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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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Preface

Agriculture is an important sector to Sudan economy. It seems that the gross domestic product and trade balance will relay on it in the coming years since mining activities are shrinking. In agriculture itself we are facing several challenges. Marginal cropping returns is diminishing due to high cost of energy and other production inputs. Quit a lot dynamics could make it more difficult to grow crops in a similar techniques as we have done in the past. Changes in climatic condition and the frequency and intensity of extreme weather could not only be the cause to have significant impacts on cropping environment. We have however, suffered in addition epidemics, national, regional and global conflicts that make production difficult to be continued. Consumer goods and food material prices were raised a ski high.

We have to follow several plans to minimize the risks of changes related to the structure of cropping pattern and the agricultural practices followed, by planting new varieties that are more resource-saving and more tolerant to adverse conditions expected to overrun.

It is necessary to continue developing new varieties of crops that are more adaptable to rising temperatures, and to choose the optimal date for planting to increase crop productivity and reduce negative effects. Then it is high time to rethink about what was valued during the green revolution time. We are in need to seek biological nitrogen fixation means rather than to seek high fertilizer demanding variety, more use of crop rotation techniques to avoid weed competition , pest and disease accumulation rather than to intensively use agricultural chemicals. In view of this changing some agricultural practices like optimal planting date, planting density and more other practice could be changed.

Editorials

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Effect of Different Potting Media on Growth and Flowering of Bougainvillea sp.

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Abstract

This study was conducted at the Ornamental Plants Nursery of the Department of Horticulture, Faculty of agriculture, University of Khartoum, Shambat, Sudan during 2015. The objective was to study the effect of mixing silty soil/SS (Revarian sediments) and field soil with compost and leaf mould (organic amendments) at different ratios on growth and flowering of bougainvillea (Bougainvillea sp.). Bougainvillea transplants were potted into polyethylene bags (40 cm diameter and 50 cm height) containing the following media as treatments: silty soil (SS) 100%, SS 75% + compost 25%, SS 50% + compost 50%, SS 75% + leaf mould 25%, SS 50% + leaf mould 50%, field soil 100%, field soil 75% + compost 25%, field soil 50% + compost 50%, field soil 75%+leaf mould 25%, field soil 50% + leaf mould 50%. Treatments were arranged in a randomized complete block design and replicated thrice. Three plants represented an experimental unit. Data were collected on plant height, number of branches per plant, number of leaves per plant, stem diameter, plant fresh and dry weights, and number of inflorescences per plant. Bougainvillea plant response towards organic amendments was higher in SS than in field soil. The treatment SS 75% + compost 25% resulted in highest plant height, stem diameter, plant fresh weight and plant dry weight. The highest number of branches/plant was recorded by the treatments SS 75% + leaf mould 25% and field soil 75% + leaf mould 25%. The treatment SS 50% + compost 50% resulted in highest number of leaves/plant and number of inflorescences/plant. The lowest values of all parameters was recorded by the treatment field soil 50% + leaf mould 50%. It can be concluded that 25% compost or leaf mould added to 75% field soil is a reasonable potting medium for bougainvillea.

Key Words: Bougainvillea sp., Potting media, Compost, Leaf mould, Growth, Flowering.

تأثير أوساط تعبئة مختلفة على نمو وإزهار نبات الجهنمية

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المستخلص

أجري هذا البحث في مشتل نباتات الزينة التابع لقسم البساتين – كلية الزراعة – جامعة الخرطوم في شمبات السنة 2015. كان الهدف إختبار تأثير خلط التربة السلتية (ت س) و تربة الحقل مع الكمبوست و الأوراق المتحللة (اضافات عضوية) بنسب مختلفه على نمو و إزهار نبات الجهنمية. زرعت شتلات الجهنمية في أكياس بلاستيك (40 سم قطر و 50 سم ارتفاع) محتوية على الأوساط التالية كمعاملات: ت س 100%، ت س 75% + كمبوست 25%، ت س 50% + كمبوست 50%، ت س 75%+ أوراق متحللة 25%، ت س 50% + أوراق متحلله 50%، تربة حقل 100%، تربة حقل 75% + كمبوست 25%، تربة حقل 50% + كمبوست 50%، تربة حقل 75% + أوراق متحلله 25%، تربة حقل 50% + أوراق متحلله 50%. رتبت المعاملات في تصميم قطاعات كاملة العشوائية بثلاث مكررات. مثلت الوحدة التجريبية بثلاثة نباتات.

جمعت بيانات حول ارتفاع النبات، عدد الأفرع بالنبات، عدد الأوراق بالنبات، سمك الساق، وزني االنبات الرطب والجاف وعدد النورات بالنبات. استجابة نبات الجهنمية للاضافات العضوية كانت أعلى في التربة السلتية (ت س) منها في تربة الحقل. المعاملة ت س 75% + كمبوست 25% سجلت أعلى قيم لارتفاع النبات، سمك الساق و وزني االنبات الرطب والجاف. المعاملتين ت س 75% + أوراق متحلله 25% و تربة حقل 75% + أوراق متحلله 25% نتج عنهما أعلى قيم لعدد الأفرع بالنبات. المعاملة ت س 50% + كمبوست 50% سجلت أعلى قيم لعدد الأوراق بالنبات و عدد النورات بالنبات. أدنى قيمة لكل المعايير سجلت بواسطة المعاملة تربة حقل 50%+ أوراق متحلله 50%. يمكن الختم بأن اضافة 25% كمبوست أو أوراق متحللة إلى 75% تربة حقل يعتبر وسط تعبئة مناسبا لنبات الجهنمية.

كلمات مفتاحية: الجهنمية، أوساط تعبئة، الكمبوست، أوراق متحللة، النمو، الإزهار.

Introduction

The genus bougainvillea has a wide variety of traits that made it excellent ornamental plant, a plant for environmental industries on account of large flexibility in different agro climatic regions of the world (Khandaker *et al,* 2015*;* Saifuddin *et al,* 2010*).* Bougainvillea has many uses as shrubs or bushes, ground cover, hedges, barriers, specimen plant (standards), in hanging baskets, in containers as potted flowering Plant and for bonsai (Kobayashi *et al,* 2007). Increasing awareness of environment-related issues, as well as the need to dispose of and use of rising amounts of waste along with the need to reduce the consumption of nonrenewable resources like peat have encouraged the use of composted organic biomass in agriculture. Growing media are the substrates in which a plant will grow. They greatly influence growth and development of plants in the nursery. They are an integral part of horticultural production systems. In nursery production industry, a variety of growing media are used worldwide.

Compost was reported to promote the physical and chemical properties of growing media. Maheswarappa *et al.* (1999) and Pandey and Shukla (2006) reported that the application of compost favorably affects soil pH, microbial population and soil enzyme activities. It improves soil structure, increase organic matter content, water holding capacity and reduces the frequency and rate of irrigation (Azores-Hampton *et al,* 1998; Mitchell and Edwards, 1997; Liang *et al,* 2005). Compost is a good source to provide both macro - and micronutrients for plant growth. Courtney and Mullen (2008) found that nutritional elements such as potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), iron (Fe),copper (Cu) and manganese (Mn) increased, when compost was applied. Compost increases plant tolerance to soil salinity. Liang *et al.* (2005) reported that application of organic compost to soil improves physical and chemical characteristics of the soil, enhance tolerance of crops to salt stress by increasing drainage and soil water retention. The use of compost can reduce environmental pollution. Stofella and Graetz, (2000) stated that compost application reduces the proportion of water-soluble chemical species, which cause possible environmental contamination. Applications of chemical fertilizers have harmful effects on soil flora, fauna, and enzymes. This ultimately leads to decrease their activity for maintaining the natural fertility of soil (Gupta *et al*. 2014). In order to use soil nutrients more efficiently and to overcome pollution hazards the application of organic matter is gaining acceptance among farming communities (Riyaz, *et. al*. 2015). Leaf mould is formed from decaying leaves and produces an invaluable soil conditioner. Good quality, well decomposed leaf mould can be used as seed-sowing compost, or mixed equally with coarse sand, garden compost and good quality soil for use as potting compost (Anonymous, 2014). The positive effects of using composted organic biomass with growing media on vegetative growth and flowering of plants have been recorded by many research workers (Gupta *et al*. 2014 in marigold; Riyaz, *et. al*. 2008 in *Zinnia elegans*; Riyaz, *et. al*. 2015 in *Gerbera jamesonii*; Khayyat, *et. al.* 2007 in *Epipremnum aureum* and Kiran *et. al*. in *Dahlia pinnata*). Research on potting media for bougainvillea had not been carried out in Sudan and hence there is immense need for reliable research data regarding this field of research. The objective of this experiment was to study the effect of mixing silty soil/SS (Revarian sediments) and field soil with compost and leaf mould at different ratios on growth and flowering of *Bougainvillea* sp.

MATERIALS AND METHODS

This study was conducted at the Ornamental Plants Nursery of the Department of Horticulture, Faculty of agriculture, University of Khartoum at Shambat, (latitude 15 40 N, longitude 30 32 E), 280 inches above sea level, Khartoum state, during the period May-November. 2015. The potting mixes were prepared from silty soil/SS (Revarian sediments), field soil, compost, leaf mould and their combinations. The compost was brought form Socorro for organic fertilizers, energy and environment services Co. LTD, Sudan. Leaf mould was prepared from partially decomposed mango leaves from the mango orchard of the Department of Horticulture. Rooted cuttings of *Bougainvillea* sp. about two months of age were used for this experiment. The media were potted in polyethylene bags with a dimension 40cm diameter and 50 cm height. The media were irrigated before transplanting the cuttings. After transplanting the bags were watered two times a week. A randomized complete block design was used; three plants represented an experimental unit, and each experimental unit was replicated three times. Statistical analysis was carried out using the SPSS program (version 20/ 2014); means were compared for significance by using Duncan's multiple range tests at 5% level of significance. Parameters measured were plant height, number of branches/plant, number of leaves/plant, stem diameter, plant fresh and dry weights and number of inflorescences/plant. Some properties (determined at the lab. of the Department of Soil and Environmental sciences, Faculty of Agriculture,University of Khartoum) of field soil are shown in table 1 and those of silty soil/SS (Revarian sediments), compost and leaf mould are shown in table 2. The ten treatments are shown in table 3.

Table 1: Field soil chemical and physical properties:

PH	ECe dS/m	Ca meq/l	Mg meq/l	Na meq/l	K meq/l	SAR	N %	P ppm	Sand %	Silt %	Clay %
7.5	1.9	1.8	3.7	14.4	0.75	9.0	0.09	10.0	17	20	63

Table 2: Some properties of Silty soil (SS), compost and leaf mould:

	PH	ECe dS/m	Ca meq/l	Mg meq/l	Na meq/l	K meq/l	SAR	N %	P ppm
Silty soil (SS)	7.8	1.1	2.1	5.8	1.8	0.26	1.0	0.04	6.0
Compost	6.7	2.4	17.0	21.0	84.6	105.0	19.0	0.30	34.0
Leaf mould	7.9	4.19	9.9	7.2	24.8	0.40	8.0	0.59	15.0

Table 3: Treatments:

Treatments	Composition
T_1	SS (100%)
T_2	SS 75% + compost 25%
T_3	SS 50% + compost 50%
T_4	SS 75% + leaf mould 25%
T_5	SS 50% + leaf mould 50%
T_6	Field Soil (100%)
T_7	Field Soil 75% + compost 25%
T_8	Field Soil 50% + compost 50%
T_9	Field Soil 75% + leaf mould 25%
T_{10}	Field Soil 50% + leaf mould 50%

RESULTS AND DISCUSSION

Growth medium is known to have a large effect on value of potted ornamental plants (Vendrame *et al.,* 2005). Both physical and chemical characteristics of the growth medium exert substantial effect on growth of plants. Among the physical characteristics, aeration and water holding capacity are probably the most important factors while, among the chemical characteristics, nutritional status, and salinity level have a crucial role on plant development (Dewayne *et al*., 2003).

Plant height: As shown in table 3, the treatments T2 (SS 75% + compost 25%), T3 (SS 50% + compost 50%) and T4 (SS 75% + leaf mould 25%) resulted in significantly higher plant height than T1 (SS 100%) with no significant differences between them. Although the difference between them was not significant, T5 (SS 50% + leaf mould 50%) also recorded higher value of plant height than T1 (SS 100%). The difference in plant height between T6 (Field soil 100%), T7 (Field soil 75% + compost 25%) and T8 (Field soil 50% + compost 50%) was not significant. The medium SS 75%+compost 25% recorded the highest value of plant height while the lowest value of plant height was recorded by T10 (Field soil 50% + leaf mould 50%). Several research workers observed increase in plant height using different organic amendments with potting media in different plants (Treder, 2008 in oriental lily 'star gazer'; Riaz *et al.*, 2015 in gerbera; Mehmood *et al.,* 2013 in *Antirrhinum majus* and Bashir *et al.,* 2007 in jojoba).

Number of branches/Plant: As shown in table 3, T4 (SS 75% + leaf mould 25%) and T9 (Field Soil 75% + leaf mould 25%) resulted in higher values compared to the rest of the treatments with significant difference from only T1 (SS 100%) and T7 (Field soil 75% + compost 25%). These findings confirmed those of Bashir *et al.* (2007) who noted maximum number of shoots of *Sinmondsia chinensis* in Leaf mould-containing medium . Similar findings were also reported by Riaz *et al.*, 2008 in *Zinnia elegans* cv. Blue Point having much increased side branches in coconut compost growing media in combination with silt + leaf manure.

Number of leaves/Plant: Table 3 demonstrates that all treatments of SS amendment with compost or leaf mould (T2, T3, T4, T5) differed non significantly with T1 (SS 100%) in terms of number of leaves per plant. However, all of them gave higher number of leaves per plant than T1 (silt 100%). This result is in agreement with that of Riyaz, *et. al*. (2008) in *Zinnia elegans* where SS amended with leaf manure and coconut compost differed non significantly with SS in terms of number of leaves per plant. The treatments of field soil T6 (field soil 100%) and field soil amended with compost or leaf mould (T7, T8, T9) differed non significantly among themselves with regard to number of leaves per plant. However, all of them differed significantly from T10 (field soil 50% + leaf mould 50%) which recorded the lowest value of leaves per plant. Such results might be attributed to natural fertility of field soil (table 3) and influence of environmental conditions on number of leaves (Riyaz, *et. al*. 2015).

Stem diameter: Plants exhibiting thick stem have more mechanical strength to resist breaking and bending against stress environmental conditions. Table 3 demonstrates that all treatments of SS amendment with compost or leaf mould (T2, T3, T4) except T5 (SS 50% + leaf mould 50%) resulted in significantly higher values of stem diameter than T1 (SS 100%) with no significant differences between them. In case of treatments of field soil amendment with compost or leaf mould only T7 and T8 resulted in significantly higher values of stem diameter than T6 (Field Soil 100%). This result is in agreement with that of Kiran *et al.* (2007) who observed thickest stem of dahlia (*Dahlia pinnata*) in sand + silt + leaf mould medium and Mehmood *et al.* (2013) who observed thickest stem in *Antirrhinum majus* using silt and top soil mixed with leaf mould or peat moss.

Plant fresh weight: As shown in table 4, all treatments of silt amendment with compost or leaf mould (T2, T3, T4) except T5 (SS 50% + leaf mould 50%) resulted in significantly higher fresh weight than T1 (SS 100%) with no significant differences between them. With regard to field soil amendment with compost or leaf mould all treatments except T8 (Field Soil 50% + compost 50%) differed non significantly among themselves. T8 resulted in significantly higher fresh weight than T9 (Field Soil 75% + leaf mould 25%) and T10 (Field Soil 50% + leaf mould 50%).

Plant dry weight: Table 4 demonstrated significant differences among treatments. All treatments of SS amendment with compost or leaf mould (T2, T3, T4) except T5 (SS 50% + leaf mould 50%) resulted in significantly higher dry weight than T1 (SS 100%) with no significant differences between them. Regarding field soil amendment with compost or leaf mould all treatments except T10 (Field Soil 50% + leaf mould 50%) which recorded the lowest dry weight, differed non significantly from T6 (Field Soil 100%). Increase of plant fresh and weights using organic amendments with potting media was reported by several research workers. Wang and Konow (1999) observed highest increase in fresh weight of Moth Orchid in peat comprising medium than any other media. Mehmood *et al.* (2013) observed highest fresh and dry weights in *Antirrhinum majus* using leaf mould and peat moss amendments. Similar results were observed for *Epipremum aureum* by Khayyat (2007).

