present study sought to assess the influence of ambient temperature and relative humidity on the foraging activities of termite in Siro and Hillatsaeid- Sinnar State in the Sudan.

Termites foraging activity at Siro site

The lowest mean damage to wood baits placed on the soil surface in trees canopy occurred in 15th May (48.85) (Table 1) where the ambient temperature was 34.4°C and RH of 51% (Figure 1). On the other hand, the highest mean damage was recorded in 15th June (57.99) (Table 1) with temperature at 31.3°C and RH at 58% (Figure 1). This result suggested that the small decrease in ambient temperature accompanied by a moderate rise in relative humidity added advantage for termites activity.

Levels of foraging activity on wood baits placed in the open area are shown in (Table 2), where baits were attacked throughout the exposure period which extended from 15thApril to 15thJuly.The maximum mean damage was recorded in 15thApril (51.96) with temperature at 36.5°C and RH at 34 % (Figure 1). The lowest mean damage occurred in 1stJuly (35.44) with temperature at 29.0°c and RH 78% (Figure1). This result indicated that the combination of low temperature

(29.0°C) and high relative humidity (78%) in July did not enhance foraging and this was not expected and was not in consistent with Potter (2001) who stated that low temperature and high relative humidity influence foraging behavior of termites.

Termites foraging activity at Helat Saeed site

Foraging by termites in the tree canopy at this site (Table 3) followed a fluctuating pattern (up and down) throughout the experimental period. The lowest mean damaged baits occurred in15th April (47.90) with temperature at 40.9°C and RH at 32 % (Figure 2). On the other hand, the highest damage was recorded in 15th May (58.30) with temperature at 39.8°C and RH at 49 % (Figure 2). It is interesting to notice that a decrease in temperature as small as 1% (40.9°C to 39.8°C) was adequate to increase foraging activity of termites resulting in high damage to wood baits.

Foraging activity by termite in open area at the same site followed an increasing pattern during April and early May, then followed by a sudden decline in mid May and continued steadily thereafter up to the end of the experimental period. The lowest mean damage to wood baits (37.10) (Table 4) was found in 1st July with temperature at 33.2°C and RH at 80 % (Figure 2), whereas, the highest damage to wood baits (55.50) (Table 4) was recorded in 1st May with temperature at 39.8°C and RH at 49 % (Figure 2). The results of foraging activity in the open area indicated that some termite species might have a wide range of acceptable temperature and relative humidity levels. Generally the findings of this study suggested that foraging by termites in tree canopies was influenced by temperature and relative humidity. This approves the statement mentioned by Renaud *et al*. (2011) that tree canopy and tree transpiration has moderating effect on meteorological parameters such temperature and relative humidity.

Conclusion

The ecological considerations to know the minimum, maximum and optimum temperature and relative humidity, that enable termites to maximize their foraging activity, was very important in suggestion of termites control strategies. Accordingly, conclusions could be drawn that termites damage increases with the increase of relative humidity, whereas it decreases as temperature increases. However, the termites foraging activity in tree canopy is greater than that in open area.

Table (1): Percentage mean attack on wood baits placed in trees canopy in Abuhujar site (Sairo) during 3 months exposure period (15thApril-15thJuly, 2014)

Rows of wood baits	1	2	3	4	5	6	7	8	9	10	Mean
15th/April	58.28ab (70)	51.34ab (60)	64.18ab (80)	38.67ab (40)	32.90b (30)	41.99ab (45)	73.40a (85)	50.90ab (60)	57.11ab (70)	50.90ab (60)	**55.35**
1st/May	45.00a (50)	47.88a (55)	57.10a (70)	50.89a (60)	35.33b (70)	64.17a (80)	67.50a (85)	45.00a (50)	53.78a (65)	67.50a (85)	**55.59**
15th/May	63.83a (80)	57.10a (70)	42.11bc (45)	47.88abc (55)	36.22c (35)	53.84ab (45)	56.79ab (70)	50.77abc (60)	35.78c (35)	56.79ab (70)	**48.85**
1st/June	57.10ab (70)	67.50a (85)	54.22ab (85)	56.79ab (70)	45.00b (50)	50.89ab (60)	54.22ab (65)	54.22ab (65)	63.44ab (80)	47.88ab (35)	**55.12**
15th June	63.44a (80)	56.79a (70)	50.77a (60)	64.17a (80)	45.00a (50)	63.44a (80)	56.79a (70)	61.16a (75)	60.11a (75)	58.28a (70)	**57.99**
1st/July	64.18ab (80)	50.77ab (60)	54.22ab (65)	53.78ab (65)	54.22ab (65)	48.01ab (55)	48.01ab (55)	47.99b (45)	53.79ab (65)	71.56a (90)	**57.99**
15th/July	54.22a (65)	54.22a (60)	56.79a (70)	57.11a (70)	61.17a (75)	64.18a (80)	50.90a (60)	48.01a (55)	48.01a (55)	61.17a (75)	**54.5**
Mean	**58.01**	**55.09**	**56.10**	**52.76**	**44.26**	**55.22**	**58.23**	**51.15**	**53.15**	**59.16**	

Means with same letter (letters) row wise are not significant at (0.05) probability level according to Duncan's Multiple Range Test (DMRT); data between parentheses are the actual data.

Table (2): Percentage mean attack on wood baits placed in open areas at Abuhujar site (Sairo) during 3 months exposure period (15thApril-15thJuly, 2014)

Rows of wood baits	1	2	3	4	5	6	7	8	9	10	Mean
15th/april	48.33a (70)	61.61a (60)	45.00a (80)	45.00a (40)	57.11a (30)	36.44a (45)	61.17a (85)	52.39a (60)	80.78a (70)	38.67a (60)	**51.96**
1st/may	45.00a (50)	41.68a (45)	45.00a (50)	45.00a (50)	41.68a (45)	41.61a (35)	54.22a (65)	29.89a (25)	38.67a (40)	33.21a (30)	**40.89**
15th/may	51.76ab (65)	50.89ab (60)	47.88ab (55)	45.00ab (50)	57.10ab (70)	50.74ab (60)	60.10a (75)	45.00ab (50)	46.22ab (35)	38.66ab (40)	**48.51**
1st/june	51.33a (60)	33.21a (30)	39.10a (40)	39.33a (40)	32.89a (30)	45.00a (50)	45.00a (50)	45.00a (50)	39.10a (40)	39.23a (40)	**40.91**
15th june	39.00ab (25)	47.88ab (50)	53.78a (65)	29.88b (25)	39.23ab (40)	29.00b (15)	47.88ab (55)	32.82b (20)	47.88ab (55)	41.61ab (45)	**37.90**
1st/july	33.32bc (20)	33.71bc (15)	45.00ab (50)	50.77a (60)	39.10abc (40)	26.50bc (20)	42.11ab (45)	44.11ab (40)	45.00ab (50)	32.32bc (20)	**35.44**
15th/july	50.89a (60)	45.00a (50)	47.88a (55)	29.88a (25)	45.00a (50)	45.00a (25)	29.88a (55)	48.01a (35)	35.78a (50)	45.00a (15)	**39.98**
Mean	**45.66**	**44.85**	**46.23**	**40.69**	**44.58**	**39.18**	**48.62**	**42.46**	**47.63**	**38.38**	

Means with same letter (letters) row wise column are not significant at (0.05) probability level according to Duncan's Multiple Range Test (DMRT); data between parentheses are the actual data.

