Current status of sweet orange (*Citrus sinensis* L.) orchards in the River Nile State, Sudan

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ABSTRACT

Production of sweet oranges in the Sudan does not cover domestic needs and sweet oranges are currently imported from Egypt, Iran and South Africa to satisfy the increasing demand. Hence, there is a need to investigate factors involved in the decline of sweet orange trees in one of the most important States for orange production in the Sudan. This research aims to study and evaluate different agronomic practices contributing to the prevailing sweet orange performance in the River Nile State, Sudan. A questionnaire and interviews with 120 sweet orange growers from Ketiab, Zeidab and Gandato citrus projects indicated that 75.8% of the farmers have orchards less than 2.9 ha. Low yielding cultivars such as “Sinnari”, the local selection (Baladi), Hamlin and Nori 16 dominate in the areas, 96.7% of the trees were budded on sour orange rootstocks, 85.8% of the seedlings were budded in private nurseries using bud wood collected from non-certified mother trees from private orchards. All sweet oranges were grown with other fruit species in 100% of the orchards, 80.8% used flat surface irrigation. There is no fixed fertilizer program. The type and quantity of chemical and organic fertilizers varied with different growers. No foliar fertilizers were used and nutrient deficiencies of Zn, Fe and Mn were observed in most orchards. Extension services for citrus production are highly needed for improvement of yield and quality of sweet oranges in the River Nile State.

INTRODUCTION

Cultural practices including tree spacing, pruning, irrigation and fertilization are known to influence citrus yield and fruit quality. Production of high yields of good quality citrus fruits needs properly managed irrigation and fertilization programs. Root systems of citrus trees are developed from the rootstocks utilized, which have direct effects on water and nutrient uptake and translocation. Rootstocks have several physiological and biochemical effects on plant development, productivity and fruit quality which are well documented in several citrus species (Kaplankiran and Tuzca, 1993; Protopapadakis *et al.*, 1998; Georgiou and Gregoriou, 1999; Kaplankiran *et al.*, 1999; Al-Jaleel and Zekri, 2003).

Sweet oranges are grown commercially in the River Nile State for more than seven decades. However, in spite of long experience in sweet orange production and suitable environmental conditions, production systems are far below the international standards. Old clones of local cultivars are dominant in the area, irrigation systems are traditional, there is a lack of fertilization and pruning programs and harvesting is practiced using traditional methods that damage the fruits and increase post harvest losses.

Hence, in order to solve the existing sweet orange production problems and plan for the future to have a sound sweet orange industry in the River Nile State, there is a need to investigate the factors involved in citrus production and quality.

Therefore, this research aims to study and evaluate different agronomic practices contributing to the prevailing sweet orange performance in the River Nile State.

MATERIALS AND METHODS

This study was intended to investigate the current status of sweet orange orchards in the River Nile State which is located between latitude 16^0 to 22^0N and longitude 32^0 to 35^0 E. The State lies within an arid climate of hot summer and warm winter and with a relatively very low annual rainfall mostly in July and August (25 mm). The amount of rainfall increases in the southern parts of the State and decreasing moving toward the north. Humidity is generally low with a peak of 45% in August and decreases to about 15% in April. Water resources depend on the River Nile and underground water.

Data collection included a questionnaire and interviews with sweet orange growers. A questionnaire was designed to evaluate agronomic cultural practices and status of sweet orange orchards in the River Nile State. One hundred and twenty sweet orange growers were selected randomly from the citrus projects in the River Nile State. The projects were Ketiab project, which consists of five divisions (Elnuba and Elfadnia, Ketiab, Jabrab, Hunnik and Musalamab), Zeidab and Gandato projects, to represent sweet orange growers in the River Nile State. The data were collected during May 2010.

The questionnaire covered the following :

1. Experience of citrus growers in sweet orange production.
2. Area of sweet orange orchards.
3. Cultivars of sweet oranges.
4. Rootstocks for budding sweet orange.
5. Source of sweet orange seedlings (own nursery, government nursery or private nursery).
6. Cultivation of other fruit species beside citrus in the same orchard.

7. Methods of surface irrigation, farmer's opinion and source of knowledge on methods of irrigation and irrigation interval.
8. Nutritional program : Use of a fixed fertilizer program and type and quantity of fertilizers.

Data were analyzed using Statistical Package for Social Sciences (SPSS) to calculate frequency distribution and simple percentage for descriptive analysis.

RESULTS AND DISCUSSION

Table 1 shows duration of farmer's experience in sweet orange growing at the River Nile State. More than 90% of farmers practiced orange cultivation for five to more than 20 years. This indicates that most farmers practiced sweet orange cultivation for a long time and have accumulated experience in sweet orange growing and they know very well the importance of orange production.