Number of inflorescences/plant: As shown in table 5 all treatments of SS amendment with compost or leaf mould resulted in significantly higher number of inflorescences/plant than T1 (SS 100%). Similar results were reported by Riyaz, *et. al*. (2015) who found highest number of flowers in gerbera in a medium of silt + compost. Regarding field soil amendment with compost or leaf mould all treatments except T10 (Field Soil 50% + leaf mould 50%) which recorded the lowest number of inflorescences/plant, differed non significantly from T6 (Field Soil 100%). Such results might be attributed to natural fertility of field soil (table 3). Nowak and Strojny (2004) observed that optimum amount of P in organic residues provide maximum increase in flowering of gerbera. Treder (2008) reported that oriental lily 'star gazer' plants had long stem, and maximum flowering in growing media with optimum P and K contents. It is worth mentioning that the compost used in this research was rich in P and K (table 1). The low values of most parameters (Tables 3, 4, 5) recorded by T1 (SS 100%) might be due to its high pH (table 1). Proper soil pH is essential because it affects the availability of mineral elements. Bougainvillea does best with a slightly acidic soil having a pH of 5.5-6.0 (Kobayashi *et a*l, 2007). High percentage of leaf mould in the medium especially with field soil in T10 (Field Soil 50% + leaf mould 50%) resulted in lowest values of most parameters (Tables 3, 4, 5). This might be due to increase in water retention with increase in leaf mould content in the medium. To some extent the same applies for the treatment (SS 50% + leaf mould 50%) which resulted in relatively lower values of most parameters among the treatments of SS amendment with compost or leaf mould. Bougainvillea is characterized by an extremely fine root system, and should be planted in well-drained soils. Soil mixes with high peat levels and water retention should be avoided (Kobayashi *et a*l, 2007). Substrates having higher EC affect plant growth (Miller, 2001). High salinity (EC) in leaf mould (table 1) might also be a reason of lower values obtained.

Conclusion: Since organic amendments and SS are to some extent expensive, it can be stated that 25% compost or leaf mould added to 75% field soil is a reasonable potting medium for bougainvillea.

Table 3. Effect of different potting media on growth parameters of bougainvillea (*Bougainvillea* sp.) twenty four weeks after transplanting.

Potting media	Plant height (cm)	Number of branches/plant	Number of leaves per plant	Stem diameter (mm)
T1 (SS 100%)	56.4^{de}	6.4^{b}	239^{a}	7.3^{cd}
T2 (SS 75% + compost 25%)	101.8^{a}	9.9^{ab}	327^{a}	9.9^{a}
T3 (SS 50% + compost 50%)	87.3^{abc}	10.8^{ab}	385.9^{a}	9.9^{a}
T4 (SS 75% + leaf mould 25%)	95.2^{ab}	15.2^{a}	364.9^{a}	9.5^{ab}
T5 (SS 50% + leaf mould 50%)	67.9^{bcd}	9.7^{ab}	285.1^{a}	7.9^{bc}
T6 (Field soil 100%)	84.8^{abcd}	9.4^{ab}	277.6^{a}	8^{bc}
T7 (Field soil 75% + compost 25%)	74.9^{abcd}	6.7^{b}	243^{a}	9.5^{ab}
T8 (Field soil 50% + compost 50%)	91.3^{ab}	8.4^{ab}	268.1^{a}	9.6^{ab}
T9 (Field soil 75% + leaf mould 25%)	58.9^{cde}	15.3^{a}	364.8^{a}	7.2^{cd}
T10 (Field soil 50% + leaf mould 50%)	34^{e}	10.3^{ab}	101.8^{b}	5.6^{d}

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

Table 4. Effect of different potting media on growth parameters (Plant fresh and dry weights) of bougainvillea (*Bougainvillea* sp.) twenty four weeks after transplanting.

Potting media	Plant fresh weight (gm)	Plant dry weight (gm)
T1 (SS 100%)	53.5[c]	25.5[cd]
T2 (SS 75% + compost 25%)	146.6[a]	60.4[ab]
T3 (SS 50% + compost 50%)	135.7[a]	63.6[a]
T4 (SS 75% + leaf mould 25%)	118[ab]	58.6[ab]
T5 (SS 50% + leaf mould 50%)	84.2[abc]	35.6[bcd]
T6 (Field soil 100%)	83.3[abc]	41.9[abc]
T7 (Field soil 75% + compost 25%)	93.2[abc]	38.4[bcd]
T8 (Field soil 50% + compost 50%)	125.3[a]	58.7[ab]
T9 (Field soil 75% + leaf mould 25%)	62.2[bc]	26.6[cd]
T10 (Field soil 50% + leaf mould 50%)	32.7[c]	15.1[d]

Means followed by the same letter “s” in the same column are not significantly different (P = 0.05) according to Duncan’s Multiple Range Test.

Table 5. Effect of different potting media on number of inflorescences/plant of bougainvillea (*Bougainvillea* sp.) twenty weeks after transplanting.

potting media	Number of inflorescences/plant
T1 (SS 100%)	86[d]
T2 (SS 75% + compost 25%)	154.3[bc]
T3 (SS 50% + compost 50%)	234[a]
T4 (SS 75% + leaf mould 25%)	198.3[ab]
T5 (SS 50% + leaf mould 50%)	152.7[bc]
T6 (Field Soil 100%)	126.1[cd]
T7 (Field Soil 75% + compost 25%)	177.4[abc]
T8 (Field Soil 50% + compost 50%)	173.9[abc]
T9 (Field Soil 75% + leaf mould 25%)	80.9[de]
T10 (Field Soil 50% + leaf mould 50%)	19.6[e]

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

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Evaluating Water-stress as Flowering and Fruiting Stimulus to Sweet Orange (*Citrus sinensis*. L) in Tropical Conditions

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Abstract

This study aimed to find out the optimum water stress period to induce rest as stimulus after which irrigation should be resumed to obtain flowering and best fruit yield for sweet orange. The experiment was conducted at Kitayab, AlRaw and Central Zeidab Schemes in River Nile State, Sudan during 2014/15 and 2015/16 seasons. Mature orange trees (local Sinnari cultivar) grafted on sour orange root stock from farms where basin irrigation and different irrigation stopping periods after harvest were practiced. Nine trees spaced at 7×7 m. and with at least 10 years' age, were randomly selected for experimentation in four sites. The soil at the experimental sites is mostly homogenous representing Nile fluvent sediments of entisols with loamy to clay loam texture. The experimental design was randomized complete block design (RCBD) with three replicates. The periods for irrigation stress after harvest and before the new flowering season were 2, 3, 4, 5, 6, 7, 8 and 9 weeks. All intervals ending at the onset of winter season. Parameters taken were: time of flowering, number of flowers/ squire meter, number of fruits/tree, number of dry branches/tree, difference in maturity/tree as percentage of mature fruits over others. Results obtained indicated that early flowering noticed after 9 weeks of irrigation stress compared to short periods. Number of flowers per a square meter increased in both seasons by increasing irrigation-stress period. Irrigation stress period affected significantly number of fruits per tree in both seasons, but not following the same trend of number of flowers per square meter. In both seasons, the highest number of fruits was registered by 3-week dry period treatment. Increasing irrigation-stress period increased dry branches per tree and differences in fruit maturity.

Keywords: Sweet orange, flowering stimulus, water stress period, tropical conditions

تقييم الاجهاد المائي كمحث لإزهار واثمار البرتقال في ظروف المناطق المدارية

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المستخلص
هدفت هذه الدراسة لإيجاد الفترة المناسبة لا يقاف الري والتي يمكن بعدها ان تزهر شجرة البرتقال لإعطاء انتاجية جيدة من الثمار. استخدم الصنف سناري من البرتقال المطعوم على اللارنج في موسمي 15/2014 و 16/2015 بمناطق مشاريع الكتياب ووسط الزيداب والراو بولاية نهر النيل. يستخدم المزارعين الري الغمري بالحياض مع فترة تعطيش قبل موسم الازهار. تم اختيار تسعة من الاشجار المسافة بينها 7X7 متر بعمر عشرة اعوام في الأقل بكل من المناطق الاربع في تربة متجانسة تمثل الطمي و طمي الطين النيلي. استخدم تصميم المربعات كاملة العشوائية لثلاثة مكررات لتنفيذ التجربة. فترة التعطيش بعد الحصاد وقبل بداية موسم الازهار الشتوي كانت 2، 3، 4، 5، 6، 7، 8 و9 اسابيع لتنتهي كلها مع دخول الموسم الشتوي. القراءات المأخوذة تمثلت في الفترة حتى الإزهار، عدد الأزهار في المتر المربع، عدد الثمار في الشجرة، عدد الافرع الجافة في الشجرة، الفروق النسبية في نضج الثمار. أوضحت النتائج ان الإزهار الابكر نتج عن فترة التسعة اسابيع من ايقاف الري مقارنة مع الفترات القصيرة. عدد الأزهار في الموسمين زاد بزيادة فترة الاجهاد المائي و اثرت هذه الفترة معنويا على عدد الثمار في الشجرة في كلا الموسمين، ولكن لم تكن مماثلة لنمط التزهير في المتر المربع. أعلى انتاجية للثمار نتجت عن فترة الاجهاد المائي (التعطيش) لثلاثة اسابيع، كما نتج عن فترات الاجهاد المائي الطويلة زيادة في عدد الأفرع الجافة بالشجرة وزيادة في الفروق بنسبة نضج الثمار.
كلمات مفتاحية: البرتقال، محثات الإزهار، الاجهاد المائي ، البيئات المدارية.

Introduction

Sweet orange (*Citrus sinensis*) is the most important trading species of family *Rutaceae* and the genus Citrus. Most of citruses grow in the world between latitudes 20- 40 north and south where flowering is controlled by seasonal change in temperature degrees. The total world production is about 51.8 million metric tons (USDA, 2019). Citrus is very important for human health, rich in ascorbic acid and other antioxidants such as carotenoids and phenolic compound. It has may nutritional and medicinal benefits (Yarkwan and Oketunde, 2016).

Sweet orange (*Citrus sinensis*) is a perennial tree crop that displays a very strange reproductive behavior. Regulation of fruit bearing in citrus is of complicated nature depending upon many internal and external factors that may interact or act individually. The mechanisms whereby endogenous and environmental stimuli affect reproductive growth are fully discussed by researchers to provide knowledge that allow optimizing flowering and fruit set (Banuet, 2001; Zhang *et al*., 2018).

Citrus species usually exhibit tremendous flowering over season. This floral behavior depends on the cultivar, tree age, environmental conditions, nutritional status and crop management practices (Monselise, 1986; Iglesias *et al*., 2007). Sweet orange (*Citrus sinensis*) may develop 250,000 flowers per tree in a bloom season although only a small amount of these flowers (usually less than 1%) becomes mature fruit (Erickson and Brannaman, 1960; Goldschmidt and Huberman, 1974). Thus, flowering behavior for citrus trees represents, as described by some researchers, as a waste of resources. However, this reproductive pattern may be linked to a survival strategy (Bustan *et al*., 1995; Bustan and Goldschmidt, 1998).

Citrus trees require a reasonable water management and a balanced nutrition to provide good yield in quality and quantity. Sufficiently irrigated and served trees grow stronger, with adequate tolerance to stresses, consequently giving more yield with good quality fruits. On the other hand, deficiency levels of these important production inputs will result in low fruit yield with poor quality.

In subtropical regions, where citruses are usually grown, flowering occurs during the spring flush along with the vegetative sprouting. Under such environments, flowering takes place after a period of bud dormancy and on exposure to low temperatures and short days of winter after which flower bud induction is stimulated in a time dependent manner. In tropical environment, as in Sudan, these conditions prior to flowering are not as ideal as in subtropical regions, citrus flowers in response to re-hydration after a period of water deficit rather than with low temperature stimuli (Banuet, 2001; Iglesias *et al*., 2011).

The need for water stress induced rest period to encourage flowering is anticipated, but its magnitude (in terms of a drought stress index or period) does not have been identified accurately.

Irrigation depend on type of soil, climatic condition and tree age and for bearing trees irrigation should continue in systemic way. Continuous irrigation helps in absorption of nutrients and decrease the flowers drops. Irrigation is an important factor determining yield and flowering in citrus, water stress impose different yield losses depending on the time that plant subjected to water stress (Ginestar and Castel, 1996; Pérez-Pérez *et al*., 2008; Hutton and Loveys, 2011). Water stress application depends mainly on the crop nature, and the different effects caused by it in different growth stages. Critical growth stages, in which water should not be reduced have to be considered (Chalmers *et al*., 1986). Moderate levels of stress can result in an inadequate flowering response. On the other hand, severe water stress involves negative effects, such as excessive leaf senescence, twig drying, root system damage and high percentages of flower abortion (Torrisi, 1952; Crescimanno, 1959). The correct amount of drought stress necessary to induce flowering is important, since excessive stress can be harmful. Some reports indicate that 64% of the flowers aborted after excessive drought stress, compared with only 20% after a moderate drought. Excessive drought stress also harms the development of fruits already on the trees and will reduce substantially regular yield (Levy, 1998).

The objectives of this study are to determine the effect of length of different periods of water stress to induce rest period as stimulus to citrus flowering with special emphasis on finding out the optimum stress period at which irrigation should be resumed to obtain best fruit yield.

Materials and Methods

The experiment was conducted at citrus growing areas in River Nile State (Kitayab, AlRaw and Central Zeidab Schems) during 2014/15 and 2015/16 seasons where citrus is considered as the main cash crop. Farmers used basin irrigation and practice different irrigation stopping periods after harvest thinking this practice will result in intense flowering and consequently high yield. The area is characterized by arid climate where potential evapotranspiration is very high (1806 mm meaning a water deficit by subtracting annual rainfall mainly during August of more than 1700 mm). Mean maximum and minimum temperatures in the hottest month (June) are 48-28 C^o, while the mean maximum and minimum during the coolest month (January) are 31 and 8 C^o.

Eight farms with mature orange trees (*Citrus sinensis* L. Local Sinnari cultivar) grafted on sour orange (*Citrus aurantium*, L.) root stock that use different irrigation stress periods was selected. Nine trees from each farm were randomly selected and tagged for further readings. The selected trees with at least 10 years' age, spaced at 7×7 m. The soil at the experimental sites is mostly homogenous representing Nile fluvent sediments of entisols with loamy to clay loam texture and water characteristics of 33-34% vol. as field capacity and 19-20% vol. as permanent wilting point and matric and osmotic potential of 14-15 bar. The experimental design was randomized complete block design (RCBD) with three replicates. The period for irrigation stress after harvesting and before the new flowering season was 2, 3, 4, 5, 6, 7, 8 and 9 weeks. All intervals ending at 30th of October to 15th November and the flowing parameters taken were:

1- Time of flowering.
2- Number of flowers/ squire meter (counted by naked eye).
3- Number of fruits/tree (counted at beginning of phase II, onset of fourth month).
4- Number of dry branches/tree.
5- Difference in maturity/tree as percentage of mature fruits over others counted at phase III based on fruit shape and colour.
6- Statistical analysis applied by using MSTT-C computer software

Results and Discussion

Results showed that time of flowering was affected by irrigation stress period and as this period increased, early flowering occurs. Early flowering noticed after 9 weeks of irrigation stress and late flowering noticed after 2 weeks' period (Table 1). Number of flowers per square meter was significantly affected by irrigation stress period and as this period increased, number of flowers per square meter increased in both seasons. Combined analysis showed that the highest number of flowers (67.4) resulted from 9 weeks 'dry period and the least number (49.1) resulted from 2 weeks' period (Table 2). Interaction between number of flowers and site was not significant.

Table 1: Effect of irrigation stress period on time of flowering of Sweet orange in River Nile State, season 2014/ 15 and 2015/ 16.