Table (3): Percentage mean Mean attack on wood baits placed in trees canopy in Elsuki site (Hilatsaeed) during 3 months exposure period (15th April-15th July, 2014)

Rows of wood baits	1	2	3	4	5	6	7	8	9	10	Mean
15th/April	45.00a (50)	45.00a (50)	33.21a (30)	51.34a (60)	51.44a (50)	55.40a (55)	52.39a (60)	41.68a (45)	39.34a (25)	67.50a (85)	**47.90**
1st/May	56.79ab (70)	50.77b (60)	50.22b (65)	46.18ab (80)	60.12ab (75)	61.17ab (75)	42.12b (45)	39..11b (40)	51.34b (60)	80.78a (95)	**56.10**
15th/May	53.78a (65)	51.34a (60)	54.22a (65)	64.18a (80)	64.18a (80)	58.28a (60)	48.01a (55)	55.40a (65)	63.44a (80)	70.39a (80)	**58.30**
1st/June	42.12a (45)	36.22a (35)	50.77a (60)	45.00a (50)	63.44a (80)	53.78a (65)	47.89a (55)	45.00a (50)	52.50a (50)	47.89a (55)	**47.70**
15th June	67.50a (85)	56.79cde (70)	63.44bc (80)	53.78def (65)	47.88f (55)	50.77ef (60)	56.79def (70)	71.56a (90)	60.10bcd (80)	47.88f (55)	**57.70**
1st/July	60.12a (75)	60.17ab (75)	53.78ab (65)	48.01ab (55)	61.17ab (75)	60.12ab (75)	45.00ab (50)	39.11b (40)	42.12b (45)	73.40a (85)	**54.40**
15th/July	61.16a (75)	57.10ab (70)	45.00ab (50)	45.00ab (50)	45.00ab (50)	57.10ab (70)	64.17a (80)	53.79ab (65)	63.44a (80)	36.22b (35)	**52.80**
Mean	**55.22**	**51.05**	**50.09**	**50.49**	**56.17**	**56.66**	**50.91**	**49.37**	**53.18**	**60.58**	

Means with same letter (letters) row wise column are not significant at (0.05) probability level according to Duncan's Multiple Range Test (DMRT); data between parentheses are the actual data.

Table (4): Percentage mean attack on wood baits placed in open area in Elsuki site (Hilatsaeed) during 3 months exposure period (15thApril-15thJuly, 2014)

Rows of wood baits	1	2	3	4	5	6	7	8	9	10	Mean
15th/April	45.00abc (50)	50.77ab (60)	29.89bc (25)	29.89bc (25)	23.50c (15)	35.61abc (35)	35.78abc (35)	47.89abc (55)	61.17a (75)	39.11ab (40)	**39.76**
1st/May	56.79a (70)	63.44a (80)	61.17a (75)	47.89a (55)	57.11a (70)	56.79a (70)	57.11a (70)	60.12a (75)	38.62a (40)	57.11a (70)	**55.50**
15th/May	41.68abc (45)	36.22abc (35)	26.56bc (20)	38.33ab (55)	54.22a (65)	20.44c (10)	50.90ab (60)	45.00abc (50)	36.22abc (35)	48.01ab (55)	**42.40**
1st/June	48.01a (55)	29.84a (25)	29.89a (25)	35.78a (35)	33.21a (30)	41.68a (45)	42.12a (45)	33.21a (30)	50.77a (60)	53.78a (65)	**39.70**
15th June	36.22abc (35)	53.78a (65)	54.22a (65)	38.66abc (40)	45.00abc (50)	26.82bc (20)	47.88ab (55)	25.82c (20)	42.11abc (45)	29.88bc (25)	**39.90**
1st/July	29.88a (25)	42.11a (45)	42.11a (45)	39..23a (35)	41.99a (60)	38.66a (35)	36.22a (35)	31.72a (25)	18.44a (10)	41.99a (45)	**37.10**
15th/July	36.22a (35)	45.00a (50)	41.68a (45)	45.00a (50)	35.78a (35)	33.21a (30)	45.00a (50)	25.83a (20)	50.90a (60)	32.90a (30)	**39..20**
Mean	**41.97**	**45.88**	**40.78**	**44.96**	**40.25**	**36.17**	**40.00**	**38.51**	**42.60**	**42.82**	

Means with same letter (letters) row wise column are not significant at (0.05) probability level according to Duncan's Multiple Range Test (DMRT); data between parentheses are the actual data.