Table 1. Farmer's experience in sweet orange growing in the River Nile State (2010).

Duration of experience	Frequency	Percent
Less than 5 years	11	9.2
5-10 years	27	22.5
11-20 years	47	39.2
More than 20 years	35	29.2
Total	120	100.0

Table 2 shows the area of sweet orange orchards (ha) at the River Nile State. Results showed that 75.8% of the farmers have orchards of 2.9 ha or less. Elamin (2011) reported that small area of orchards is one of the factors limiting large scale fruit production in the Sudan. Elbashir and Imam (2010) reported that one of the most important factors limiting programs and plans of fruit export is the small holdings and poor cultural practices. On the other hand, small area of orange orchards has an advantage of easy management and can lead to high yield, especially if the technical packages are applied.

Table 2. Area of sweet orange orchards (ha) in the River Nile State (2010).

Orchard area (ha)	Frequency	Percent
0.42-1.3	66	55
1.7-2.9	25	20.8
3.4-4.2	22	18.3
More than 4.2	7	5.8
Total	120	100.0

Table 3 shows the most important sweet orange cultivars, rootstocks and source of seedlings. The results indicated that low yielding cultivars such as Sinarri", the local selection "Baladi", "Hamlin"

and "Nori 16" were dominant in the area. Ali-Dinar and Osman (1983) compared the performance of several sweet orange cultivars at Hudeiba Horticultural Research Station in the River Nile State and reported that the highest yield and juice content were obtained by "Frost Valencia" and the highest total soluble solids were found in "Butler Valencia".

The Valencia sweet orange group includes also Campbell, Diller and Olinda. Sidahmed and Geneif (1984) reported high yields of Butler and Campbell. The term "Baladi" cultivar is used for cultivars of unknown origin, mainly seedy and used for local consumption. "Nori 16" is probably a Valencia cultivar of unknown origin, grown for more than 50 years. Yields of "Nori 16" are generally low but it's area is increasing because it is a commercially seedless cultivar. Seedlessness is an important characteristic for citrus fruits for fresh consumption (Fitzpatrick *et al.*, 1991). Elbashir and Iman (2010) stated that one of the most important factors affecting programs and plans for fruit export is the absence of suitable cultivars.

Table 3. Cultivars, rootstocks and source of seedlings of sweet oranges in the River Nile State (2010).

Parameter	Frequency	Percent
Cultivars :		
Sinnari	48	40
Nori 16	36	30
Hamlin	18	15
Baladi	18	15
Rootstocks :		
Sour orange	116	96.7
Baladi lime	4	3.3
Source of seedlings :		
Own nursery	55	45.8
Government nursery	17	14.2
Private nursery	48	40.0

The results showed that sour orange is the main rootstock in the area and 96.7% of the trees were budded on sour orange rootstock. Sour orange performs very well in a wide range of soils including heavy clay soils (Ramin and Alirezanezhad, 2004). It produces fruits of good quality but it is known to be susceptible to tristeza virus and other diseases. Most of citrus producing countries have replaced sour orange with other citrus rootstocks. Rootstock trials need to be conducted in the area to select the best rootstock suited to high temperature, salinity and diseases prevailing in the area together with good fruit quality. Rootstocks such as Cleopatra Mandarin, Citrumelo, "Carizo" and "Troyer" citranges and Volkameriana, should be considered to replace sour oranges.

The source of bud wood for budding citrus is very important for producing healthy, high yielding trees of good fruit quality. Virus free bud wood from certified trees of the recommended cultivars must be used for propagation. The results indicated that 85.8% of the seedlings were budded in private nurseries using bud wood collected from non-certified mother trees from private orchards. Even in government nurseries, bud wood for budding is collected from private orchards. The results indicated the importance of establishing a program to produce virus free bud wood of the recommended cultivars.

Table 4 shows sweet orange orchards which have fruit tree species beside sweet oranges. There are no farms growing sweet oranges only. Sweet oranges are grown beside other fruit species such as mango, guava and banana. Results showed that 100% of the sweet orange orchards have fruit species other than citrus and 71.7% of the orchards grow mango with orange trees, while 15% grow banana and 13.3% grow guava. Generally, it is better to have orchards specialized in sweet oranges only. Other fruit species such as guava and mango are classified as host plants for fruit fly species (Gesmallah, 2009).

Table 4. Fruit species beside sweet oranges in orchards in the River Nile State (2010).