Irrigation stress period	Time of flowering
2 week	1st w Feb
3 weeks	1st w Feb
4 weeks	2th w Jan
5 weeks	4th w Dec
6 weeks	2th w Dec
7 weeks	1th w Dec
8 weeks	4th w Nov
9 weeks	4th w Nov

Table 2: Effect of irrigation stress period on number of flowers per square meter in Sweet orange in River Nile State, season 2014/ 15 and 2015/ 16.

Irrigation stress period	Flowers No. per square meter								
	Season 2014/2015				Season 2015/2016				
	Area1	Area2	Area3	Mean	Area1	Area2	Area3	Mean	Combine
2weeks	50.0	55.2	57.3	54.2	44.7	50.2	37.3	44.1	49.1
3weeks	50.0	47.4	48.9	43.2	56.2	56.8	48.0	53.6	51.2
4weeks	55.5	54.4	51.0	53.7	53.3	39.0	44.2	45.6	49.6
5weeks	50.3	52.5	44.2	49.0	63.7	56.1	48.0	53.5	51.3
6weeks	55.4	59.8	56.7	57.3	72.4	58.4	56.7	62.5	59.9
7weeks	63.4	61.0	63.4	62.5	78.3	71.2	62.7	70.6	66.6
8weeks	63.4	56.7	67.2	62.4	76.1	65.7	70.2	70.7	66.5
9weeks	61.8	70.3	69.3	67.2	89.0	72.3	71.7	67.7	67.4
Mean					62.9	58.7	53.9		
CV %				33.4					26.9
SE ±				6.4ns					4.0**
Interaction				11.4ns					6.3**

Number of fruits per tree was significantly affected by irrigation stress period in both seasons (Table 3) but not following the same trend of number of flowers per square meter. In both seasons the highest number of fruits was registered by 3-week dry period treatment (1683.5 and 1711.7 fruits per tree in the first and second season, respectively) and the least number was registered by the longest dry period (945.1 and 972.2 7 fruit per tree, respectively). This may be due to the fact that although long dry period stimulates abundant flowering, it may in the same manner adverse fruit set that means not all flowers set fruits. Interaction between number of fruit per tree and the area was not significant. Results obtained were in line with statement of Bustan *et al*. (1995) and Bustan and Goldschmidt (1998) when discussing intense flowering as a survival strategy following stress period so that citrus bloom abundantly and then also show high abscission of buds, flowers, fruitlets and fruits.

Table 3: Effect of irrigation stress period on number of fruits per tree on Sweet orange in River Nile State, seasons 2014/ 15 and 2015/ 16.

Irrigation stress period	Fruits No. per tree								
	Season 2014/ 15				Season 2015/ 16				
	Area 1	Area 2	Area 3	Mean	Area 1	Area 2	Area 3	Mean	Combined
2weeks	1546.8	1725.3	1086.0	1492.7	1518.2	1735.4	984.8	1412.0	1427.8
3weeks	1428.5	1266.2	959.9	1683.5	1423.4	2662.2	1049.6	1711.7	1697.6
4weeks	1389.0	1966.3	1103.2	1486.2	1330.2	1863.4	919.6	1371.1	1428.6
5weeks	1311.4	1170.7	998.1	1493.4	1378.8	1663.9	1003.2	1348.6	1218.7
6weeks	1363.6	1486.1	788.9	1212.9	1407.8	1419.4	846.1	1224.4	1145.7
7weeks	1064.1	1504.1	807.1	1125.1	1252.4	1504.1	742.5	1166.3	103.8.7
8weeks	985.4	1306.3	792.1	1027.9	1160.0	1232.0	756.6	1049.5	958.6
9weeks	1018.1	1031.4	785.7	945.1	1133.6	1100.9	682.2	972.2	
Area mean	1259.6	1731.6	915.1		1325.6	1647.7	873.0		
CV %				21.7				22.6	24.8
SE ±				44.3**				76.6**	45.1**
Interaction				57.7n.s				167.2sig	127.6ns

In this table and the flowing ones, ns = not significant and ** highly significant, sig = significant

As stated by Banuet (2001) and Malik *et al*. (2015) flower bud induction after the rest period has been extensively studied in various plants, and it is well known that several internal and external factors (e.g., day-length, temperature conditions, water stress, nutritional and internal carbohydrate level) play important role in controlling bud break. Majority of studies on bud break in citrus are related to flowering and are thoroughly discussed in various review articles. It is clear then, in tropical condition of Sudan, prolonged dry period induced rest period which can enhance abundant flowering upon rehydration but may not enhance flowers to set fruits. Many factors control fruit set, among them environmental condition and tree nutritional status are the most important. Despite abundant flowering, carbohydrate supply for the flower or fruit load may be some times insufficient and environmental conditions may become too adverse for normal fruit set to the majority of the tree bloom.

Result also indicated that number of dry branches per tree and differences in fruit maturity per tree were significantly affected by irrigation stress period. They were increased with increasing irrigation stress period and vise verse. More dry branches per tree resulted from 9 weeks' period (7.3) and the least number (1.0) resulted from 2 weeks' period (Table 4). Similarly, differences in fruit maturity follow the same trend, more percentage of early maturing fruits (10.3) resulted from 9 weeks' period and the least percentage resulted from 2 weeks' period (0.0) (Table 5). The interaction between area and maturity differences and area and dry branches was not significant in both seasons.

Table 4: Effect of irrigation stress period on number of dry branches per tree in Sweet orange in River Nile State, season 2014/ 15 and 2015/ 16.

Irrigation stress period	Dry branches per tree								
	Season 2014/ 15				Season 2015/ 16				
	Area 1	Area 2	Area 3	Mean	Area 1	Area 2	Area 3	Mean	Combined
2weeks	2.0	1.7	0.3	1.7	1.0	1.7	0.3	1.0	1.2
3weeks	2.3	2.7	2.0	2.3	1.0	1.0	0.0	1.7	2.0
4weeks	2.7	3.7	3.4	3.3	1.3	2.7	4.0	2.7	2.9
5weeks	4.1	3.9	4.7	4.2	4.1	3.7	6.1	4.6	4.4
6weeks	5.5	4.7	3.7	4.8	5.2	4.7	5.3	5.1	4.9
7weeks	6.7	5.7	4.2	5.5	6.0	5.6	5.3	5.7	5.6
8weeks	8.2	6.8	7.1	7.3	6.9	6.4	7.8	7.0	7.2
9weeks	8.7	8.3	7.9	8.3	7.5	7.1	7.4	7.3	7.8
Mean	5.0	4.7	4.2		4.1	4.3	4.7		
CV %				25.5				30.7	
SE ±				0.39**				0.57**	
Interaction				0.07ns				0.98n.s	

Table 5: Effect of irrigation stress period on percentage of fruit maturity differences per tree in Sweet orange in River Nile State, season 2014/ 15 and 2015/ 16.

Irrigation stress period	Percentage of fruit maturity differences per tree								
	Season 2014/ 15				Season 2015/ 16				
	Area 1	Area 2	Area 3	Mean	Area 1	Area 2	Area 3	Mean	Combine
2weeks	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3weeks	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4weeks	0.4	0.0	0.007	0.124	0.0	0.02	0.7	0.22	0.2
5weeks	1.4	0.3	5.33	2.4	3.7	1.2	0.4	1.7	2.1
6weeks	5.5	5.9	9.0	6.8	9.0	7.4	6.0	7.4	7.1
7weeks	7.6	8.9	9.3	8.6	6.2	8.3	8.0	8.7	8.7
8weeks	8.0	10.03	9.33	9.13	9.1	10.3	9.0	9.4	9.3
9weeks	9.5	11.33	9.7	10.2	9.3	10.5	10.2	10.13	10.3
CV %				39.9				36.9	34.1
SE ±				618**				0.58**	0.45**
Interaction				14ns				1.006ns	0.65ns

Conclusion

For citrus in tropical conditions, long water stress period may enhance abundant flowering but may not lead to good yield and may induce more twig and branch dryness.

Homogeneity in soil types didn't reflect any difference in results in this study, but different soil types may need different water stress periods, Accuracy in dry period to stimulate flowering without harming the tree or its yield need more research work.

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Evaluation of Six Tomato (*Solanum lycopersicum* Mill.) Hybrids Under Cooled Plastic Tunnel Conditions in the Sudan

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Abstract

The experiment was conducted during the summer seasons of the three years; 2012, 2013 and 2014 (April to August) consecutively at Shambat Research Station, under cool plastic tunnel (dome shape). The objective was to evaluate the performance of six tomato hybrids for growth, yield and quality under cooled plastic tunnel conditions. The six tomato hybrids were namely: (SAKER, BARAKA, NIELLY, T.GLORY, DRW6799 and ATHYLA). Randomized complete block design (RCBD) replicated three times was used. Data collection comprised plant growth, yield and fruit quality. The individual and combined ANOVA were performed. statistical analysis showed that there was significant difference among the six hybrids for all of studied characters.The results indicated that the hybrids "T. Glory, ATHYlLA and BARAKA" gave the best yield and fruit quality showing vigorous plant growth with huge canopy, the fruits were round to round-oblate in shape, large size, with attractive red colour, good firmness and long shelf life. The hybrids: T. Glory, ATHYLA and BARAKA could be recommended to be cultivated commercially under cool plastic tunnels conditions in the Sudan.

Keywords: Tomato (*Solanum lycopersicum* Mill.), Hybrids, Cool plastic tunnel, Growth, Yield, Quality

تقييم ستة هجن من الطماطم تحت ظروف الأنفاق البلاستيكية المبردة في السودان

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هيئة البحوث الزراعية، مركز المحاصيل البستانية

المستخلص

أجريت التجربة بمحطة بحوث شمبات – هيئة البحوث الزراعية، السودان بهدف تقييم ستة أصناف هجن من الطماطم تحت ظروف الأنفاق البلاستيكية المبردة خلال فصل الصيف (أبريل – اغسطس) لثلاثة مواسم متتالية للسنوات 2012، 2013 و 2014. أصناف الهجن هي صخر، بركة، نيللي، تي قلوري، دراو6799 و أثيلة. تم إستخدام تصميم القطاعات الكاملة العشوائية بثلاث مكررات. أشتمل التقييم علي صفات النمو والنوعية و الإنتاجية. أظهرت نتائج التحليل الإحصائى المنفرد والتجميعي وجود فروقات معنوية بين أصناف الهجن في كل الصفات التي تمت دراستها، كما أظهرت النتائج أن الأصناف الثلاثة تي - قلوري، أثيلة و بركة هي الأفضل من ناحية النمو، الأنتاجية و النوعية، بناءً علي ذلك فان أصناف الهجن الثلاثة تي- قلوري، أثيلة و بركة يمكن التوصية بزراعتها تجارياً تحت ظروف الإنتاج المحمي في الأنفاق البلاستيكية المبردة في السودان.

كلمات مفتاحية: الطماطم، هجن، بيوت بلاستيكية مبردة، النمو، الإنتاجية، النوعية.

Introduction

Vegetable production in the Sudan is developing into a commercial enterprise favoured by such factors like the increasing consumption of vegetables and their products, the increasing economical returns from the activity, the development of several agro-industries and the newly opened export markets for Sudanese vegetables.

Tomato (*Solanum lycopersicum* L.) belongs to the family *Solanaceae*, is believed to be originated in South America where it grows as a perennial crop. It is one of most popular vegetables. Due to its high value as a crop it is distributed throughout the world in large areas with an average production of 146 million metric tons (Taylor and Locascio, 2004; Heuvelink, 2005; FAO, 2010 and FAOSTAT, 2012).

Tomato is considered one of the most important vegetables in Sudan. It currently occupies about 28% of the total area of vegetables grown in Sudan (Ahmed, 2009) with about 950 thousand tons per year. It is an important source of vitamin A. It's considered an anti oxidant, an active compound in the prevention of cancer, cardiovascular risk and in slowing down cellular aging, in addition to vitamins B and C (Gerster, 1997; Di Cesare *et al*., 2012; and Abdel- Monaim, 2012).

Tomato is grown in Sudan in almost all parts of the country during the winter months and rainy season in a wide range of soil conditions. The major production areas are located in Gezira, Sinnar, Blue Nile, White Nile, Khartoum, Northern and Nile States under irrigation from the Nile and under rain fed in Southern Blue and White Nile. (Ahmed, 2009; HAAR, 2010). Tomato yield is very low during summer months (March – June) because of the high temperature, low relative humidity and severe infection by pests and diseases such as Tomato Yellow Leaf Curl Virus (TYLCV) (Omara, 2001). High temperature is considered a major environmental factor that limits tomato production during summer. It adversely affects vegetative growth, flowering and development of tomato plants (Sato *et al.*, 2001, Wahid and Shabbir 2007). Also drying of stigmatic surface leads to reduction in stigma receptivity and tomatoes productivity is decreased (Ansary, 2006 and Elsharief *et. al.*, 2011). The fruit size, ripening and fruit colour formation are also affected (Mulholland *et al.,* 2003) compared to fruits which matured under optimum temperature conditions. (Abdalla and Verkerk 1970; Hanna and Hernandez, 1982; Ahmed 2009).

Cool plastic tunnel production is a very dynamic economic sector that cope with rapid changes in market trends and consumer preferences. Consequently, choosing the right hybrid for cool plastic tunnel production is essential for the production process (Tuzel and Leonardi 2009).

Vegetables production in cool plastic tunnel has traditionally been located near urban centers. Khartoum State has become an ideal area for future development of this industry, particularly during the summer months when prices of most vegetables particularly tomato are very high.

The tomato hybrids for protected production are indeterminate and require constant maintenance and physical support of the plants for long term fruit production. Indeterminate tomato varieties will need additional nitrogen to continue to grow and produce fruits compared to determinate tomato varieties (Farrer, 2011).

Choosing which hybrid varieties to grow is crucial for successful tomato production under cool plastic tunnels conditions. Up to date, no tomato hybrids have been released for commercial production under cooled plastic tunnels in the Sudan though it is a prerequisite, becoming very important and needs further research and development.

The study aims to evaluating the performance of different tomato hybrid varieties for high productivity and quality under cool plastic tunnels with ultimate goal and identify the suitable one (s) for commercial release under cool plastic tunnels in the Sudan.

Materials and Methods

The experiment was conducted during the summer seasons of the three years: 2012, 2013 and 2014 under cool plastic tunnel at Shambat Research Station, Agricultural Research Corporation (ARC), Sudan, (Lat.15º 40′ N, Long.23º 32′ E, and 380 meters above sea level). The soil is clay loamy type with high content of clay predominantly montemorillonite, slightly alkaline with pH range of 7.5 - 7.7. **Materials:**

Plant material

Six tomato hybrids were used, namely: Athyla, DRW6799, Saker, Baraka, Nielly, and T.Glory.

Cool plastic tunnel

A cool plastic tunnel (dome shape) type is used. It consists of Evaporative cooling fan and pad system to provide 27 ± 5ºC temperature and 65 - 77% relative humidity at mid day and covered with polyethylene sheet (200 micron) thick.

Methods

Husbandry

Sowing date was in the first week of April with crop duration extending up to third week of August. The experimental area was prepared in the form of bed 80cm wide “mustaba”. The plot size was 10.3m X 0.80m. Organic fertilizer was added before transplanting. Nursery raised seedlings were planted on the two sides of the 80 cm ridges at 40 cm plant spacing. The plants were fertilized with 20-20-20 formulation on a regular schedule throughout the growing season after transplanting. Micronutrients and foliar fertilizers were applied also with irrigation system. Irrigation was applied using drip system every day for 10 – 15 minutes. Weeding and pruning of side branches were done, chemical insect pests and diseases control, were done when needed.

Harvesting

The crop harvest started after about two months from transplanting with duration differing according to hybrids (Table 1). Fruit picking was done at 3 – 4 days interval for the first month and weekly for the last month.