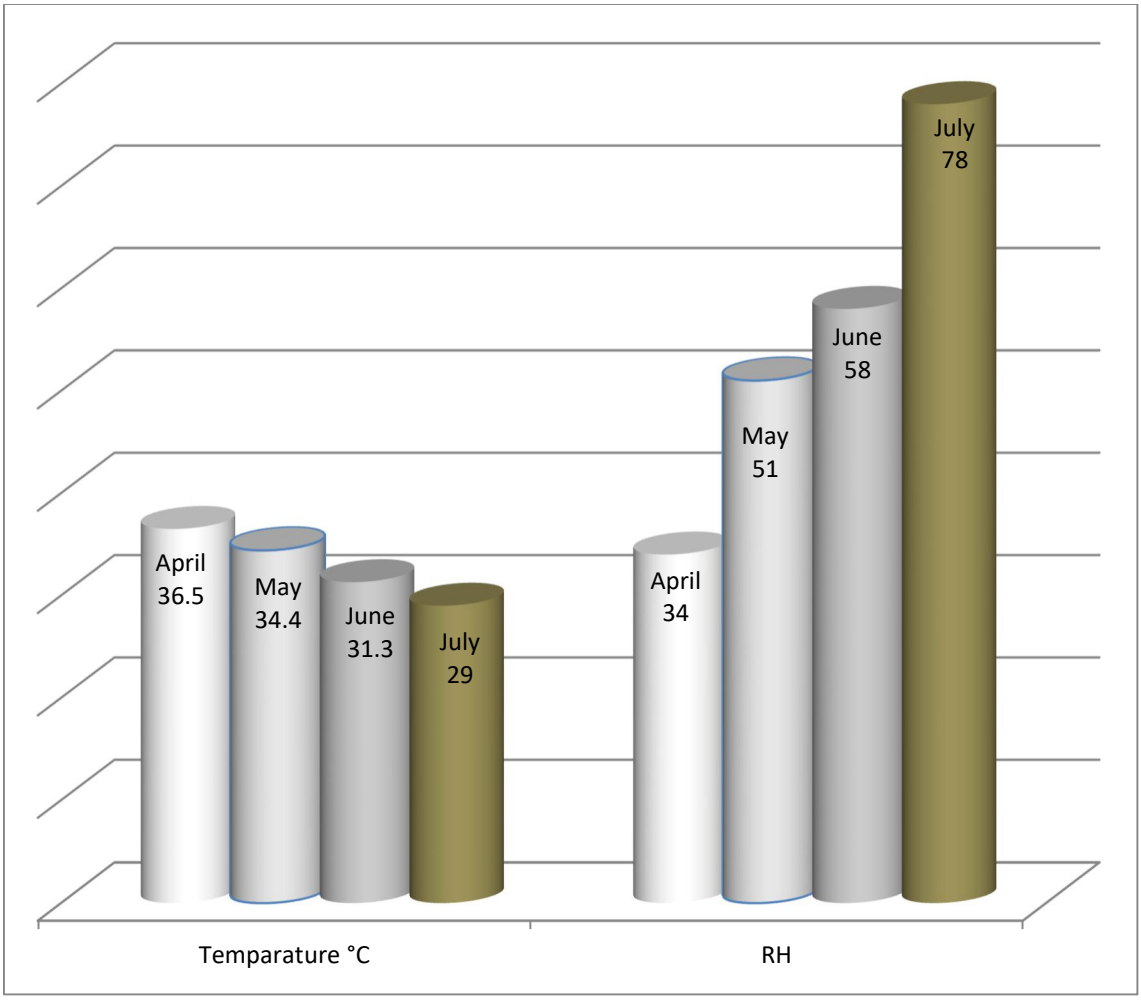

Figure (1): Average monthly temperature and RH for Siro site

Source: Abunaama Metrological Station.

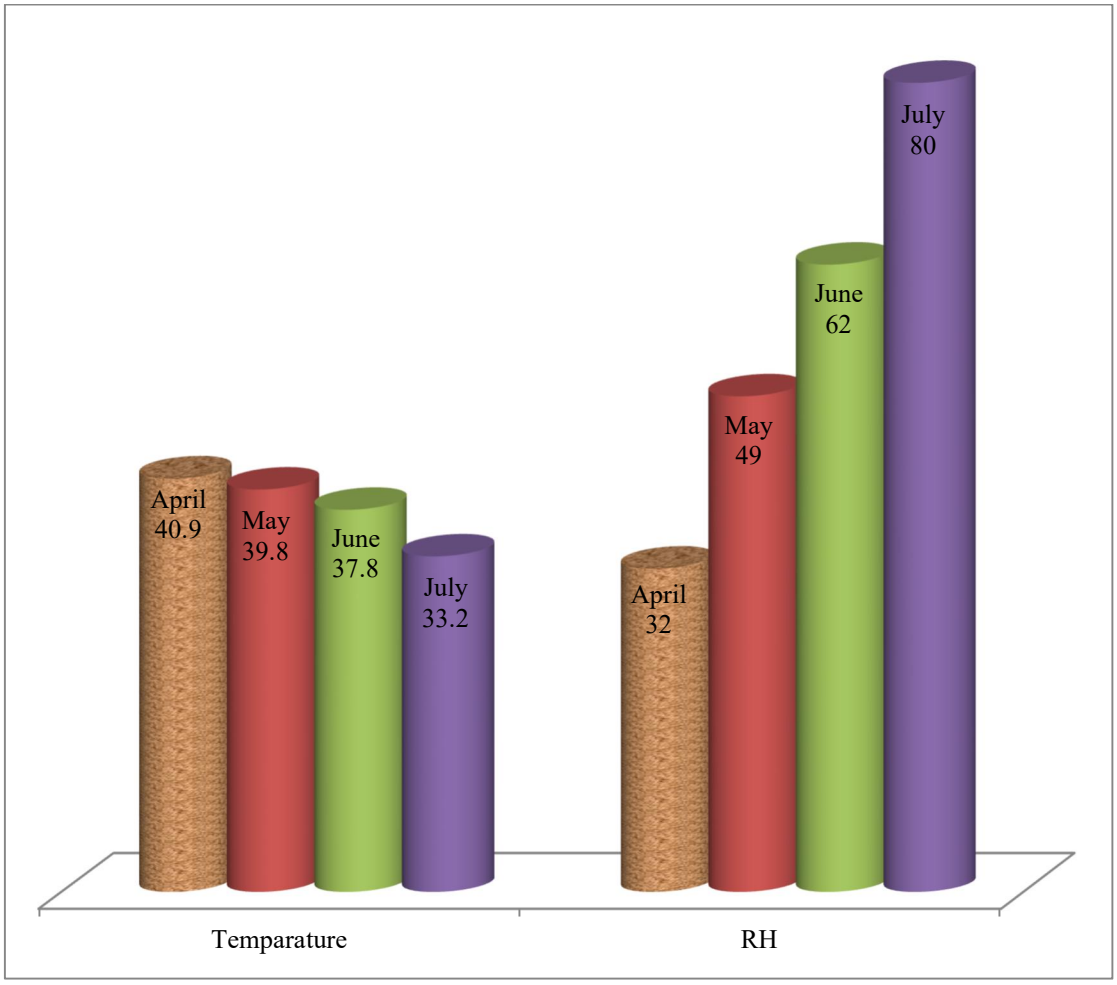

Figure (2): Average monthly temperature and RH for Hillat Saeed site

Source: Aumbenain Metrological Station.

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Research paper

تقييم ومقارنة الكفاءة الاقتصادية لنظم الري التقليدي والحديث لإنتاج القمح بمحلية بربر- ولاية نهر النيل – السودان

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المستخلص

أجريت الدراسة في ولاية نهر النيل- محلية بربر فى الموسم الشتوي 2016/17م وذلك بهدف تقييم ومقارنة الكفاءة الاقتصادية لنظم الري التقليدي والحديث لإنتاج القمح. تم اختيار مشروع يستخدم الري بالرش المحوري (استثماري) ومشروع يستخدم الري التقليدي (حكومي). من أجل تحقيق أهداف الدراسة تم جمع البيانات عن طريق استبيان لجمع بيانات المشروعين واستبيان اخر لمزارعي المشروعات الخصوصية الصغيرة، بالإضافة للبيانات الثانوية التي تم جمعها من الجهات ذات الصلة بالموضوع. اتبعت الدراسة الأسلوب التحليلي الاحصائي الوصفي البسيط بالإضافة الى تحليل الانحدار وتحليل الميزانية المزرعية لمحصول القمح. توصلت الدراسة الى أن مزارعي العينة متجانسون في خصائصهم الاقتصادية والاجتماعية وذلك من خلال نتائج التحليل الوصفي للمزارعين، بينت الدراسة أن المشروع (الاول) الذي يستخدم الري المحوري هو الأعلى ربحية بالنسبة لمحصول القمح مقارنة بالمشروع (الثاني) الذي يستخدم نظام الري التقليدي والمشاريع الخصوصية الصغيرة حيث بلغ معامل الربحية لمحصول القمح للمشاريع أعلاه (1.53، 1.27، 1.22) على التوالي. أوضحت نتائج تحليل الانحدار أن المتغيرات (عمر المزارع، المستوى التعليمي، عدد سنوات الخبرة، تكاليف الري، تكاليف البذور، تكاليف الأسمدة، تكاليف المبيدات) كانت ذات تأثير معنوي وذلك لمزارعي المشروعات الخصوصية الصغيرة. بينت نتائج تحليل برنامجي Cropwat8، Climwat أن كفاءة استخدام مياه الري لمحصول القمح كانت 73، 39، 39 % في المشروع الاول، الثاني والمشاريع الخصوصية الصغيرة، على التوالي، وهذا يؤكد أن أن استخدام الري الحديث يرفع من كفاءة استخدام المياه. أوصت الدراسة بتشجيع الاستثمار خاصة في المشاريع التي تستخدم الري الحديث حيث أن نتائج الدراسة بينت ارتفاع كفاءته مقارنة بالري التقليدي. كما أوصت الدراسة بتوفير التمويل اللازم لمحصول القمح في الزمن المناسب وبالقدر الكافي لإتاحة استخدام المدخلات الزراعية والتي أظهرت النتائج أثرها المعنوي الايجابي على انتاج القمح.

كلمات مفتاحية: تقييم، كفاءة الري، نظم الري، القمح.

Evaluation and Comparison of Economic Efficiency of Traditional and Modern Irrigation Systems on Wheat Production at Berber Locality, River Nile State, Sudan

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Abstract

The study was conducted in the River Nile State- Berber Locality during winter season 2016/17 to evaluate and compare the economic efficiency of traditional and modern irrigation systems for wheat production. The study selected a scheme where sprinkler irrigation is used (investment), and another scheme (public) where traditional irrigation is used and some small private traditional schemes. In order to achieve the objectives of the study, data was collected through two questionnaires one for the two first schemes and the other for the small private schemes' farmers in addition to the secondary data collected from the relevant authorities. The study followed a simple descriptive statistical analysis method, regression analysis and analysis of the farm budget for wheat crop. Through the results of descriptive analysis, the study showed that farmers in the sample are homogeneous in their economic and social characteristics. The study showed that the first scheme which use sprinkler irrigation showed the highest profitability for wheat crop compared to the second scheme which use traditional irrigation and small private schemes with coefficient of private profitability of 1.53, 1.27, 1.22, respectively. The results of regression analysis showed that the variables (farm age, educational level, years of experience, irrigation costs, seeds costs, fertilizer costs, pesticide costs) had a significant effect for the farmers of small private schemes. The results analysis of the two programs (Cropwat8) and Climwat showed that the efficiency of using irrigation water for wheat crop was 73, 39, 39% in the first and second schemes and the small private schemes, respectively. This confirms that the use of modern irrigation increases the efficiency of water use. The study recommended: encouraging of investment in the modern irrigation schemes, especially that the results of the study reflects high efficiency compared to traditional irrigation. It was also recommended to provide the necessary funding for wheat crop production in a timely manner and sufficient to allow the use of agricultural inputs which had a significant positive impact on wheat production.

Keywords: Evaluation, irrigation efficiency, irrigation systems, wheat.

مقدمة

يعتبر السودان من أكبر الدول الافريقية مساحةً وذلك قبل انفصال دولة جنوب السودان في عام 2011م، اذ كانت جملة المساحة الكلية 2,56 مليون كلم^2 منها 1,861,000 كلم^2 (72,7%) للسودان، 699 ألف كلم^2 (27,3 %) لجنوب السودان. وتبلغ جملة الأرض السودانية الصالحة للزراعة 200 مليون فدان (84 مليون هكتار، المستغل منها 18 مليون هكتار)، بينما تبلغ المساحة الإجمالية للغابات والمراعي في السودان نحو 279 مليون فدان (عبد الله ، 2012م). من بين ولايات السودان الهامة في مجال الإنتاج الزراعي ولاية نهر النيل وتقع بين خطى عرض 16^o – 22^o شمالاً، وخطى طول 32^o – 35^o شرقاً. تقدر مساحة الولاية الإجمالية 124 ألف كلم^2 (29.5 مليون فدان تقريباً) (Abdel-Aziz, 1999).

تتميز الولاية بوفرة الموارد الزراعية إذ تبلغ الأراضي الصالحة للاستثمار الزراعي حوالي 3.2 مليون فدان وتحتل مرتبة هامة في الإنتاج الزراعي وتتمتع الولاية بميزات نسبية متمثلة في الأراضي العالية الخصوبة والتركيبة المحصولية المتنوعة، حيث تزرع محاصيل هامة مثل القمح والبقوليات والتوابل بأنواعها والنباتات الطبية والعطرية والخضروات والذرة والأعلاف إضافة للمحاصيل البستانية (ابراهيم، 2008م). القمح محصول قديم في السودان ولكن ظلت زراعته ولعقود طويلة محصورة في أقصى شمال السودان وذلك لتوفير الظروف البيئية لإنتاجه وتأصله في العادات الاستهلاكية لسكان تلك المنطقة، وكانت المساحات التي تزرع بالقمح في الولاية الشمالية محدودة في الشريط الساحلي الضيق المروي من النيل مباشرة، حيث يزرع القمح بهدف الاكتفاء الذاتي لأسر المزارعين، في ستينيات القرن الماضي غزت الولايات المتحدة الأمريكية دول العالم الثالث بما يعرف ببرنامج المعونة الأمريكية الغذائية مما سبب تغير النمط الغذائي للسكان، ونتيجة لذلك ازداد استهلاك أهل السودان للقمح.

أصبح نقص المياه حادا في جميع انحاء العالم بما في ذلك الدول العربية نتيجة للتزايد المستمر في عدد السكان مع تناقص في الموارد المائية نتيجة للتغيرات المناخية والتي تسود العالم نتيجة للثورة الصناعية وما صاحبها من أثر سلبي أدى لتغيير في المناخ ونقص في معدلات الأمطار وبالتالي نقص في الموارد المائية، والسودان رغم أن حباه الله تعالى بموارد مائية كبيرة إلا أن المشكلة تطاله إذا لم تتوفر الحلول المناسبة.