Data collection

The data recorded included morphological characteristics, yield, and yield components as follows:

- Plant vigour: a scale from 1 (small or poor canopy) to 9 (very large canopy).
- Growth habit: described as indeterminate.
- Fruit set: described as low, medium, high, and very high
- Fruit shape: described as round, semi round, round-oblate, round- flat
- Rind colour: ranged from light red to red colour.
- Fruit weight: calculated as total fruit weight / total number of fruit (g).
- Yield per plant: The total yield of the 5 plants was recorded and the yield per plant was calculated.
- Yield per m^2: The total yield of each experimental unit was recorded and then transformed to yield per m^2
- Fruit diameter: measured using a vernier calibre (cm).
- Total Soluble Solids (TSS): measured using a hand refractometer (^{0}Brix).
- Fruit acidity: the fruit acidity of five randomly selected fruits was determined using Titrable Acid method as described by Ranganna (2001) and the average fruit acidity was calculated.
- Subjective quality analysis: Evaluation tests were performed for tomato fruits by panel of ten persons. They evaluated the sensory characteristics of tomato samples. A questionnaire examining consumer attitudes was developed. The panellists evaluated the product separately and made their scores. The scoring was based on one to five scale. Each panellist was presented with random samples of tomatoes from each variety with three replications. The panellists evaluated the colour, taste, shape and firmness. Also firmness was measured subjectively with the help of fingers pressure.
- **Statistical design and data analysis**

The hybrid varieties were arranged in randomized complete block design (RCBD) with three replications. Data were subjected to separate analysis of variance for traits. Combined ANOVA across the three years was performed to yield per plant and yield per m^2. The means were separated using Duncan's Multiple Range Test (DMRT) at $P \leq 5$ % level. The statistical package GenStat edition 12th was used to run the analysis.

Results and Discussion

Yield and yield components

Tables 2, 3 and 4 show the performance of the studied varieties and the combined analysis across the three years. There were significant differences among hybrids in most parameters measured related to yield and its components. The hybrids T. Glory, Athyla and Baraka recorded the highest yield per plant in terms of number of fruits and fruit weight with the former being the earliest to mature (91 day). The respective yields were 8.3, 7.1 and 6.9 kg/plant. Similarly they showed the highest yield per unit area (m^2) across the three years of 23.5, 21.6 and 21.3 kg/m^2 respectively. The hybrid Saker gave the lowest yield (4.9 kg/plant) and was the latest to mature (105 day). The two hybrids (T. Glory and Athyla) gave the highest number of fruits per plant (46 and 41 fruits/ plant) and per unit area (136 and 123 fruits/m^2), respectively. Hybrid Saker gave the lowest number of fruits per plant (33). The yield of tomato hybrids obtained by this study was within the range of that reported for tomato hybrids under greenhouse conditions (Elina *et al*. 2017) and this may be attributed to the high plant vigour resulting from the greater photosynthetic area (Elina *et al*. 2017). Other yield ranges for tomato hybrid (11.7 to 15.4kg/m^2) were reported by Hussain, *et al.*, (2002). The fruit number per plant in this study (33 - 46) also agree with the range reported by Yebrzaf *et al*., (2016) who found that number of fruits per plant from other varieties was (26 - 46 fruits). The high yield of tomato plants under cool plastic tunnel obtained in this study could be attributed to plant vigour and high flower set resulting from the extended seasonal production.

Fruit weight (g)

Table 6) shows the significant differences among the hybrids in average fruit weight. Hybrid Baraka gave the biggest fruit weight (200.0 g) followed by T. Glory (180.0g) and Athyla (172.3g), whereas, hybrid Saker showed the smallest fruit weight (140.0g). The highest fruit weight reported by Elina *et al.* 2017 was 160g and the lowest was 79g which was below than that found in this study.

Fruit diameter (cm)

As shown in Table 6 there were significant differences among hybrids in fruit diameter with hybrid Baraka showing the largest fruit diameter (7.2 cm) compared to the other hybrids. The hybrid Saker showed the smallest fruit diameter (4.4 cm). These findings agree with Yebrzaf *et al*. (2016) who find larger fruit diameter (7.3cm), the variation in fruit size and diameter in different tomato varieties is associated with the genetic makeup of the varieties.

Total soluble solids (TSS)

The juice analysis indicated significant difference among varieties for TSS (Table 7). The hybrid Athyla recorded the highest total soluble solids (5.5%) across the three years followed by Baraka (5.1%) and T. Glory (4.5%) while the hybrid Nielly recorded the lowest TSS (3.8). The total soluble solids content is one of the most important quality parameters in tomato. The results of TSS found in this study agree with that reported by Cramer *et al.*, (2001) and Moraru *et al.*, (2004) who mentioned that total soluble solids of different varieties of tomato fruit ranged from 4 to 6 ºBrix, and the significant variation for total soluble solid due to varietal differences.

Acidity

Table 7 illustrates that there was difference among the hybrids in fruit acidity, hybrid Nielly showed highest fruit acidity with an average of (4.7) compared to (3.5) recorded by hybrid Athyla. The findings are in agreement with Amira *et al.* (2013) who found that acidity in the range between 2.52 – 9.05 (g/l citric acid) in other tomato varieties and titratable acidity was found to be highly significant affected by the variety. According to Tigist *et al*. (2011), Tittonell *et al.* (2001) and Meseret (2010) genetic factor is the major determinant of tomato fruits acid content. Also large size tomato fruits have higher acidity than the small size fruit which also noticed in some with some varieties in this study.

Fruits shelf life

Firmness is an important criterion for determining the marketability of tomatoes, because it is associated with good culinary quality and long shelf life. Firmness and keeping quality were better maintained in tomatoes where they retained attractive red colour that could be the main reason for their acceptability by producers and by consumers.

The six hybrids showed differences in the number of stored day at room temperature with and without calyx. Hybrids T. Glory, Athyla, and Saker recorded the longest shelf life when stored with calyx (15, 13 and 12 days) and without calyx (10, 9 and 8 days), while hybrid Nielly showed the shortest shelf life when stored with and without calyx (Table 8). This finding agree with Rehman *et al.,* (2000) who found that some variety has a shelf life of about 15 - 20 days. Also the same trend in shelf life has been reported by Ghosh *et al*. (2010) and Shashikanth *et al*. (2010) they reporting there were varietal differences in shelf life of tomato hybrids and also stated that the differences may due to their genetic characteristics.

Fruit colour, firm, shape and taste

There were a few differences among hybrids in colour, firm, shape and taste. most hybrids were round (Athyla, Baraka and Nielly) while the colour ranged from light red (Nielly) to red.

Results of panel tests for the preferences (panelists) indicate that the consumers prefer some hybrids to other according to their taste. They gave hybrids Athyla, T. Glory and Baraka the highest score in the most of characters tested (Taste, shape, colour, size and firmness) as shown in Table 9.

Conclusions

There is no tomato hybrids released for production under cooled plastic tunnels in Sudan though it is a prerequisite, becoming very important and needs further research and development. The results obtained from three years summer research revealed that out of six hybrids three varieties: T. Glory, Athyla, and Baraka proved to be superior with respect to yield and quality and accepted by the consumers. Therefore, these three varieties: T. Glory, Athyla, and Baraka are suitable for commercial production in Sudan under cool plastic tunnels.

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Table 1: Morphological performance and fruit characteristics of six tomato hybrids evaluated under cooled plastic tunnel during three year summers (2012, 2013 and 2014)

Variety	Plant vigour [a]	Growth habit [b]	Fruit set [c]	Rind colour[d]	Fruit shape [e]	Fruit weight [f]	Firmness [g]	Days to first harvest
T. glory	L	ID	V.H	R	R-O	170-190	VFM	91
Athyla	L	ID	H	R	R	170-180	VFM	94
Baraka	L	ID	H	R	R	200-225	FM	99
DRW6799	M	ID	M	R	RF	190-200	FM	102
Nielly	S	ID	M	L.R	R	140-150	FM	97
Saker	S-M	ID	S	R	SR	140-155	FM	105

a= plant vigour whereas S: small, M: medium, L: large. b= growth habit whereas ID: is indeterminate. c= fruit set whereas S: small, M: medium, H: high, V.H: very high d= rind colour LR: light red, R: red. e= fruit shape R: round, R.O: round oblate, R.F: round flat, S.R: semi round. f= fruit weight: weighted in grams. g= firmness: whereas VFM: very firm, FM: firm.

Table 2: Mean squares form the combined analysis of variance of productivity (weight of fruits/plant and/ m^2) and number of fruits/plant and/m^2) of six tomato hybrids under cooled plastic tunnel during three year summers (2012, 2013 and 2014)

Source of variation	Character												
	Fruit weight							Number of fruit					
	kg/plant				kg/m^2			per plant			per m^2		
	d.f	Mean squares	F value	F prob	Mean squares	F value	F prob	Mean squares	F Value	F prob	Mean squares	F value	F prob
Years	2	2.1035	0.93	0.446	7.4491	0.48	0.641	15.389	0.17	0.849	14.52	0.03	0.970
Hybrids	5	7.7883	413.13	<0.001	62.0602	238.32	<0.001	46.311	40.73	<0.001	431.35	40.05	<0.001
Years* Hybrids	10	0.1759	9.33	<0.001	1.9664	7.55	<0.001	5.367	4.72	<0.001	35.41	3.28	0.006
Error	30	0.0189			0.2604			1.137			10.77		

Table 3: Total fruit yield (number and weight) per plant of six tomato hybrids under cooled plastic tunnel during three year summers (2012, 2013 and 2014)

Hybrid	Yield (kg/plant)			combined mean	Number of fruits/plant			combined mean
	Years				Years			
	2012	2013	2014		2012	2013	2014	
T.GLORY	8.7[a]	7.9[a]	8.2[a]	8.3[a]	48[a]	43[a]	46[a]	46[a]
ATHYLA	7.9[b]	6.4[b]	7.0[b]	7.1[b]	46[b]	37[b]	41[b]	41[b]
BARAKA	7.4[c]	6.6[b]	6.8[b]	6.9[b]	38[c]	34[c]	32[c]	34[b]
DRW\6799	6.2[d]	5.6[c]	5.9[c]	5.9[c]	37[c]	34[c]	36[c]	36[b]
NIELLY	5.8[d]	5.0[d]	5.5[d]	5.4[c]	39[c]	35[c]	39[b]	38[b]
SAKER	5.2[e]	4.4[e]	5.0[e]	4.9[c]	35[d]	31[d]	34[c]	33[b]
Mean	6.9	5.9	6.4	6.4	41	36	38	38
SE±	0.066	0.075	0.063	0.0458	0.574	0.993	0.691	0.3554
LSD($p \leq 0.05$)	0.207	0.213	0.198	1.132	1.709	1.901	2.078	1.027
C.V%	1.4	1.8	1.6	2.0	2.4	2.5	2.9	2.6

Table 4: Total fruit yield (number and weight) per unit area (m^2) of six tomato hybrids under cooled plastic tunnel during three year summers (2012, 2013 and 2014)

Hybrid	yield kg / m^2			combined mean	Number of fruits / m^2			combined mean
	Years				Years			
	2012	2013	2014		2012	2013	2014	
T.GLORY	25.2[a]	23.9[a]	24.4[a]	23.5[a]	136[a]	132[a]	139[a]	136[a]
ATHYLA	23.2[b]	19.9[b]	21.6[b]	21.6[b]	130[b]	116[b]	123[b]	123[b]
BARAKA	22.9[b]	20.0[b]	20.9[b]	21.3[b]	116[c]	103[c]	97[d]	105[c]
DRW6799	19.3[c]	17.5[c]	18.2[c]	18.3[c]	115[c]	105[c]	112[c]	111[c]
NIELLY	17.2[d]	16.0[d]	16.3[d]	16.5[d]	118[c]	113[b]	115[c]	115[c]
SAKER	15.8[e]	14.0[e]	14.7[e]	14.8[e]	107[d]	98[c]	102[d]	102[c]
Mean	20.6	18.6	19.4	19.3	121	111	115	116
SE±	0.357	0.253	0.263	0.1701	1.679	1.725	2.182	1.094
LSD($p \leq 0.05$)	1.124	0.757	0.729	0.4913	5.020	5.135	6.477	3.259

C.V%	2.9	2.2	2.3	2.5	2.3	2.4	3.0	2.6

Table 5: Means of total fruit yield/ plant / unit area (m^2, / $300m^2$, / and / ha) of six tomato hybrids under cooled plastic tunnel during three year summers (2012, 2013 and 2014)

Hybrid	Yield (kg/plant)	yield(kg/m^2)	Yield (tunnel) ton/$300m^2$	yield (ton/ha)
T.GLORY	8.3	23.5	7.1	236.7
ATHYLA	7.1	21.6	6.5	216.7
BARAKA	6.9	21.3	6.4	213.3
DRW6799	5.9	18.3	5.5	183.3
NIELLY	5.4	16.5	4.9	163.3
SAKER	4.9	14.8	4.4	146.7

Table 6: Fruit weight (g) and fruit diameter (cm) of six tomato hybrids under cooled plastic tunnel during three year summers (2012, 2013 and 2014)

Hybrid	Fruit size(g)			Mean	Fruit diameter (cm)			Mean
	Years				Years			
	2012	2013	2014		2012	2013	2014	
T.GLORY	180^b	185^b	178^b	181.0	6.0^a	6.7^a	5.9^b	6.2
ATHYLA	175^c	172^c	170^c	172.3	5.7^b	5.6^b	5.5^b	5.6
BARAKA	200^a	195^a	210^a	201.7	7.1^b	7.0^a	7.6^a	7.2
DRW6799	167^d	165^d	160^d	164.0	5.4^b	5.3^b	5.1^b	5.3
NIELLY	150^e	140^e	141^e	143.7	4.9^{bc}	4.6^b	4.6^b	4.7
SAKER	140^f	135^f	145^e	140.0	4.5^{bc}	3.9^b	4.7^b	4.4
Mean	168.7	165.0	167.3		5.6	5.5	5.6	
SE±	1.065	1.411	2.053		1.178	0.533	0.295	
LSD($p\leq0.05$)	3.033	4.094	5.324		0.523	1.042	0.836	
C.V%	3.4	3.0	4.2		2.0	3.1	2.8	

Table 7: Total soluble solids (brix°) and acidity of six tomato hybrids under cooled plastic tunnel during three year summers (2012, 2013 and 2014)

Hybrid	Total soluble solids			Mean	Acidity			Mean
	Years				Years			
	2012	2013	2014		2012	2013	2014	
T.GLORY	4.6^b	4.3^b	4.5^c	4.5	4.3^a	4.0^a	4.0^b	4.1
ATHYLA	5.5^a	5.2^a	5.8^a	5.5	3.6^{bc}	3.3^a	3.5^{bc}	3.5
BARAKA	5.3^a	4.9^a	5.0^b	5.1	3.9^{bc}	3.5^a	3.6^{bc}	3.7

DRW6799	4.4[b]	4.3[b]	4.1[d]	4.3	4.0[bc]	4.1[a]	4.0[b]	4.0
NIELLY	3.8[b]	4.0[b]	3.7[e]	3.8	4.9[a]	4.6[a]	4.7[a]	4.7
SAKER	4.1[b]	4.0[b]	3.9[e]	4.0	4.5[b]	4.3[a]	4.2[b]	4.3
Mean	4.6	4.5	4.5		4.2	3.9	4.0	
SE±	0.384	0.171	0.057		0.151	0.617	0.138	
LSD(p≤0.05)	0.813	0.542	0.264		0.345	1.034	0.411	
C.V%	2.7	3.7	2.0		1.8	2.7	2.2	

Table 8: Fruits shelf life (days with and without calyx) of six tomato hybrids under cooled plastic tunnel during three year summers (2012, 2013 and 2014)

Hybrid	**Fruit shelf life with calyx (days)**			**Mean**	**Fruit shelf life without calyx (days)**			**Mean**
	Years				**Years**			
	2012	2013	2014		2012	2013	2014	
T.GLORY	16[a]	14[a]	14[a]	15	10[a]	9[a]	10[a]	10
ATHYLA	14[b]	12[b]	13[a]	13	10[a]	9[a]	9[b]	9
BARAKA	10[c]	9[c]	10[b]	10	7[c]	6[b]	6[d]	6
DRW6799	11[c]	8[c]	9[b]	9	7[c]	4[c]	4[c]	5
NIELLY	8[d]	9[c]	6[c]	8	4[c]	6[b]	3[c]	4
SAKER	13[b]	12[b]	11[b]	12	8[b]	8[a]	7[b]	8
Mean	12	11	11		8	7	7	
SE±	0.605	0.566	0.683		0.576	0.306	0.483	
LSD(p≤0.05)	0.754	0.925	1.043		1.708	0.931	1.513	
C.V%	2.7	3.0	3.2		2.9	3.4	3.1	

Table 9: Fruit panel test of six tomato hybrid varieties under cooled plastic tunnel (full score = 5)

Hybrid	**Fruit panel test**			
	Colour	Firm	Shape	Taste
T.GLORY	4.6^{a}	4.7^{a}	4.4^{a}	4.2^{b}
ATHYLA	4.0^{b}	4.5^{ab}	4.3^{a}	5.0^{a}
BARAKA	3.8^{bc}	4.2^{bc}	4.3^{a}	4.0^{b}
DRW6799	3.6^{bc}	4.1^{bcd}	4.2^{a}	3.7^{c}
NIELLY	3.5^{bc}	4.0^{cde}	3.5^{b}	3.5^{c}
SAKER	3.3^{c}	3.7^{de}	3.5^{b}	3.4^{c}
SE±	0.1540	0.1856	0.0839	0.1568
LSD(p≤0.05)	0.3430	0.4135	0.1869	0.3494
C.V%	5.2	5.4	2.5	5.1

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Potato (*Solanum tuberosum* L.) Nodal Regeneration as Affected by Different Concentrations and Immersion Time of Commercial Clorox, Sugar Concentration and Murashige and Skoog (MS) Salt Strength

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Abstract

A study was conducted to investigate the effects of different concentrations and immersion time of commercial Clorox, sugar concentration and Murashige and Skoog (MS) salt strength on nodal regeneration of potato (*Solanum tuberosum* L.). Results indicated that commercial Clorox containing sodium hypochlorite at a concentration of 10% for a period of 10-20 minutes immersion, despite its preference over higher concentrations, was not very effective in sterilizing plant parts, as the percentage of survived and free of contaminants cultures did not exceed 50% at the end of the experiment. Sugar concentration of 3% gave the highest number of leaves and roots compared with the lowest concentrations. Three quarters concentration of MS salts gave the highest number of leaves and the highest number of roots in in vitropotato explants.