ولاية نهر النيل هي من الولايات التي لها ميزة تنافسية لإنتاج الكثير من المحاصيل الحقلية خاصة محصول القمح والمحاصيل البستانية وتعتمد في ري هذه المحاصيل بصورة أساسية على نهر النيل ونهر عطبرة. أسلوب الري المستخدم هو الري التقليدي عن طريق السحب بواسطة الطلمبات والتي تعمل غالبيتها بوقود الديزل، أو عن طريق الري الفيضي في موسم الدميرة. الاعتماد على الري السطحي لإنتاج محاصيل الحبوب يعتبر من وسائل الري ذات الكفاءة المنخفضة مما يؤدى لهدر كميات كبيرة من المياه كان من الممكن استخدامها في زراعة مساحات اضافية أخري والاستفادة من التوسع الأفقي. وعليه فان استخدام الأسلوب التقليدي ينعكس سلبا على انتاج المحاصيل عموما وانتاج القمح بصفة خاصة حيث انها تزيد من تكاليف مدخلات الانتاج خاصة وان الري يمثل التكلفة الأعلى من تكاليف المدخلات الزراعية مما يقلل من صافي العائد وهذا بدوره يؤثر سلباً على دخل المزارع. وقد تم تقدير كفاءة الري في المتوسط بحوالي 45 % للمحصول يقابل ذلك ضعف في الإنتاجية ونقص في مصادر الطاقة الرخيصة (ELGilany *et al.*, 2007).

إن ترشيد استهلاك المياه لأغراض الري لإنتاج القمح يقود للتفكير في اساليب مستحدثة للري من شأنها توفير المياه والمحافظة على الموارد المائية وتقليل الفاقد عن طريق البخر والتسرب واستخدامات مياه الري وفقاً للمقننات المائية للمحاصيل. من اساليب الري الحديث الري بالتنقيط والري بالرش والري المحوري والتي انتظمت الولاية في الآونة الأخيرة كما موجود في مشروع الكفاءة الزراعي (الراجحي) في منطقة بربر، مشروع الأمن الغذائي بمدينة عطبرة، مشروع البشاير الأردني وغيره. هذا النوع من الري في الولاية يصلح كأسلوب لري المحاصيل الحقلية والبستانية خاصة في أراضي التروس العليا البعيدة عن النيل ومن خلاله يمكن إضافة الأسمدة والمبيدات بمختلف أنواعها كما أنه يوفر الأيدي العاملة ويعتبر من انماط الري الصديقة للبيئة بالإضافة للغرض الرئيسي منه وهو ترشيد استخدام مياه الري.

سكان العالم في تزايد مستمر فمن المتوقع أن يتزايد عدد السكان الذي يبلغ الآن 7بليون نسمة إلي حوالي 9 بليون نسمة بحلول عام 2050م، وفي ذلك الوقت، سيصبح لزاما إنتاج مليار طن أخري من الحبوب و200 طن إضافية من المنتجات الحيوانية كل عام (FAO, 2011).

ولتحسين التغذية وتقليص انعدام الأمن الغذائي ونقص التغذية يجب أن يزيد الإنتاج الزراعي في المستقبل بمعدل أسرع من نمو السكان ويلزم أن يحدث هذا الي حد كبير على مساحة الأراضي الزراعية القائمة وسيتعين بالتالي أن تأتي التحسينات من عمليات تكثيف مستدامة تستخدم فيها الأراضي والموارد المائية استخداما فعالاً وهذا الوضع رفع من مستوى التنافس على الأراضي والمياه خاصة في الدول (FAO, 2011). عرف السودان زراعة القمح منذ الاف السنين إلا أن زراعته انحصرت حتي نهاية الخمسينات من القرن المنصرم، في الولاية الشمالية وولاية نهر النيل (بين خطي عرض 17 و 23 درجة شمالا) وفي مساحة لا تتجاوز 30 الف فدان كان انتاجها يكفي استهلاك الولايتين (محجوب، 2018). كما بينت دراسة عجيمي (2009) زيادة استهلاك القمح في السودان خلال العقود الأخيرة مما دفع الدولة لزيادة الاهتمام بتوفيره من خلال الإنتاج المحلي ومن خلال الإنتاج.

أورد Scherer (1998) أنه توجد أربعة طرق رئيسية للري وهي 1/الري السطحي أو الانسيابي، 2/الري تحت السطحي، 3/الري بالتنقيط، 4/الري بالرش. والري السطحي الانسيابي هو الأسلوب السائد في السودان ولدينا أمثلة كثيرة في السودان متمثلة في مشروع الجزيرة ومشروع الرهد ومشاريع السكر وفيها جميعا ظل يسود الري الانسيابي في توصيل المياه الى الحقل ومن الملاحظ أن الري السطحي يشتمل على كلا النوعين من الري وهما: الري التقليدي والري الحديث مثل الري بالرش، والري بالتنقيط، ولكل من هذه الأنواع مزاياها وعيوبها.

عند الحديث عن أي نوع من نظم الري، فإنه من المفيد وجود مفهوم الكفاءة ليتسنى عمل مقارنة لأنظمة مختلفة، حتى الآن هناك أكثر من 20 طريقة لتحديد أو تقدير كفاءة مقترحة لنظم الري، أغلب هذه الطرق مفيدة على الرغم من أن بعضها يبدو معقداً وبعضها بسيط.

التعريف المطلق للكفاءة هو عبارة عن النسبة بين المنتج (Output) والمدخل (Input) ويمكن تعريفها بالمعادلة التالية (Smith, 2000):

$$.Efficiency = \frac{Output}{Input}$$

وهي:

وقد تم جعل هذه التعاريف أكثر تخصيصاً وعليه تكون كفاءة الري عبارة عن النسبة بين كمية مياه الري المستخدمة بفائدة من قبل النبات أو المحصول إلى كمية مياه الري المضافة (Wong *et al.*, 1999) وذلك حسب المعادلة أدناه:

$$\text{Irrigation efficiency} = \frac{(Amount\ of\ irrigation\ water\ beneficially\ used)}{(Amount\ of\ irrigation\ water\ applied)}$$

ويقصد بالكمية في حالة نظم الري حجم الماء، ويمكن اعتبار أن الماء المضاف لأسباب متنوعة واسعة هو مستخدم بكفاءة في الري، وينطوي تحت الاستخدامات العادية ذات الفائدة ما يفي باحتياجات نتح النبات والبخر من النبات والتربة والكميات المستخدمة لغسيل الأملاح الذائبة خارج قطاع الجذور، وحماية الصقيع، وتبريد النبات (Cuenca, 1989).

أورد Michael (1997) أن كفاءة الري هي النسبة بين حجم المياه المستخدمة بواسطة النبات من خلال عملية البخر – نتح، وحجم المياه الواصلة من المصدر إلى الحقل، وتشير الكفاءة الى مدى استخدام كميات الماء المتاح اعتمادا على أساليب مختلفة للتقييم، كتصميم نظام الري، ودرجة إعداد الأرض ومهارة واهتمام العاملين وكل هذه عوامل مؤثرة في كفاءة الري. Lamaddalena *et al.* (2005) بينوا أن الكفاءة عموماً تُعرف على أنها النسبة بين المخرجات إلى المدخلات ويُعبر عنها كنسبة مئوية، أما بالنسبة للري تُعرف على أنها النسبة بين مياه الري المستخدمة بواسطة المحاصيل خلال فترة النمو إلى المياه الواصلة من المصدر خلال نفس الفترة، وقد طُور التعريف ليشمل ثلاث مجموعات رئيسية:

أ) تعاريف مبنية على أساس قياس حجم الماء: وهذا النوع يعتمد على نسب أحجام المياه ومن مزاياه سهولة قياس حجم الماء الواصل للحقل أو قياس حجم الماء الموزع باسطة نظام الري، أو قياس حجم الماء في منطقة الجذور، أو قياس حجم الماء في عملية البخر- نتح، ومن العيوب أنه لا يضع في الحسبان تجانس الري في الحقل.