Keywords: Potato, Disinfection, Nodal regeneration, Sugar , Salt Strength

التجدد العقدي للبطاطس وتأثره بالتركيز وفترة الغمر للكلوروكس التجاري وتركيز السكر وقوة املاح مورشيجي واسكوج

نمارق عبد الرحيم وعبد العظيم محمد علي

كلية الزراعة جامعة وادي النيل

المستخلص

أجريت دراسة لمعرفة تأثير التركيزات المختلفة وفترة الغمر لمحلول الكلوروكس التجاري وتركيز السكر و املاح موراشيجي وسكووج (MS) على التجدد العقدي للبطاطس (*Solanum tuberosum* L). أشارت النتائج إلى ان الكلوروكس التجاري المحتوي على هيبوكلوريت الصوديوم بتركيز 10٪ لمدة 10-20 دقيقة من الغمر ، بالرغم من افضيلته على التركيزات الأعلى ، لم يكن فعالاً جداً في تعقيم أجزاء النبات ، حيث أن النسبة المئوية للمزارع الباقية علي قيد الحياة والخالية من الملوثات لم تتجاوز 50٪ في نهاية التجربة. أعطى تركيز السكر 3 % أعلى عدد من الأوراق والجذور مقارنة بالتراكيز الاقل. أعطت ثلاثة أرباع تركيز أملاح موراشيجي وسكووج أعلى عدد من الأوراق وأعلى عدد من الجذور في نبيتات البطاطس داخل المختبر.

كلمات مفتاحية: البطاطس، تعقيم ، التجدد العقدي، السكر، قوة الاملاح

Introduction

Microbial contamination is one of the most injurious problems affecting tissue culture.The sources and causes of microbial contamination in the laboratory vary, but one of the most possibilities of its source is plant to be cultured, especially if it comes from field conditions. The surface sterilization of the cultured plant is one of the key steps of tissue culture (Onwubiko, *et. al*, 2013). Surface sterilization is a vital step in preparing healthy and viable *in vitro* plants because plants in the field are highly susceptible to microbial contamination. Most surface contaminants as bacteria and fungi can be eliminated by plant surface sterilization using an appropriate disinfecting agent (Mahmoud and Al-Ani, 2016). Surface sterilization of plant materials is complex but is a very important step in the formation of healthy plant tissues within the protocol of cultures before being placed on sterile media (Bello Oluwakemi *et al*., 2018.). Therefore, a specific and successful standard sterilization protocol must be developed for sterilizing the cultures to prevent microbial contamination bearing in mind that laboratory environment and presence of nutrients can encourage the growth of microbes. Determining the time of sterilization without causing negative effects on the culture with the chemicals used in the sterilization processes also is an important factor to produce healthy plants.

Clorox (commercial bleach) often contains 5% of sodium hypochlorite. In this case, the use of double the dose (2 ml of bleach per 100 ml of water) gives a concentration of 10% sodium hypochlorite and dipping the plants in it for a period ranging 20- 30 minutes is sufficient to disinfect Plant parts (Ali and Abdalla, 2010).

Nasr El-Din *et al*., (2014) mentioned that a dose of 10-20% of commercial bleach contains often 5-10% sodium hypochlorite, in which the explant is dipped with shaking for a period of 5-30 minutes for disinfection. Mahmoud, (2007) also mentioned that 2-2.5% of sodium hypochlorite, which is often equivalent to 5—20% of the commercial bleaching solution known as Clorox, is sufficient for sterilization, taking into account the type of plant tissue and the time of immersion.

Plants benefit from light to manufacture carbohydrates in the presence of chlorophyll pigment. Since the plants in tissue culture are weak in the vegetative system and grow under weak lighting, they will not have a full ability to manufacture energy materials. Therefore, plants are provided with sugar in tissue culture media, which is known as non-autotrophic (heterotrophic), and many scientists have suggested that raising the proportion of carbon dioxide in the atmosphere surrounding the plant will enforce it to become autotrophic instead of adding sugar to the environment. However, experiments proved a low feasibility for this.

Medium for plant tissue culture is commonly supplemented with MS salts and other organic and inorganic components, but optimum salts strength (concentration) is a subject of species and specific perpous. Ibrahim *et al*., (2016) found no significant differences in plant height observed in two potato cultivars as affected by MS salt strength, while there was a significant increase in the number of leaves when using the full MS, While, the lowest concentration (1/4 MS) resulted in a significant increase in root growth compared with higher MS salt strength. Abd- Elaleem *et al*., (2009) found that shoots regenerated from callus were rooted most effectively on half-strength MS medium containing 0.5 mg/l IBA.

The objective of this research was to investigate the effects of different concentrations and immersion time of commercial Clorox, sugar Concentration and Murashige and Skoog (MS) salt strength on nodal regeneration of potato (*Solanum tuberosum* L.).

Materials and method

This study was conducted at the tissue culture laboratory of Al-Rajhi Company in Berber city in order to identify the effect of Clorox as a disinfectant for potato cultures and the effect of each of the concentration of sugar and Murashige and Skoog salts on *in vitro*potato growth .

Planting material selection and surface sterilization

Bukhari cultivar was selected from the greenhouse of Al-Rajhi Agricultural Company as starting experimental materials. The growing top of the plant was taken after removing the surrounding leaves and this process was done outside the laboratory. The plant was washed well with soap and water, to get rid of the soap effect and for further sterilization, drops of Clorox and running water were used.

Media preparation and sterilization techniques

Murashige and Skoog (1962) medium (MS) was used by preparing working solution from stock solutions as described by Nasr El-din *et al*. (2014). Addition of growth regulators were made according to their heat stability and according to their need for each experiment, before autoclaving. Sucrose added, as specified in each experiment. Gelrite was added at rate of two grams per liter as media gelling agent. Medium (pH) was adjusted to 5.8 using both potassium hydroxide and hydrochloric acid followed by heating on hot plate till full blend. Finally, 30 ml of nutrient medium was poured into 250 ml containers and covered with a polypropylene cap. The containers were placed in the autoclave at a temperature of 121°C and a pressure of 15 psi for 20-30 minutes to sterilize the nutrient medium, then the containers were incubated at a temperature of 20-24 overnight before experimentation.

Experimentation

In the first experiment, Clorox was used as a sterilizing agent with different concentrations and exposure time (dipping time) to study its effect as a sterilization substance on potato cultures. Sterilization by Clorox was done at three concentrations (10, 20, 30%) for (10, 20, 30 minutes). To test for decontamination. A medium containing 3/4 strength of Murashige and Skoog salt (MS) supplemented with appropriate plant growth regulators (kinetin at a rate of 2 mg / liter) was used in the laboratory and placed in containers and monitored for four weeks. The pH of the medium was adjusted to 5.8 and the containers were then sterilized using an autoclave at 121 °C for 20 min. Ten explants were used for each sterilization treatment.One explant was cultured in each container. The cultures were placed in a growth incubator at 24 ± 1 °C for four weeks, with a 16/8-hour light/dark period under 1000 lux illumination provided by cool white fluorescent light. Aeration and humidity were also properly maintained in the growth incubator throughout the assay period. After four weeks, the percentages of contaminated, surviving and dead nodes were recorded.

In the second experiment, the effect of sucrose concentration on potato nodal explant growth was studied. The explants were cultured on a medium containing ¾ Murashige and Skoog salt strength.Growth regulator (kinetin at a concentration of 2 mg / liter) and gelrite as a gelling agent at rate of two grams per liter were added. Sucrose concentrations were 10, 20, 30 grams per liter. Ten culture samples were planted in four replicates, and the experiment was statistically analyzed according to a randomized complete block design (RCBD) with means separated by LSD using SAS statistical computer package. The readings namely, the appearance of leaves and roots were taken in different periods of the experiment as shown in the results tables, At the end of each 7days for four weeks the number of leaves and the number of roots in the culture medium were registered.

In the third experiment, the effect of Murashige and Skoog (MS) salt strength on the growth and development of potato cultures inside the tissue culture laboratory was studied. Sugar was used at a rate of 30 grams per liter. Growth regulator (kinetin at a concentration of 2 mg per liter) and gelrite as a gelling material at a rate of two grams per liter were added. Ten cultures in four replicates were studied, and the experiment was statistically analyzed according to a randomized complete block design (RCBD) with means separated by LSD using SAS statistical computer package. Parameters namely, the appearance of leaves and roots were investigated at different periods of the experiment as shown in the results tables. At the end of each 7days for four weeks, the number of leaves and the number of roots in the culture medium were registered.

Results and Discussion

The best results from sterilization with commercial Clorox were obtained when using it at a concentration of 10% with the survival of 80% or more of the plants at the end of the experiment time after four weeks of culture for the three immersion times. Also, immersion for 10 minutes had better results compared to the longer times. Fifty % of the plants are free of contamination four weeks after planting. Concentrations of 20 and 30% of the sterilization solution showed in terms of the percentage of contamination and the explant survival. Explant survival rate decreased with the increase in the duration of immersion (Table 1).

Results obtained seem to be in line with many researchers findings. From them Badoni and Chauhan, (2010) who for sterilization of the potato varieties Kufri and Himalinimadea compared between sodium hypochlorite and mercuric chloride for three immersion periods of 2, 5 and 8 minutes to detect the non-growing, infected and healthy cultures with no contamination. Results indicated that hypochlorite (NaOCl) was better in controlling the infection and it did not have any negative effect on the explants even in the long term. It was shown that sodium hypochlorite for 8 minutes was a suitable chemical for sterilization used after 5 minutes of washing with saflon, immersion for 30 seconds in ethanol and finally washing with double distilled water.
Amissah, *et al*., (2016) obtained best results from the use of 70% ethanol for 3 minutes, followed by 20% sodium hypochlorite for 10 minutes, where 90% of the cultures remained intact from contamination after four weeks of cultivation when three methods were tried for surface sterilization of sweet potato, including the addition of 70% ethanol for 1 minute, followed by 10% sodium chloride for 15 minutes and 70% ethanol for 3 minutes, followed by 20% sodium chloride for 10 min and 90% ethanol for 3 min, followed by 30% sodium chloride for 10 minplus control where only distilled water was used to rinse the explants.

Unlike others Onwubiko *et al*., (2013) studied the effect of different levels of sodium hypochlorite concentration and exposure time on sweet potatoes. His results showed that sodium hypochlorite was not a very good sterilizer as a very high percentage of the cultures were contaminated in all the experiments conducted. But a low percentage (40%) of the clean cultures was observed at 20% concentration, with a duration of 20 minutes as exposure time. It seems that decontamination effect of hypochlorite will be magnified when supported by use of other disinfectant, while too long immersion period may harm treated explants.

Table 1: Performance of potato explants(*in vitro*) as affected by Clorox concentration and immersion time

Hypochlorite conc.	Clorox conc. %	Time of immersion (minutes)	contaminated plants No.	Contaminated plants %	No of dead plants	Plants survival %	Response Rate%
0.5	10	10	5	%50	1	90 %	90%
		20	8	%80	1	90 %	90%
		30	8	%80	2	80 %	80%
1	20	10	7	%70	10	0%	0%
		20	10	%100	4	60%	60%
		30	10	%100	7	30%	30%
1.5	30	10	10	%100	7	30%	30%
		20	10	%100	9	10%	10%
		30	0	0	10	0%	0%

Response rate include survived plants even if with microbial contaminants by the end of four weeks

Significant differences in the number of leaves as affected by sucrose concentration were noticed(Table 2). The greatest number of leaves resulted from 30 g/l sucrose across the four weeks readings (22.20, 30.00, 38.60 and 59.20 leaves in the first, second, third and fourth week respectively). The least number of leaves resulted from 20 g/lsucrose (3.50) in the first reading at the end of the first week, from 20 and 10 g/l, respectively (7.40 and 7.10) by the end of the second week, 10 g/l (9.60) in the third week. and from 10 and 20 g/l, respectively in the fourth week (41.40 and 42.00). Results indicated the positive effect of high sugar concentration in increasing leaves numbers. Ibrahim *et al*., (2016) obtained similar results.

As for the roots, in the first week, the differences were not significant. The concentration of 20 g/l of sucrose gave the highest number of roots (2.20) and no roots appeared for the lower sugar concentration (10 g/l). In the second week, the high concentration of sugar (30 g/l) resulted in a significant increase in number of roots (8.40), and the lowest number resulted from lowest sugar concentration (1.70). In the third week, the two highest concentrations of sugar 30 g/L and 20 g/l gave a significant increase in the number of roots (23.00 and 9.60, respectively) and the lowest number of roots resulted from the lowest concentration (2.10). In the fourth week, the higher sugar concentrations (30 and 20 g/l) gave a significant increase in number of roots (60.90 and 28.80, respectively) and the lowest roots resulted from lowest concentration (4.90).

It seems that at the beginning, root growth did not follow the same trend of leaf growth, however, later higher sugar concentrations seem to increase root development.

Table 2: Potato *in vitro* nodal regeneration manifested in leaf and root number as affected by MS Sugar concentration

Weeks	Sugar conc. (g/l)	Root No.	Leaf No.
First	10	0.00	4.80
	20	2.20	3.50
	30	0.70	22.20
Second	10	1.70	7.10
	20	4.60	7.40
	30	8.40	30.30
Third	10	2.10	9.60
	20	9.60	36.60
	30	23.00	38.60
Forth	10	4.90	41.40
	20	28.80	42.00
	30	60.90	59.20
CV %		97.28	37.17
P sugar		***	***
P weeks		***	***
P interaction		***	***
LSD		5.28	6.09

Regarding salt strength effects, there were significant differences in the number of leaves between all concentrations used for salt strength through the four weeks period (Table 3). Salt strength of three quarters concentration gave the highest number of leaves (22.20, 30.70, 36.00 and 59.20in the first ,second, third and fourth week respectively), while the lowest number of leaves resulted from half salts strength (2.80, 4.50,6.50 and 9.10 in the first ,second, third and fourth week respectively). Results obtained resemble that obtained by Ibrahim *et al*., (2016). Root numbers followed the same trend as in leaf number as affected by salt strength except the first week,where

3/4 salt strength recorded the highest root number in the three later weeks (9.00, 23.00, 60.00 in the second, third and fourth week respectively). The result obtained resemble that obtained by Abd-Elaleem *et al*., (2009). Result obtained indicated that full MS salt did not record the highest root number. High osmotic potential resulted from full MS salts might reduce root number compared to 2/4 and ¾ salt strength.