ب) تعاريف مبنية على أساس عمق الري: وهذه تعتمد على حجم الماء الكلى الواصل مقسوماً على المساحة الإجمالية ومن عيوب هذه الطريقة أنه لا يمكن قياس عمق الري في جميع أنحاء الحقل.

ت) تعاريف معتمدة على معايير أخرى مرتبطة بالإنتاجية: وهذه نادراً ما تستخدم ويرجع ذلك لحقيقة أن انتاجية المحصول تتأثر بعوامل أخرى مثل التسميد والمكافحة وخلافه أحياناً تتأثر الإنتاجية بإدارة الري. يتم نقل ماء الري من مصادره إلى الحقول وتجهيزه للمحاصيل الزراعية بطرق مختلفة، وبعبارة أخرى فأن ماء الري ينقل من نقطة ضخه وحتى مكان استغلاله من قبل النبات، وعليه يتخلل هذه العملية بعض الفاقد المائي تؤثر على كفاءة الري.

تاج السر (2006م) في دراسته التي اجراها لمعرفة الموارد المائية بولاية نهر النيل وممارسات الري السائدة فيها، بهدف تحسين وتحديث هذه الموارد والممارسات، هدف الدراسة الاسهام في تنمية موارد الري من مصادرها المختلفة وذلك اما بحسن استعمالها او اضافة مصادر جديدة اليها، كما هدفت الدراسة لتقليل الهدر في طرق الري السائدة ورفع كفاءة وحدة المياه وتقليل الأثر السلبى لهدر المياه على الموارد الأخرى وذلك بتطوير الوحدة الأيكولوجية , كما هدفت الدراسة الى تطوير طرق الري بهدف التوسع الأفقي والرأسي لزيادة انتاجية وحدة المياه في الزراعة والمرعى. وخرج منها بنتائج اهمها:

ان طرق حصادا المياه الحالية تهدر الكثير من المياه وقد تحقق الباحث بان نسبة الهدر تصل الى 90% وأن عدم وجودا تخزين على النيل الرئيسي قد ادى الى مشاكل عديدة في كل انواع الري التقليدي كالهدام، الإطماء، التصحر وانحسار المياه .استغلال مياه الري بالطرق التقليدية يهدر كميات كبيرة من المياه وقد تحقق الباحث بانها تتجاوز في المتوسط ال 70 % بينما يقل الهدر في الري بالرش. تسعير المياه يؤدى الى ترشيد استهلاكه وقد تحقق الباحث من ان علاقة الانتاج المبنية على اساس طلب المياه لها أثر إيجابي في تقليل المسحوب من المياه.

دراسة Ahmed (2008) أجريت بولاية نهر النيل وذلك لتحديد مشاكل الإنتاج الزراعي بالولاية وذلك مثل: تدني الإنتاجية، ارتفاع تكاليف الإنتاج، ضعف التمويل، تدني الدخل المزرعي، تدني كفاءة النظام التسويقي وإساءة استخدام مياه الري .وتهدف هذه الدراسة لمعرفة الوضع الاقتصادي الأمثل لاستخدام مياه الري وكذلك الموارد المحدودة الأخرى بالمشاريع الحكومية بالولاية. من أهم السياسات والتوصيات التي توصلت لها الدراسة والتي يمكن أن تفيد في رفع كفاءة الإنتاج بالولاية هي:

-تدخل المؤسسات الحكومية المختصة لتوفير مياه الري، رفع مستوى المعرفة لدى المزارع بأهمية المياه في الحياة ,يمكن رفع كفاءة استخدام الموارد بالاستفادة من نماذج الحل المقدمة في الدراسة، يجب وضع سياسات تلائم وتشجع إنتاج المحاصيل الاستراتيجة، ضرورة استنباط نظام تسويقي فعال للمحاصيل الزراعية و مدخلات الإنتاج.

دراسة Elhassan (2008) في مشروع الحامداب الجديدة الزراعي، أحد مشاريع إعادة التوطين الجديدة المصاحبة لسد مروي. هدفت الدراسة لإجراء مسح شامل على نظم الري المحوري في السودان وتركيب عدد خمسة أجهزة ري محوري على مواقع محددة سلفا على أراضي رملية (تروس عليا) لمشروع الحامداب. مقارنة عوامل النمو والإنتاجية للقمح بالري المحوري مع كل من المزارع التجريبية والتقليدية أظهرت فروقا معنوية عالية للري المحوري في المزارع التجريبية والتقليدية.

تتمثل أهداف الدراسة الحالية في النقاط الآتية:

1/ التعرف على الخصائص الاقتصادية والاجتماعية للمزارعين بمنطقة الدراسة.

2/ مقارنة ربحية محصول القمح بين مشاريع الري الحديث والتقليدي اعتمادا على معامل الربحية الخاصة لمحصول القمح.

3/ مقارنة كفاءة الري بين المشاريع الحديثة والتقليدية.

4/ قياس العوامل المؤثرة على انتاج القمح بمنطقة الدراسة.

تتمثل فرضيات الدراسة في النقاط الآتية:

1/ مزارعو المنطقة متجانسون من حيث الخصائص الاقتصادية والاجتماعية.

2/ كفاءة الري التقليدي منخفضة مما يؤدى لهدر المياه المستخدمة في الري.

3/ كفاءة الري الحديث عالية مقارنة بالري التقليدي.

4/ استخدام طرق الري الحديثة تؤدي الي انتاجية عالية وعائد اعلى مقارنة بطرق الري التقليدية.

الحدود المكانية: تم إجراء الدراسة في: الكفاءة الزراعي، الحصا الزراعي والمشاريع الصغيرة (الخاصة) بمحلية بربر ولاية نهر النيل حيث يستخدم الأول الري المحوري (Centre Pivot) ويستخدم الري التقليدي (الري السطحي) في كل من الحصا الزراعي والمشاريع الصغيرة (الخاصة).

الحدود الزمانية: تم إجراء الدراسة للموسم الزراعي 2016/17م.

المنهجية وطريقة التحليل

تم إجراء الدراسة في ثلاثة أنواع من المشاريع وهي: مشروع الكفاءة الزراعي (الراجحي) ، مشروع الحصا الزراعي ، المشاريع الخصوصية الصغيرة بالمنطقة .