Table 3: Potato *in vitro* nodal regeneration manifested in leaf and root number as affected by MS salt strength

Weeks	**MS salt conc. (quarters)**	**Root No.**	**Leaf No.**
First	4/4	2.40	9.90
	¾	1.40	22.20
	2/4	1.00	2.80
Second	4/4	6.70	16.50
	¾	9.00	30.00
	2/4	2.00	4.50
Third	4/4	10.00	22.30
	¾	23.00	36.90
	2/4	5.00	6.50
Forth	4/4	41.90	42.30
	¾	60.90	59.20
	2/4	12.00	9.10
CV %		90.33	51.18
P sugar		***	***
P weeks		***	***
P interaction		***	***
LSD		5.85	4.9

Conclusion

Commercial Clorox containing sodium hypochlorite at a concentration of 10% for a period of 10-20 minutes immersion, despite its preference over higher concentrations, was not very effective in sterilizing plant parts, as the percentage of survived and free of contaminants cultures did not exceed 50% at the end of the experiment. Therefore, it is preferable to be used with other sterilizers.

Sugar concentration of 3% gave the highest number of leaves and roots compared with the lowest concentrations.

Three quarters concentration of MS salts gave the highest number of leaves and the highest number of roots in *in vitro* potato explants.

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Effect of Sowing Methods on Growth and Seed Yield of Rhodes grass (*Chloris gayana* L. Kunth) Cultivars Under High Terraces Soil

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Abstract

The effects of four sowing methods on growth and yield of two Rhodes grass (*Chloris gayana* L. kunth) cultivars under high terraces soil were investigated at a farm of Elamn Elgisai scheme-Eddamer in River Nile State, Sudan for two consecutive seasons (2017/18 and 2018/19). The results showed that broadcast sowing significantly improved growth and yield parameter compared to the other sowing methods. Sowing broadcast on flat produced highest plant height, leaf area and higher number of spikes per plant, while sowing broadcast on ridges produced highest 1000 - seed weight and higher seed yield of the crop. Cultivars were varied from each other for seed yield and other recorded characters. Fine cut cultivar was superior to reclaimer cultivar in all growth parameters, while reclaimer cultivar was superior to fine cut cultivar in 1000 seed weight and the final seed yield.

Keywords: Rhodes grass, high terraces sowing methods

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أثر طرق الزراعة على النمو وإنتاجية الحبوب لأصناف حشيشة الرودس في أراضى التروس العليا

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المستخلص
تأثير أربعة طرق للزراعة على النمو وإنتاجية الحبوب لصنفين من حشيشة الرودس درست في أراضي التروس العليا في مزرعة بمشروع الأمن الغذائي بالدامر بولاية نهر النيل، السودان لموسمين متتالين(2017/ 18 و 19/2018). أوضحت النتائج أن الزراعة نثراً حسنت معنوياً من مكونات النمو والإنتاجية مقارنة ببقية طرق الزراعة. الزراعة نثراً في الأرض المسطحة نتج عنها أعلى إرتفاع للنبات، مساحة ورقية وأكبر عدد من السنابل بالنبات، بينما نتج عن الزراعة نثراً في السرابات أكبر وزن للألف حبة وأعلى إنتاجية من للحبوب للمحصول. إختلفت الأصناف في مابينها في إنتاجية الحبوب وبعض الصفات الأخرى المسجلة. الصنف فاين كت كان تفوق على الصنف ريكلايمر في كل قياسات النمو، بينما تفوق الصنف ريكلايمر على الصنف فاين كت في وزن الألف حبة وإنتاجية الحبوب.

كلمات مفتاحية: حشيشة الرودس ، التروس العليا ، طرق الزراعة

Introduction

Rhodes grass (*Chloris gayana* kunth) is a perennial or annual leafy grass cultivated as sown pastures in irrigated terraces (Quattrocchi, 2006 and Cook *et al*., 2005). It is a summer – growing, stoloniferous grass. Rhodes grass is an important multi and multi- tillering annual forage for pasture and hay, drought-resistant and very productive, of high quality when young. Its ability to establish rapidly make it valuable for soil conservation (Yossif and Ibrahim, 2013). It is useful as a cover crop and soil improver, as it improves fertility, soil structure and helps to decrease nematode numbers (Cook *et al*., 2005). However, Rhodes grass was shown to outcompete summer weeds and has been considered helpful for controlling their development (Moore, 2006). Seasonal water logging over 30 cm kills the plant (FAO, 2014). Rhodes grass grows on a wide range of soils from poor sands to heavy clays (Arshad *et a*l, 2014).

There are many types of Rhodes grass cultivars but among all fine cut is most popular cultivar. (Arshad, 2015) reported that fine cut cultivar is popular because of its productive yield. The maximum plant height, tillers/plant, leaf area and green fodder yield was also observed for the cultivar fine cut. It was derived from katambora. Production of Fine cut was remarkable when nitrogen fertilization was applied in a separate split dose (Valenzuela and Smith, 2002). Reclaimer, is a fine stemmed Rhodes grass with a very high leaf to stem ratio when compared to other katambora types. Sowing methods vary considerably on different soil types. This is mainly related to irrigation requirements and drainage (Elkarouri and Mansi, 1980). In heavy clay soils the crop should be extensively on ridges to prevent lodging. Hanan (2004) reported that sowing maize on ridges and on flat resulted in the same yield. Also, he reported that sowing on flat or in ridges had no effect on seedling emergence of maize, so there was no difference in number of plant per unit area. Samia (2001) conversely reported that the plant population of alfalfa resulted in a higher plant density when sown on flat compared to that on ridges. Suliman (2018) indicated that sowing sorghum on flat increased plant height, number of panicle/m^2 and seed yield. Also, Mehissi (2017) reported that sowing guar on flat increased growth and seed yield of the crop.

Rhodes grass can be vegetatively propagated or established from seeds. For vegetative propagation, larger clumps can be cut into pieces and planted at one meter distance from each other

(NSWDPI, 2004). Because Rhodes grass seeds are fluffy, they may need to be coated or mixed with a carrier to improve the flow through the seeder (Moore, 2006). Seeds can be broadcasted or shallow-drilled (5 - 10 mm depth) during fall. The seeds can germinate under dry conditions provided that the soil has residual moisture (NSWDPI, 2004).

Research work is little and more studies for this crop are therefore needed. In addition, farmers are not aware of most of its cultural practices such as sowing methods. Therefore, the objective of this study was to investigate the effect of sowing methods on growth and seed yield of two Rhodes grass cultivars (fine cut and reclaimer) under irrigation on the high terraces soil.

Materials and Methods

Afield experiment was conducted for two consecutive seasons (2017/18 and 2018/19) in a farm of Elamn Elgisai Scheme at Eddamer in River Nile State, Latitude 17º 48⁻ N, Longitude 34º 00⁻E on heavy clay alkaline soil (clay 42.13) with a pH of 9.0.

The treatments consisted of two Rhodes grass cultivars fine cut (I) and reclaimer (E) and four sowing methods which were (broadcast on ridges, line on ridges, broadcast on flat and line (row) on flat). The experiment was laid out in split plot design with four replications. Forage cultivars were assured to the main plots and sowing method to the sub plots. The experimental unit was a plot having an area of 9 m^2 with four ridges or four rows per plot at 60 cm spacing between ridges or rows. The seeds used in the experiment were obtained from Hudieba Research Station. The crop was seeded at a rate of 10 kg/ha on 27^{th} of March in the first season, and on 7^{th} of April in the second season.

The parameters which were measured during the course of the study included plant height, leaf area, number of spikes per plant, 1000 seed weight and seed yield. Plant height was taken at 30, 45 days after sowing and at each cut. Five plants were randomly selected, measured from the soil surface to the plant tip. Average plant height was recorded in cm. Leaf area was determined each time at harvest. Five plants were randomly selected from each plot. The length and the width of leaf were measured. The leaf area was calculated using the following formula:

Leaf area = leaf length ×leaf width ×0.75 as reported by Watson and Watson (1953).

For number of spikes per plant, five plants were randomly selected from each treatment for the last cut. Number of spikes were counted and average was recorded. For 1000 seed weight, a sample containing 4000 seeds was counted for each treatment. A sub sample of 1000 seeds was weighed to determine the 1000 seed weight. For seed yield determination the seeds collected at harvest time from an area of one m^2 for each treatments were weighed and seed yield per hectare was estimated.

Data was analyzed using the least significant difference (LSD) method (Gomez and Gomez, 1984).

Results and Discussion

Plant height (cm):

Sowing broadcast on flat produced higher plant during both seasons except for the first, second and third measurement of the first season compared to the other sowing methods. This increase in plant height was significant in the first, second, third and fifth measurements of the second season. On the other hand, broadcast on ridges increased plant height in the first measurement and significant in second measurement of the first season (Table1). These results agreed with those obtained by Hong *et al*. (1987) and Ibrahim *et al*.(2006).

Also Table (1) showed that Fine cut outscored reclaimer cultivar in plant height in seven out of ten measurements during both seasons. These differences reached the significant level for the second, third and fifth measurements of the first season. Result obtained agreed with those reported by Yousif and Ibrahim (2013).

Table (1) : Effect of sowing methods on plant height of Rhodes grass cultivars during (2017 - 2019) seasons:

sowing methods										
season	1st					2nd				
measure / Treatment	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
FB	10.42	26.60^{ab}	51.42	46.95	46.22	27.02^{a}	53.50^{a}	98.25^{a}	84.17	103.95^{a}
RB	10.80	27.90^{a}	53.30	43.96	38.70	23.97^{ab}	49.70^{ab}	83.07^{b}	83.75	100.50^{ab}
FL	9.85	22.87^{b}	54.30	43.80	42.92	20.40^{bc}	44.42^{bc}	85.45^{ab}	79.90	94.10^{c}
RL	10.00	23.92^{ab}	51.07	37.95	33.95	18.05^{c}	37.35^{c}	68.40^{c}	82.12	$96.90b^{c}$
Mean	10.26	25.32	52.52	43.16	40.45	22.36	46.26	83.79	82.48	98.86
LSD	NS	4.49	NS	NS	NS	5.35	8.07	14.18	NS	5.39
Cultivars										
I	10.63	27.45^{a}	54.73^{a}	42.53	48.12^{a}	23.03	46.62	87.27	82.07	98.21
E	9.90	23.20^{b}	50.31^{b}	43.80	42.76^{b}	21.58	45.91	80.31	82.90	99.51
LSD	NS	2.01	3.84	NS	5.17	NS	NS	NS	NS	NS
C.V	21.04	15.77	14.53	14.77	25.41	16.85	16.30	14.18	6.67	6.47

Means flowed by the same letter (s)in a given column are not significantly different $p = 0.05$

FB Sowing broadcast on flat. RB Sowing broadcast on ridges. FL Sowing in line(row) on flat. RL Sowing in line on ridges. I Fine cut cultivar. E Reclaimer cultivar. NS Not significant.

Leaf area (cm^2):

Broadcast sowing on flat produced higher leaf area in three out of six cuts during both seasons, while broadcast sowing on ridges increased leaf area in the first and second cuts of the first season. Furthermore, broadcast sowing on flat significantly increased leaf area in the third count of the second season (Table 2). This result agreed with those reported by Springer and Gillen (2007).

Fine cut outnumberd reclaimer cultivar in leaf area in all cuts of both seasons. This increase in leaf area was significantly obtained in the first and second cuts of the first season (Table 2). Result obtained agreed with those reported by Mirza *et al* (2002).

Table(2) : Effect of sowing methods on leaf area of Rhodes grass cultivars during two seasons (2017 - 2019):

sowing method						
Season	1st			2nd		
Cut / Treatment	1st	2nd	3rd	1st	2nd	3rd
FB	16.10	12.98	9.39	19.64	20.71	11.62[a]
RB	18.08	14.95	7.47	19.84	15.66	10.75[ab]
FL	15.90	13.37	8.85	20.81	16.41	11.08[ab]
RL	16.27	13.13	7.66	16.48	16.53	8.78[b]
Mean	16.59	13.61	8.34	19.19	17.33	10.56
LSD	NS	NS	NS	NS	NS	2.66
Cultivars						
I	17.24[a]	14.41[a]	8.61	19.27	18.41	10.95
E	15.93[b]	12.80[b]	8.07	19.12	16.24	10.17
LSD	1.06	1.11	NS	NS	NS	NS
C.V	12.74	16.25	22.29	11.87	22.44	28.24

Number of spikes per plant:

Differences between sowing methods with respect to number of spikes per plant were not significant during both seasons, while broadcast on flat and on ridges slightly increased number of spikes per plant in the first and second seasons, respectively (Table 3). Similar observation was made by Elkarouri and Mansi (1980).

1000 seed weight (g):

Differences between 1000 seed weight as a result of sowing methods were not significant in both seasons. However, broadcast sowing on ridges and sowing in line on flat increased 1000 seed weight in the first and second seasons, respectively (Table 4). Similar result was reported by Ishiaku *et al*.(2016).

Table (3 and 4) showed that number of spikes per plant and 1000 seed weight did not differ greatly for both cultivars and the differences were not big enough to reach the significant level. On the other hand, reclaimer cultivar had the higher mean number of spikes per plant and the highest mean of 1000 - seed weight during both seasons compared with fine cut cultivar. This may be due the highest number of tillers/plant which was reflected in lower 1000 - seed weight. This result was similar to the observation of Ali *et al* (2001).

Table (3): Effect of sowing methods on number of spikes per plant of Rhodes grass cultivars during two seasons (2017 - 2019):

sowing methods		
Season / Treatment	1st	2nd
FB	11.35	8.55
RB	9.90	8.67
FL	10.85	8.57
RL	11.17	8.57
Mean	10.81	8.61
L.S.D	NS	NS
Cultivars		
I	10.77	9.07
E	10.86	9.15
L.S.D	NS	NS
C.V	15.91	18.34

Table (4): Effect of sowing methods on 1000 seed weight of Rhodes grass cultivars during two seasons (2017 - 2019):

sowing methods		
Season / Treatment	1st	2nd
FB	0.33	0.37
RB	0.41	0.38
FL	0.33	0.42
RL	0.32	0.40
Mean	0.35	0.39
L.S.D	NS	NS
Cultivars		
I	0.31	0.35
E	0.39	0.43
L.S.D	NS	NS
C.V	21.79	18.98

Seed yield (kg/ha):

Sowing on flat (broadcast and in line) produced higher seed yield compared to sowing on ridges (broadcast and in line) during both seasons (Table 5). However, the differences were not big enough to reach the significant level. The increase in seed yield as a result of flat sowing could be explained on the basis that all growth and yield component parameters measured in this experiment (plant height, leaf area, number of spikes per plant and 1000 seed weight) were favored by flat sowing and this was reflected in higher seed yield. Similar result interpretations were also reported by Suliman (2018) and Mihessi (2017).

Reclaimer cultivar out yielded fine cut cultivar in seed yield and gave slight increase during both seasons. This differences were not big enough to reach the significant level (Table 5). This might be explained by the fact that reclaimer cultivar had greater number of spikes per plant and higher 1000 - seed weight. Similar result was reported by Abusuwar and Abdella (2001) who reported that the increase in final seed yield of clitoria could be a result of the increase in 1000 – seed weight.

Table (5) : Effect of sowing methods on seed yield of Rhodes grass cultivars during two seasons (2017 - 2019):

sowing methods		
Season / Treatment	1st	2nd
FB	2.99	7.17
RB	2.37	8.22
FL	2.10	8.42
RL	1.31	7.23
Mean	2.19	7.76
L.S.D	NS	NS
Cultivars		
I	1.99	7.54
E	2.39	7.98
L.S.D	NS	NS
C.V	24.49	20.32

Conclusion

It can be concluded from the results of this study, that under high terraces soil reclaimer cultivar produced higher seed yield. Moreover, sowing on flat (broadcast or in line) increased seed yield of the crop.

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Comparative Field Performance Evaluation of Two Seed Drills Under River Nile State Condition

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Abstract

The experiment was conducted in Atbara in one of the food security project (10 km north of Atbara) during 2018/ 19 to study the effects of seed drill type (Agro master BM22 and Titan3000) and three forward speeds (6, 7.5and 9 km/hr.) on machine performance parameters such as: wheel slippage, the fuel consumption (lit/hr.), the actual field capacity (fed /hr.) and field efficiency (%). The results showed that, wheel slippage, the fuel consumption (lit /hr.), the actual field capacity (ha /hr.) and field efficiency were better in the seed drill I (Agro master BM22) than in the seed drill II (Titan 3000). Seed drill I registered wheel slippage of 8.4%, fuel consumption 11.24 lit/ha,actual field capacity 1.16 ha/hr. and field efficiency 57.1 % .Seed drill II registered wheel slippage 9.6 % ,fuel consumption 13.5 lit/ha ,actual field capacity 0. 95 ha/hr. and field efficiency 45 %. As the forward speed increased from 6 km/hr. to 9 km/hr., the average fuel consumption (lit./hr.), the actual field capacity (ha /hr.) and field efficiency were increased by .6%. The wheel slippage was decreased by 10 % for both seed drills as speed was increased. Statistically, the differences between the effects of two seed drills and forward speeds on slippage and fuel consumption were found highly significant ($P<0.05$) under the two seed drill types.

Keywords: seeder, Fuel consumption, wheel slippage and effective field capacity

مقارنة تقييم الأداء الحقلي لزراعتي بذور تحت ظروف ولاية نهر النيل

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المستخلص

أجريت التجربة في عطبرة في أحد مشاريع الأمن الغذائي (10 كم شمال عطبرة) خلال عام 2019/2018 لدراسة تأثير نوع الة زرعة البذور من نوع (Agro master BM22 و Titan3000) وثلاث سرعات أمامية 6 ، 7.5 و 9 (كلم /ساعة)وفقًا لمعايير أداء الالة مثل: انزلاق العجلة ، واستهلاك الوقود (لتر / ساعة) ، والسعة الحقلية الفعلية (هكتار / بالساعة) والكفاءة الحقلية (٪). أظهرت النتائج أن انزلاق العجلة واستهلاك الوقود (لتر / ساعة) والسعة الحقلية الفعلية (هكتار / ساعة) وكفاءة الحقل كانت افضل في زرعة البذور (Agro Master BM22) مما كانت عليه في زرعة البذور Titan3000) II) تم تسجيل انزلاق العجلة بنسبة 8.4٪ ، واستهلاك الوقود 11.24 لتر / هكتار ، والقدرة الحقلية الفعلية 1.16 هكتار / ساعة ، وكفاءة الحقل 57.1٪ ، وزرعة البذور الثاني ، انزلاق العجلة بنسبة 9.6٪ ، واستهلاك الوقود 13.5 لتر / هكتار ، والقدرة الحقلية الفعلية 0.95 هكتار / ساعة والكفاءة الحقلية 45٪. مع زيادة السرعة الأمامية من 6 كم / ساعة إلى 9 كم / ساعة ، تمت زيادة متوسط استهلاك الوقود (لتر / ساعة) ، والقدرة الحقلية الفعلية (هكتار / ساعة) والكفاءة الحقلية بنسبة 0.6 ٪. تم تقليل انزلاق العجلة بنسبة 10٪ لكل من زراعات البذور مع زيادة السرعة. إحصائيا ، الفروق بين تأثير اثنين من الزراعات البذور والسرعات الأمامية على الانزلاق واستهلاك الوقود وجدت اختلافا معنويا (P <0.05) تحت نوعي زراعات البذور

Introduction

Farm machinery is an important element for agricultural development and crop production in many developed and developing countries. The use of machines for agricultural operations has been one of the outstanding developments in the global agriculture during the last decade (Kheiry, *et al.*, 2017).

The planting operation is one of the most important cultural practices associated with crop production. Increases in crop yield, cropping reliability, cropping frequency and crop returns all depend on the uniform and timely establishment of optimum plant populations (Murray *et al.*, 2006).

Proper application of mechanical power for planting will improve the quality of the operation; conserve amounts of seeds and save fuel, labour and time (Dahab, *et al.*, 2007, Tillett *et al.*, 2002 and James, 2005). Proper selection of planting machine that suits the available power, crop type and soil condition is important to reduce energy required Hunt (1995).

Planting depth is a major determinant of seedling emergence and hence one of the most important operational requirements of a planting machine (Rainbow *et al.*, 1992). Inadequate depth control accuracy is recognized by farmers (McGahan, 1992) and researchers as a major deficiency of current broad acre planting machines. Providing planting machines capable of maintaining uniform depth under field conditions is a major challenge for equipment designers (Riethmuller , 1990 ; Janke, 1985), particularly under direct drilling conditions because of the greater surface roughness and variability of soil structure and residue levels.

The main objective of the present study is to evaluate the machine performance of two seed drill machines (seed drill I - Agro master BM22) and seed drill II (Titan 3000) as affected by three forward speeds (6, 7.5 and 9 km/hr.).

Materials and Methods

A field experiment was carried out in one of the food security project farms (Atbara) to investigate the effects of see drill machine type on machine performance. The soil is classified as Silt Clay. Some soil properties of the experimental area are shown in Table 1. The machinery used in the experiment was the following:

1- Two Massey Ferguson tractors, one (60 kW) for testing and the other (67.5 kW) as auxiliary for pulling and draft measurements.

2- Two seed drill machines (agro master – (seed drill I) and Titan – (seed drill II) are used. Technical specification of seed drill Agro master shown in Table 2 and plate 1 and technical specifications of seed drill Titan are shown in Table 3 and plate 2. Both are tractor mounted and of four units. Other equipment's used were, a hydraulic dynamometer for draft measurement, Graduated tube and fuel container for measuring the tractor fuel consumption.

A split-plot design with three replicates for evaluation of seed drill machines was used. The Two seed drill machines were assigned to the main plots and the three forward speeds to the subplot. The area was 1.03 fed (132 m x 32.8 m) divided into two main plots (seed drill machines) and each main plot was divided into three subplots (speeds). The area of the subplot was 192 m2 (40 m x 4.3 m) and were separated by a distance of 1 m while the main plots separated by 3m distance. Table 1 shows some soil properties of the experimental area, wheel slippage, the fuel consumption (lit./hr.),

Measurement

Measurement of Operational speed:

A distance of 280 meters under the experimental area was pre-determined. Flags marked ends. The time required for the machine to cover this distance at the recommended operating speed was recorded. The treatment was repeated four times. The machine speed was estimated by determining the mean for the times taken. The machine speed was obtained using the following equation:

$$\boldsymbol{Speed\ \left(\frac{km}{hr}\right) = \frac{280\ (m)}{time\ in\ secentes\ to\ cover\ 280\ (m)}\quad x\quad \frac{3600sec}{1000m}} \ldots \mathbf{1}$$

Measurement of wheel slippage

The measurement of wheel slippage was done for drive wheel of planters. At first, the distance traveled by planter for 10 revolutions of the drive wheel was recorded without load. Then, after three observations were taken for the same number of revolutions when operated with load, the average of these observations was calculated. The percentage wheel slippage of two planters was then calculated as follow following equation:

$$\boldsymbol{Slippage}\% \ = \mathbf{1} - \frac{\boldsymbol{actual\ distance\ traveled\ (without\ loaded)(m)}}{\boldsymbol{theoretical\ distance\ traveled\ (with\ load)\ (m}} \ldots\ 2$$

Fuel consumption measurement

The fuel tank of MF-290 tractor was filled up to its top level before field-testing. After planting, the tractor engine was stopped and the fuel tank was refilled up to the same level with the graduated cylinder to determine the quantity of diesel fuel needed to refill the tractor tank up to the same level. Fuel consumption per hectare in each plot was calculated by the following formula:

Fuel consumption in each plot was measure by the method described by James (2005) and calculated as follows:

$$\boldsymbol{The\ fuel\ consumption\ rate\ \left(\frac{l}{fed}\right) = \frac{\left(Reading\ cylinder\ \frac{ml}{1000}\right)}{Area\ of\ plot\ \frac{m2}{4200}}\ \ldots\ 3}$$

$$\boldsymbol{The\ fuel\ consumption\ rate\ \left(\frac{l}{hr}\right) = \frac{\left(Reading\ cylinder\ \frac{ml}{1000}\right)}{time\ requried\ to\ cover\ plot\ (hr)} \ldots 4}$$

Measurement of field capacity

Field capacity includes the following; a(Actual field capacity is defined as the actual rate of coverage by the machine based upon the total field time, expressed as fed/hr. Actual Field capacity in fed/hr. was calculated as follow:

$$\boldsymbol{Actual\ Field\ capacity\ = \frac{Area\ covered\ (fed)}{Time\ taken\ (hr)} \ldots 5}$$

b) Theoretical field capacity: Theoretical Field capacity in Fed/hr. was calculated as follows: Theoretical Field capacity =

$$\boldsymbol{Theoretical\ Field\ capacity = \frac{working\ width\ (m) * Speed\ (km/hr)\ *\ 1000\ (m)}{4200\ (m2)}} \ldots 6$$

Measurement of field efficiency

Field efficiency is defined as the rate of actual field capacity to the theoretical field capacity expressed as percentage. Field efficiency was calculated as follows:

$$\text{Field efficiency } = \frac{\text{Actual Field Capacity}}{\text{Theoretical Field Capacity}}\ x\ 100 \ldots 7$$

Statistical analyses

The data collected was statistically analyzed using PROC GLM (General Liner Model) procedure of SAS institute (SAS, 2002-03). The least significant difference LSD (á = 0.05) approach was used to compare the mean values of results for comparison of different treatments

Results and Discussion

Generally, the results showed that, wheel slippage and the fuel consumption (lit /hr.) in two different types of seed drill machines were greater in the seed drill II than in the seed drill I. the average values of wheel slippage for the seed drill I (agro master) was 8.4% while in Seed drill II (Titan) it was 9.6 % comparisons are made from Figure1 between both machines , it is clear that, the wheel slippage for the seed drill II is found to be greater by 1.1% than Seed drill I . The average values of fuel consumption for the seed drill I (agro master) was 11.24 lit/ha while in Seed drill II (Titan) it was 13.58 lit/ha comparisons are made from Figure1 between both machines , it is clear that, the fuel consumption for the seed drill II is found to be greater by 1.1% than Seed drill I this may be attributed to that the greater wheel slippage increase the machine draft, and with an increase in soil draft leads to increase the fuel consumption. This result agrees with the findings of (Malik *et al.*, 2017) who found that, any increase in machine draft lead to increase in the fuel consumption.

differences in field capacity for the two type of seed drill machine were, statistically, highly significant (P<0.05) .From the results shown in table 4 found that the average actual field capacity (ha/hr.) obtained from the tested implement at two seed drill machine types, was (1.16 ha/hr.) for the seed drill I and (0. 95 ha /hr) for seed drill II. Generally, it is clear that seed drill I recorded better results in actual field capacity by (1.2%) compared to seed drill II.

The average values for field efficiency at different type of seed drill machines The statistical analysis showed highly significant difference in the two types of seed drill machine (P<0.05) (Table 4). As shown in figure (1), the average value of field efficiency obtained from the field for both machine was 57% and 45% for Seed drill I and Seed drill II respectively. The average increasing percentage for field efficiency at seed drill I (1) was (1.24%) compared with seed drill II.

As shown in (Table 5) .The effects of the Seed drill types and differences in forward speeds on slippage, fuel consumption, and effective field capacity, the average slippage as percentage was observed to be was higher for seed drill II than seed drill 1

8.4% in the seed drill I and by 9.6 % in the seed drill II . This may be due to the higher draft forces exerted by the weight of the machine. This agrees with Albana and Hassan (1990). As the forward speed increased, the slippage decreased.

The result showed that the average fuel consumption in the seed drill II was generally higher compared to the seed drill I. As the forward speed was increased from 6 km/h to 9 km/h, the fuel consumption was increased (10.8- 11.8L/hr. for the seed drill I and (11.9- 13.0 L/hr.) for the seed drill II. This agrees with Malik *et al* (2017). As the fuel consumption increased linearly with increase in forward speed.

For both seed drills, the average effective field capacity increased as the forward speed increased.(50.1-62.7%)for the seed drill I and (31.9-45.5%) for the seed drill II increased it as the speed was increased from 6 km/h to 9 km/h (Table5). for the effective field capacity showed highly significant differences between effect of the two seed drill types at 5% level, while the differences between the effect of the three forward speeds was significant at 5% level.

For both seed drills, the average effective field capacity increased as the forward speed increased. The statistical analysis showed highly significant difference in the two types of seed drill machine (P<0.05) (Table 5). The average value of field capacity obtained from the field for both machine was 1.1-1.2 ha/hr and 0.7-0.9 ha/hr for Seed drill I and Seed drill II respectively**.**

Conclusion

The wheel slippage and fuel consumption and wheel slippage were better in the seed drill I than in the seed drill II also effective field capacity. The differences between the effects of two seed drill machines were found highly significantly at level 5% .also the differences between the effects of two Seed drill and forward speeds on slippage and fuel consumption were found highly significantly at level 5% under the two River Nile state conditions.

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Table (1) some soil properties of the experimental area in one of the food security project farms (Atbara)

Table (1): Soil analysis of experimental site

Depth	**pH**	**Na**	**Mg**	**Particle size distribution**			**Textural Class**
				Sand	Silt	Clay	**Silt Clay**
0-15	6.7	0.13	3.03	0.14	0.67	1.003	
15-30	6.79	0.13	3.13	0.16	1.03	1.0044	

Table (2): Technical specification (seed drill Agro master)

Technical specification	**Unit**	**BM22**
Number of dis	Pcs	22
Total width (w)	Mm	3890
Total length (L)	Mm	2940
Total height (H)	Mm	1430
Working width (L1)	Cm	3124
Length of hopper (L2)	Mm	3290
Space between wheels	Mm	4006
Fertilize hopper volume	dm3	350
Seed hopper volume	dm3	503
Fertilize hopper capacity	Kg	310
Required power	Hp	85-90
Total weight	Kg	1120

Table (3) Technical specification (seed drill Titan)

Titan 3000	Type
Working width (m)	3(m)
Hopper capacity (l)	
- Total (= available in organic)	4070
-Seed, min	1720
- Seed, max	2900
- Fertilizer, max	2350
Basic machine weight (kg)	
- Empty	
- With full hoppers	3050
- Wheat and fertilizer	6900
Basic machine dimensions (cm)	
-Height to the edge of the hopper	208
- Width	300
- Length without the drawbar	307

Plate (1) seed drill I (Agro master)

Plate (2) seed drill II (Titan-3000)

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Effect of Acacia ampliceps Shelterbelt System and Water Use on Growth and Forage Yield of Barley (*Hordeum vulgare L.*) Cultivars in High Terrace Soil

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Abstract

The study was conducted at Elmukabrab scheme in River Nile State. Soil was low in nitrogen and of few organic meters. during the years 2012/ 13 and 2013/14 with the objective of investigating the effect of Acacia ampliceps shelterbelt and water use in rows wide 5 m between hedge rows and 3 m spaces between trees on growth and yield of Barley (*Hordeum vulgare* L.) as forage crop . Treatments consisted of heavy pruned Acacia ampliceps shelterbelts with light intensity of about 60 to 65% compared with control (light intensity 100%). Heavy pruning was done to increase incoming radiation measured by solar meter in two different seasons. Treatments were arranged in a randomized complete block design with four replicates. The plot size was 6×5 m.. Results revealed that in both seasons Barley forage yield under shelterbelt was highly significant, compared with the control. Barley fresh and dry forage yield under shelterbelt was increased by 46, 42% in the first season and by 41, 59% in the second season respectively compared with the control. In addition, water applied in shelterbelts with barley was measured. Water consumption differed ($p<0.001$) between shelterbelt and mono-cropping systems. Shelterbelts plots consumed less water (739m³) than the control (883 m³). Water was saved in Acacia ampliceps shelterbelt by 23 and 26% for barley cultivars in the first and second seasons, respectively.