تم جمع البيانات الأولية من مصادرها عن طريق تصميم استمارة لجمع البيانات والمعلومات لكل من مشروعي الكفاءة الزراعي والحصا الزراعي كل على حدة للموسم الزراعي الشتوي 2016/17م حوت الاستمارة أسئلة متعلقة بالمساحات الكلية والمستغلة والتركيبة المحصولية واسلوب الري المستخدم، وكميات المياه المستخدمة لري فدان القمح كذلك متوسطات لبنود التكاليف المتغيرة ومتوسط الإنتاجية ومعلومات عن المضخات المستخدمة في الري وتصريفها وذلك في كل من مشروع الكفاءة الزراعي (الراجحي) ومشروع الحصا الزراعي، أما بالنسبة للمشاريع الخصوصية الصغيرة فقد تم تصميم استمارة استبيان تم توزيعها على المزارعين اشتملت على أسئلة متعلقة بالخصائص الاجتماعية مثل العمر والحالة الاجتماعية والمستوى التعليمي وعدد أفراد الأسرة وأخرى متعلقة بالخصائص الاقتصادية كالتركيبة المحصولية والمساحات المزروعة والانتاج والانتاجية وتكاليف مدخلات الإنتاج وعدد الريات لمحصول القمح وعدد ساعات الرية الواحدة وغيرها. تم اختيار جنوب بربر وشمال بربر باعتبارها قريبة من مشروع الكفاءة الزراعي والحصا الزراعي لتسهيل عملية المقارنة وعليه يكون جملة عدد المشاريع في هذه المناطق الثلاث 659 مشروع تم أخذ عينة عشوائية منها مكونة من 50 مزارعا بنسبة قدرها (7,59%) من جملة المشاريع بالمناطق الثلاث وذلك لعدة أسباب منها: تجانس مجتمع الدراسة من حيث الخصائص الاقتصادية والاجتماعية، ضعف الإمكانات المادية، استخدام وسائل أخرى كالملاحظة والمقابلة الشخصية.

اعتمدت الدراسة على الأسلوبين الوصفي والتحليلي (descriptive and analytical)، وتم التركيز في التحليل الوصفي على حساب بعض المؤشرات الاقتصادية اعتمادا على البيانات التي تم جمعها من خلال المسح الميداني وكذلك من البيانات الثانوية التي تم الحصول عليها من المصادر ذات الصلة بالموضوع. أما التحليل الكمي فقد تم التركيز فيه على تقدير دالة الإنتاج (كوب دوجلاس) وذلك باستخدام برنامج الحزم الإحصائية للعلوم الاجتماعية (SPSS) حيث تم إدخال جميع بيانات الاستبيانات للمزارعين في المشروعات الصغيرة، وذلك بعد تشفيرها لتتناسب مع طريقة عمل البرنامج، ومن ثم تم إجراء التحليل الوصفي لحساب المتوسطات وعمل الجداول التوضيحية، كذلك من خلال ذات البرنامج تم إجراء تحليل الانحدار (Regression analysis) ولتقدير دالة الإنتاج يتطلب الأمر وجود بيانات كمية للإنتاج ومدخلاته وكذلك الأجور والأسعار، وقد تم الحصول على البيانات المطلوبة من خلال المسح الميداني في منطقة الدراسة. في هذه الدراسة تم استخدام دالة كوب دوجلاس (Cobb Douglass Functional Approach) وذلك لمعرفة تأثير المتغيرات المستقلة على المتغير التابع وهو الإنتاجية وذلك للمشاريع الصغيرة.

تم استخدام برنامج (CROPWAT.8) وهو برنامج تم استحداثه بواسطة منظمة الزراعة والأغذية (FAO) وذلك لحساب البخر- نتح المرجعي. ويتم باستخدام هذا البرنامج حساب الاحتياجات المائية للمحاصيل المختلفة في جميع أنحاء العالم

من خلال توفير قاعدة بيانات خاصة بالمناخ والتربة والمحاصيل. كما تم أيضاً الاستعانة ببرنامج (CLIMWAT) وهو برنامج يهتم بتوفير قاعدة بيانات عن المناخ كدرجات الحرارة والرطوبة النسبية والأمطار والإشعاع الشمسي وغيرها. ونسبة لصعوبة الحصول على بيانات المناخ لفترات طويلة فقد تم استخدام البرنامجين المذكورين أعلاه وذلك لتحديد الاحتياجات المائية المثلى Crop Water Requirements (CWR) بالمتر المكعب من المياه ويتم تقدير الاحتياجات المائية للمحصول للرية الواحدة أو للموسم لكل مشروع من المشاريع موضع الدراسة، ومن ثم تم مقارنتها بكمية مياه الري المضافة فعليا للمحصول في المشاريع موضع الدراسة والتى تم الحصول عليها من خلال بيانات الدراسة من هذه المشاريع بعد ذلك يمكن حساب الزيادة أو النقصان في كميات مياه الري. ويمكن حساب كفاءة استخدام الماء (FWUE) في الحقل من خلال المعادلة التالية:

$$FWUE = Wr / Wa * 100$$

حيث:

Wr = الاحتياجات المائية في الموسم (Wr) م^3

Wa = كمية المياه المضافة فعلياً في الموسم (Wa) م^3

النتائج والمناقشة

من نتائج التحليل الوصفي تبين مدى التجانس في الخصائص الاقتصادية والاجتماعية، فقد وجدت الدراسة أن حوالي 78% من المزارعين ضمن الأعمار النشطة (أقل من 45 سنة)، المستوى التعليمي مرتفع حيث كانت نسبة المتعلمين 96% بينما كانت نسبة الأمية 4%، تراوح حجم الحيازة الزراعية بين 3-25 فدان وكانت أعلى نسبة 16% للحيازة بمساحة 10 فدان . مصادر الري هي النيل والآبار الجوفية في محلية بربر.

بالنسبة للتمويل وجد أن حوالي 78% من المزارعين يعتمدون على أنفسهم وحوالي 22% يعتمدون على أكثر من مصدر للتمويل. التمويل الرسمي يصعب الحصول عليه وهو غير متاح خاصة في القرى ولا يتم الحصول عليه بالقدر الكافي وفي الوقت المناسب، لذلك يلجأ المزارع للبحث عن مصادر أخرى للتمويل. وتبين أن غالبية المزارعين (96%) يتلقون خدمة إرشادية.