Keywords: Acacia ampliceps, pruning, radiation, Barley, solar meter, water use

تأثير نظام زراعة ممرات الاحزمة الشجرية المكونة من أشجار الأمبلسيبس على نمو وإنتاجية الشعير كمحصول علفي وعلي مياه الري بولاية نهر النيل – السودان

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المستخلص

أجريت هذه الدراسة بمشروع المكابراب الزراعي بولاية نهر النيل و تتميز المنطقة بمناخ شبه صحراوي وتربة منخفضة النتروجين والمادة العضوية في موسمي 2013/12 و2013/ 14 بهدف: معرفة تأثير نظام زراعة ممرات الأحزمة الشجرية المكونة من أشجار الأمبليسبس على نمو وإنتاجية الشعير كمحصول علفي ومياه الري- تم تقليبم شجرة الأمبلسبس (تقليم الأفرع الجانبية على إرتفاع 3.5 من سطح الأرض وثلث تاج الأشجار) بحيث أصبح الإشعاع تحت ظل أشجار الحزام حوالى 60-65 % تقريباً، مقارنة بالشاهد (الإشعاع 100%) تم قياسه بجهاز قياس الضوء (سولميتر) فى الموسمين، أوضحت النتائج إزدياد إنتاجية الشعير الأخضر والجاف كمحصول علفي داخل ممرات الحزام الشجري معنوياً في الموسمين مقارنة بالشاهد حيث كانت الزيادة بنسبة 46 ، 42% في الموسم الأول و41 ، 59% في الموسم الثاني على التوالي. كذلك وجد أن هنالك فرق معنوي في إستهلاك مياه ري الشعير كمحصول علفي بين نظام زراعة ممرات الحزام الشجري والشاهد، إستهلك حوالى 739 متر مكعب من المياه فى الزراعة بين ممرات الحزام الشجري المكون من أشجار الأمبليسبس مقارنة بحوالي 883 متر مكعب إستخدمت لري الشاهد. وفر ما مقداره 23 و 26% فى ممرات الحزام الشجري مقارنة بالشاهد فى الموسمين الأول و الثاني على التوالي.

كلمات مفتاحية: أمبلسيبس، تقليم، إشعاع، الشعير، سولميتر، المياه المستهلكة.

Introduction

The northern states (River Nile and Northern state) lie in the desert ecological zone (75-300mm rain fall) between lat.16 and 22 N and long. 25; 30 and 34 E, and severely affected by desertification processes. Particularly wind erosion. Wind erosion is the predominant desertification process in the Northern state. Wind erodibility of soils (WE) is the main indicator of wind erosion (Mukhtar and Ganawa ,2009). Desertification in Northern Sudan is a very serious problem threatening the agricultural land and the existence of people who depend on agriculture for their livelihood. Sand encroachment is the most important element that directly affects soil by causing strong erosion hazards and endangers all valuable agricultural land resulting in a continual decline in the area of cultivated crops in northern Sudan. One of the main effects of forest, shelterbelts and agroforestry on microclimate is on solar radiation, since the sun's rays bring not only light but also heat, (Shapo *et al.*, 2007). In Africa feed shortage is among the few most critical problems of livestock farming. The grazing lands are gradually shrinking in size due to expansion of crop farming to satisfy the food needs of the increasing human population (Kechero, 2008). In countries which are characterized by long cold winters, clipping of barley was reported to increase tiller density (ELshatnawi and Haddad, 2004). Up to date, only two types of forage (Abu Sabeen and Alfalfa) occupy around 95% of the area cropped to forage crops in Khartoum state (Ministry of Agriculture, Khartoum state, 2007) which resemble situation of River Nile and Northern state. There is a pressing need to diversify the present production system with variable forage types of a high-yielding and high quality forage crops suited to Sudan's condition. Barley is grown for many purposes, but the majority of all barley is used for animal feed, human consumption, or malting (Kling, 2004; Kent, 1983) and also used for medical purpose (Ceccarelli and Grando, 1996). In Sudan, barley is mainly produced in limited areas in the northern states for grain and forage production and farmers usually grow local genotype. Barley is reported to give high yield of good quality forage in a single cut in Gezira scheme (Khair *et al*., 2001 and Salih, et al, 2006).

Acacia ampliceps an exotic tree released by the Agricultural Research Corporation (ARC), used as shelterbelts in River Nile State at Mukabrab irrigation scheme in agroforestry research programme during 2006.

The objectives of this study were to assess the effects of *Acacia ampliceps* shelterbelts grown in rows wide 5 m between hedge rows and 3 m spaces between trees on growth and yield of Barley (*Hordeum vulgare* L.) as forage crop in addition to water use productivity (IWP) of shelterbelt trees and Barley as forage crop yield production.

Materials and methods

Site study

The experiment was carried out during two seasons, 2012/13and 2013/14 in River Nile State at Mukabrab Irrigated scheme. The Experimental site lies in semi-desert climatic zone between latitudes 17º26 and 17º35 N and longitudes 33º57 and 34º08 E; about 10 km south east of Ed Damer town. The soil of the experimental site is non-saline and non-sodic with alkaline soil reaction (pH = 8.2). Low in both organic carbon (0.046%) and nitrogen content (116 ppm). $CaCO_3$ (8.3). phosphorus content is 0.83 ppm. Soil under shelterbelt is more rich in total nitrogen, phosphorus and organic carbon compared to the mono-cropping.

Experiment components

Acacia ampliceps shelterbelt

Acacia ampliceps Seedlings were raised at Gezira Research Station nursery, three-month-old seedlings (35 – 40 cm length) were transplanted in 2006. The seedlings were grown at 3 meter in-row spacing and 5 meter intera rows spacing. Each hedge row was one km long and arranged in an east-west direction. A shelterbelt was composed of four rows. Heavy pruning was done by cutting all branches at 3 to 3.5 m above ground level of the main stem and one third of the tree canopy.

Crop management and practices

Land under shelterbelt and control plots was ploughed, harrowed and levelled. Barley was planted in lines (20 cm apart). Seed rate was 96 kg/ha. Nitrogen (46 % urea) was applied at the rate of 86 kg N/ha) by broadcasting in split dose given after second and fifth irrigation.

Data collection

Crop parameters

Forge crop yield and yield components were assessed at the end of the season as follows: Fresh and dry yield (ton/ha), plant height (cm), number of plant/M^2 **,** number of tiller/M^2 **,** fresh and dry weight of leaves and stem of five plants (g) and leaves to stem percentage.

Water applied

Applied irrigation water (m^3) for each plot in each irrigation event was measured directly in the field by a current meter using the following equation:

$$I = A \times T \times V \quad (1)$$

Where, I = applied irrigation water (m^3), A = cross section area (m^2), T = total time (s) and V = velocity ($m\ s^{-1}$) which was derived from the equation:

$$V = 0.008 + 0.2667n \quad (2)$$

Where, n = revolutions per second ($rev\ s^{-1}$) obtained from the formula:

$$n = \frac{\text{number of pulse counts}}{\text{times in second}} \quad (3)$$

Water productivity

For wheat crop irrigation water productivity (IWP) values were calculated as the ratio between the actual crop yield (Ya) and total amount of irrigation water applied (I):

$$IWP = Ya / I$$

Statistical analysis

Statistical analysis was carried out using GENSTAT statistical package the data obtained were analyzed for each season separately, and then combined analysis was run for the two growing seasons.

Results and Discussion

Effect of *Acacia ampliceps* shelterbelt pruned on barley forage yield

In both seasons barley as forage crop show that fresh yield, dry yield, plant height, number of plant, fresh weight of five plant leaves, dry weight of five plant leaves, fresh weight of five plant stem, dry weight of five plant stem and leaves/ stem ratio were significantly, higher ($p = 0.001$) under *Acacia ampliceps* shelterbelt compared to control. Fresh and dry yields were increased by 46, 42% and 41, 59% under *ampliceps* shelterbelt trees compared to control in the first and second seasons, respectively (Table 1). It was expected that competition for light will be from major factor affecting production. However, it was observed that the crop under shelterbelt trees perform better with (60 – 65%) transmitted radiation. The most benefit of shelterbelts is protecting adjacent soil and crops from injury of the erosive wind. Although shelterbelts occupy valuable land of production and compete for moisture and nutrients with crops. Modified microclimate might lead to an increase in the barley growth and yield component, scientific research in other parts of the temperate regions shows that improved yields adjacent to shelterbelts can help to compensate loss in production due to reduced area (Yuhai et al., 2012). Also, Dalia et al, (2020) mentioned that sorghum and cowpea as fodder crops increased under alley cropping system by 81.8, 62.4 and by 63.6, 60.2 % over control under *Sesbania formosa* and *Sesbinia sesban* respictivley. Also Adlan *et al*., (2019) mention that the yield of groundnut increased by 14 and 6% in the Ampliceps- alley and A. stenophylla-alley, respectively and maize increased by 27and 15% in the *Acacia ampliceps*- alley and *Acacia stenophylla*-alley, respectively, in additional water applied for both ampliceps and stenophylla- alley cropped with groundnut and maize water consumed less water (571m^3/ha) than the control (805m^3/ha), water was saved in the ampliceps-alley by 34 and 33% and in stenophylla-alley by 24 and 24% for groundnut and maize, respectively.

With respect to the interaction effect under shelterbelt and control treatments, though in the both seasons combined analysis, yield and yield components of barley as forage crop gave significantly higher results, except on number of tillers (m^2) (Table 2). Yield of sorghum in the alley plots was increased by 195% over the control plots as a result of microclimatic improvement in the alleys (Shapo , *et al* 2007).

Water use:

Water use consumption differed significantly (p=0.001) between heavy pruned *Acacica ampliceps* shelterbelts and mono-cropping systems. Shelterbelt plots consumed less water (739m^3) than the control (883m^3) as presented in Table (4).

Saving in irrigation water varied within different treatments, water was saved in the shelterbelt by 23 and 26% for barley cultivars in the first and second seasons, respectively. In both seasons irrigation water use productivity of barley as forage crop growth under shelterbelt was high compared with the control (Table 5 and 6). Shapo et al. (2011) reported that *Acacia stenophylla* resulted in the highest saving of irrigation water and considerably increased 40% sesame seed yield, sesame seed yield was reduced by 46% under Acacia ampliceps- alley cropping in the semi-desert region of the northern Sudan.

Conclusions

Acacia ampliceps shelterbelt has seemed to create a good and conducive environment to increase yields. The investigation was a significantly increased in barley fodder yields grown under *acacia ampliceps* shelterbelt if spaced 3 meters between trees and 5 meters between hedges rows with 60-65% light. Generally shelterbelts, which integrates crops and or livestock with trees and shrubs-has a great potential in the area as it provide farms with multiple benefits and better water use.

Table1. Yield and yield components of Barley fodder under shelterbelt and control plots during 2012/ 13 and 2013/14 season.

Season 1	2012/ 13											
Treatment	Fresh yield ton/ha	Fresh yield% as Co	Dry yield ton/ha	Dry yield% as Co	Plant height (cm)	N. of plant (M^2)	N. of tillers (M^2)	FreshW.5 p. L(g)	Dry W.5 p. L (g)	Fresh W.5 p.S (g)	Dry W.5 p.S (g)	L&S Ratio %
Shelterbelt	13.3	46	4.7	42	70	75	235	49	14	55	13	52
Control	9.3		3.3		48	58	265	18	9	21	10	47
Sig.L	*		*		*	*	No.s	*	*	*	*	*
S.E	0.5		0.1		3	1.2	11	2.4	0.6	2	0.4	0.4
C.V%	8		6		10	3	8	12	9	9	6	2
Season 2	2013/ 14											
Shelterbelt	12.7	41	4.3	59	65	70	227	54.1	13	52	12	53
Control	9		2.7		48	53	260	18	8	20	9	46
Sig.L	*		*		*	*	No.s	*	**	**	*	*
S.E	0.5		0.1		2.4	2.3	11	2.6	0.2	1	0.2	0.6
C.V%	8		6		7	7	7	13	4	5	4	2

Co= Control,N = Number, W.5 P. L = Weight of five plant leaves, W.5 P. S = Weight of five plant stem and L&S = Leaves and stem percentage.

Table 2. Combined analysis of yield and yield components of Barley fodder under shelterbelt and control plots during 2012/13 and 2013/14 and season

Season	1		2		Mean		Sig.L	S.E±	C.V%
Treatments	Shelterbelt	Control	Shelterbelt	Control	Shelterbelt	Control			
Fresh yield (ton/ha)	13.3	9.3	12.7	9	13	9.2	**	0.5	8
Dry yield (ton/ha)	4.7	3.3	4.3	2.7	4.5	3	**	0.1	6
Plant height (cm)	70	48	65	48	68	48	**	2	9
Number of plant(M^2)	75	58	70	53	73	56	**	2	5
Number of tillers (M^2)	235	265	227	260	231	263	No.s	11	8
Fresh weight five plant leaves (g)	54	21	52	20	53	21	**	1.1	7
Dry weight five Plant leaves (g)	14.3	8.7	13.3	8	13.8	8.3	**	0.3	7
Fresh weight five plant stem (g)	54	18	49	17	52	18	**	1.8	12
Dry weight five plant stem (g)	13	10	12	9	12.5	9.7	**	0.2	9
Leaves & stem Ratio %	53	46	53	46	53	46	**	0.4	2

Table 3. Irrigation water applied (m^3/ha) for Barley fodders under shelterbelt and control plots in during (2012/13 and 2013/ 14).

Season	**2012/ 13**					
Month Treatments	**December**	**January**	**January**	**January**	**February**	**Total irrigation water (M^3/ha)**
Shelterbelt	656	533	500	622	711	**3022**
Control	800	689	656	711	867	**3723**
Sig.L	No.s	*	*	No.s	*	
S.E±	44	8	21	39	21	
C.V%	11	2	6	10	5	
Season	**2013/ 14**					
Shelterbelt	655	567	533	722	767	**3244**
Control	811	767	700	911	911	**4100**
Sig.L	No.s	*	*	**	*	
S.E±	42	24	27	8	8	
C.V%	10	6	7	3	2	

Table 4. Combine analysis of irrigation water applied (m^3/ha) for Barley fodders under shelterbelt and control plot seasons (2012/ 13 and2013/ 14).

Month	December		January		January		January		February	
Treatment	Shelterbelt	Control	Shelterbelt	Control	Shelterbelt	Control	Shelterbelt	Control	Shelterbelt	Control
Season 1	656	800	533	689	500	656	622	711	711	856
Season 2	655	811	567	767	533	700	722	911	767	911
Mean	656	806	550	728	517	678	672	811	739	883
Sig.L	*		**		**		*		**	
S.E±	30		13		17		20		11	
L,s,d	118		49		67		78		43	
CV.	10		5		7		7		4	

Table 5. Amount of irrigation water applied (m^3/ha) of Barley in shelterbelt and control plots in two seasons (2012/ 13 and2013/ 14).

Season	First season (2012/ 13)		Second season (2013/ 14)	
Treatments	**Water applied (m^3/ha mean)**	**Water saved as% of control**	**Water applied (m^3/ha mean)**	**Water saved as% of control**
Shelterbelt	604	23	649	26
Control	744		820	
Sig.l	*		*	
S.E±	17		19	
l.s.d	101		115	
C.V	4		5	

Table 6. Irrigation water use productivity (m^3/ha) of Barley fodder under shelterbelt and control plots season 2014.

Season 1	**2012/ 13**			
	Fresh yield		**Dry yield**	
Treatments	**Shelterbelt**	**Control**	**Shelterbelt**	**Control**
Yield(ton/ha)	13.6	9.3	4.7	3.3
Water applied (m^3/ha)	3022	3723	3022	3723
Irrigation water use productivity (m^3/ha)	0.01	0.002	0.002	0.001
Season 2	**2013/ 14**			
Yield(ton/ha)	12.7	9	4.3	2.7
Water applied (m^3/ha)	3244	4100	3244	4100
Irrigation water use productivity (m^3/ha)	0.004	0.002	0.001	0.0007

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