بينت الدراسة (جدول 1) أن متوسط إنتاجية محصول القمح في مشروع الكفاءة الزراعي 3.3 طن/ فدان وفي مشروع الحصا الزراعي 0.855 طن/فدان أما في المشاريع الخصوصية الصغيرة فمتوسط إنتاجية القمح 0.776 طن/فدان. من نتائج تحليل الميزانية للقمح اتضح أن صافي الربح لفدان القمح 5144.82 جنيه/فدان في مشروع الكفاءة الزراعي بينما كان حوالي 814.82 جنيه/فدان في مشروع الحصا الزراعي في حين بلغ صافي الربح لمحصول القمح في المشاريع الخصوصية الصغيرة 691.12 جنيه/فدان ومن هنا يتضح الفارق الكبير بين متوسط إنتاجية الفدان من محصول القمح بين كل من مشروع الكفاءة الزراعي ومشروع الحصا الزراعي والمشاريع الخصوصية الصغيرة ويرجع هذا الاختلاف لاستخدام الكفاءة الزراعي لوسائل حديثة في العمليات الزراعية مثل الري المحوري والأسمدة والمبيدات بالكميات الكافية والاعتماد على الآلات الزراعية بدلاً عن المجهود البدني. ومن جدول (1) يتبين أن الفرق بين متوسطي إنتاجية القمح بين مشروع الحصا الزراعي والمشاريع الخصوصية الصغيرة ليس كبيراً ويرجع ذلك إلى أن الزراعة تقليدية في كليهما وتتبع الأساليب التقليدية في أداء العمليات الزراعي وتعتمد على المجهود البدني. وجدت الدراسة أن محصول القمح مربح وذلك بمتوسط سعر باب المزرعة وذلك اعتمادا على معامل الربحية حيث بلغ في مشروع الكفاءة الزراعي 1.53 وفي مشروع الحصا الزراعي 1.27 وفي المشاريع الخصوصية الصغيرة 1.22.

جدول (1): الميزانية المزرعية ومعامل الربحية لمحصول القمح

البيان	الكفاءة الزراعي	الحصا الزراعي	المشاريع الخصوصية الصغيرة
الانتاجية طن/فدان	3.3	0.855	0.776
سعر الطن	4500	4500	4500
جملة العائد ج/فدان	14850	3847.5	3880
جملة التكاليف (جنيه)	9705.18	3032.82	3188.88
صافي العائد ج/فدان	5144.82	814.82	691.12
معامل الربحية	1.53	1.27	1.22

المصدر: تم حسابه من بيانات المسح الميداني 2017/2016م

تم إجراء تحليل الانحدار للمزارعين في المشاريع الخصوصية الصغيرة وذلك لمحصول القمح لمعرفة أثر المتغيرات المختلفة على الإنتاجية للمحاصيل الثلاث وتم تطبيق دالة كوب دوجلاس في صورتها اللوغاريثمية وكانت نتائج تحليل الانحدار للنموذج ذات تأثير معنوي في تفسيرها للاختلافات في إنتاجية محصول القمح (جدول 2) وكانت النتائج على النحو الآتي:

جميع المتغيرات المستقلة التي تم إدخالها في التحليل وهي (عمر المزارع، المستوى التعليمي، عدد سنوات الخبرة، تكاليف الري، تكاليف البذور، تكاليف الأسمدة، تكاليف المبيدات) كانت ذات تأثير معنوي. وكان ذلك وفق المعادلة اللوغاريثمية:

$$\log Y=\log a+b_1\log X_1+b_2\log X_2+b_3\log X_3+b_4\log X_4+b_5\log X_5+b_6\log X_6+b_7\log X_7$$

حيث:

Y= إنتاجية محصول القمح (طن/فدان)، X_1= تكاليف الأسمدة (جنيه/فدان)، X_2= تكاليف المبيدات (جنيه/فدان)، X_3= تكاليف الري (جنيه/فدان)، X_4= كمية التقاوي (قنطار/فدان)، X_5= المستوى التعليمي (dummy variable)، X_6= عدد سنوات الخبرة (dummy variable)، X_7= عمر المزارع (بالسنوات) (dummy variable).

جدول (2): نتائج تحليل الانحدار لمحصول القمح في المشاريع الصغيرة.

المتغيرات	معامل الانحدار (b)	الخطأ القياسي ±	قيمة (ت)
تكاليف الأسمدة (جنيه/فدان)	0.005	0.002	2.287**
تكاليف المبيدات (جنيه/فدان)	0.007	0.001	5.174***
تكاليف الري (جنيه/فدان)	0.003	0.002	1.695*
تكاليف التقاوي (جنيه/فدان)	0.003	0.001	2.366**
المستوى التعليمي	0.371	0.130	2.851***
عدد سنوات الخبرة	0.051	0.029	1.748*
عمر المزارع	0.709	0.395	1.796*

R squire = 0.854

F-Statistics=35.041***

Significant at 1 %***

Significant at 5 %**

Significant at 10 % *

تم حساب الاحتياجات المائية في الموسم (Wr) م^3 بواسطة برنامج (Cropwat8) وهي تبين كمية المياه المثلى اللازمة لري فدان القمح ثم مقارنتها بكمية المياه المضافة فعليا بواسطة المزارعين (Wa) بالمتر المكعب ومن ثم حساب كفاءة استخدام المياه وفق المعادلة:

$$FWUE = Wr/Wa*100$$

فكانت في مشروع الكفاءة الزراعي 73.6% للقمح بينما كانت في مشروع الحصا والمشاريع الخصوصية الصغيرة نحو 61 % كما هو مبين في جدول (3).

جدول (3): مقارنة كفاءة استخدام المياه بين المشاريع موضع الدراسة

المشروع	الاحتياجات المائية في الموسم (Wr) م^3	كمية المياه المضافة فعليا في الموسم (Wa) م^3	كفاءة استخدام المياه (FWUE) (%)	فائض الري (%)
مشروع الكفاءة الزراعي	2353.68	3200	73.6	26.4
مشروع الحصا الزراعي	2353.68	3840	61.0	39.0
المشروعات الخصوصية الصغيرة	2353.68	3840	61.0	39.0

المصدر: تم حسابه من بيانات المسح الميداني 17/2016م.

التوصيات

اعتمادا على نتائج الدراسة وضعت التوصيات الآتية:

1- ضرورة استخدام وتطبيق الحزم التقنية فيما يتعلق بأساليب الري المستخدمة ومحاولة تبني أساليب الري الحديث والتي يمكن من خلالها توفير كميات كبيرة من المياه يمكن الاستفادة منها في زراعة مساحات جديدة، كما أنها توفر في كميات الأسمدة والمبيدات المستخدمة وتوفر في فواقد المساحات المزروعة الناتجة عن تقسيم الأرض الي أحواض وسراب.
2- محاولة توفير التمويل الرسمي بصورة ميسرة الفوائد والرهن والخروج من النمط التقليدي لأنواع الرهن وتوسيع جانب التمويل الأصغر تمشياً مع أهداف الدولة بالنهوض بالقطاع الزراعي، ليتمكن المزارعون من مقابلة احتياجاتهم من مدخلات الإنتاج كالتقاوي والأسمدة والمبيدات والوقود حتى لا يكون المزارع عرضة لمخاطر التمويل غير الرسمي.
3- تشجيع الاستثمار المحلي والأجنبي في المجال الزراعي وذلك بوضع القوانين المنظمة والميسرة، وتسهيل الإجراءات الخاصة بالاستثمار.
4- على الباحثين إجراء بحوث إضافية في إحلال أساليب الري التقليدي بالري الحديث.

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