Parameter	Frequency	Percent
Fruit species :		
Mango	86	71.7
Banana	16	15.0
Guava	18	13.3

Table 5 shows methods of surface irrigation, farmer's opinion, source of knowledge on methods of irrigation and irrigation interval for orange trees. Results showed that 80.8% of citrus orchards use flat irrigation. Most of the farmer's thought that method of irrigation is good, very good and excellent (87.5%). Irrigation of the orchard as one piece, leads to the contact of irrigation water with tree trunks. This is not recommended because it leads to the spread of diseases, especially gummosis, between trees. Most of the farmers learned the method of irrigation from their grandfathers or neighbors (80.8%) and this result indicates the absence of agricultural extension role at the

River Nile State. Osman (2005) reported that the highest yield was obtained in orchards using double ring system. This was in agreement with the findings of Dawoud *et al.* (1992) who found that the most vigorous vegetative growth and highest fruit yield of citrus were obtained with the double ring system in New Halfa. Our results indicated that only 7.5% of the orchards use the double ring system.

Table 5. Method of surface irrigation, farmer's opinion, source of knowledge on method of irrigation and irrigation interval for sweet orange trees in the River Nile State (2010).

Parameter	Frequency	Percent
Method of surface irrigation :		
Connected single basins	7	5.8
Unconnected single basins	7	5.8
Flat (as one piece)	97	80.8
Double rings	9	7.5
Farmer's opinion on method of irrigation :		
Bad	14	11.7
Good	78	65.0
Very good	18	15.0
Excellent	9	7.5
Other	1	0.8
Source of knowledge of irrigation method:		
Grandfathers	70	58.3

Neighbors	27	22.5
Agricultural extension	17	14.2
Other	6	5.0
Irrigation interval (days) :		
7	9	7.5
10	45	37.5
15	60	50.0
Other	6	5.0

Roth *et al.* (1995) studied the performance of mature Valencia orange trees irrigated by pressurized irrigation systems such as trickle, bubbler, basin, spray and sprinkler systems, as compared with the traditional border-flood irrigation methods used in south western Arizona. Results indicated that mature Valencia orange trees could

be irrigated by trickle, bubbler or spray pressurized irrigation systems to produce high fruit yield and better quality, with 33% less water than the traditional methods. Ahmed *et al.* (2015) found that applying irrigation water using bubbler system improved quality parameters of Foster grapefruit. Also, bubbler irrigation system saved irrigation water by 68% and had the highest water productivity (2.7 kg/m^3) compared to surface irrigation (0.67 kg/m^3). The highest marginal rate of return was obtained with bubbler irrigation system compared to surface irrigation.

On the other hand, half of the respondents irrigate citrus trees every 15 days during fruiting stage. Many growers stated that they irrigate when they feel a real need of irrigation. Osman (2005) indicated that the highest yield in private orchards of the Gezira Scheme is obtained at irrigation interval of 7 days compared with 14 days. Dawoud *et al.* (1992) found that the maximum yields of citrus under New Halfa conditions were obtained at an irrigation interval of 10 days.

Production of high yields of good quality sweet oranges needs properly managed fertilization programs. Nitrogen is of particular importance in the arid regions of northern Sudan. In addition, citrus is known to respond to micronutrient fertilizers containing Zn, Mn, and Fe. Table 6 shows types of fertilizers, source of inorganic nitrogen fertilizer and quantity of inorganic nitrogen used by growers for fruiting orange trees. Our results indicated that there is no fixed fertilizer program. The type and quantity of chemical and organic fertilizers varied with different growers. Most of the respondents (82.5%) added organic manure with inorganic fertilizer. Most of farmers (94.2%) applied urea as a source of nitrogen and 56.5% of them applied 2 kgs of urea/tree/year, regardless of tree age. This indicates that most of them used excess amounts of nitrogen fertilizers. Our results also

Table 6. Type of fertilizers, source of inorganic nitrogen fertilizer and quantity of inorganic nitrogen for fruiting orange trees in the River Nile State (2010).

Parameter	Frequency	Percent
Type of fertilizers :		
Organic + inorganic nitrogen	99	82.5
Inorganic nitrogen + foliar	1	0.9
Inorganic fertilizer	20	16.6
Source of inorganic nitrogen fertilizer :		
Urea	113	94.2
Nitrophosca	5	4.2
KNO_3	2	1.6
Quantity of inorganic N (kg/tree/year):		
0.5 kg	11	9.2
1.0	17	14.2
2.0	68	56.7
3.0	11	9.2
4.0	12	10.0
5.0	1	0.7

indicated that no foliar fertilizers were used. Our observations indicated incidence of Zn, Mn and Fe deficiencies in many orchards. Hence, there is a need to study the effect of nitrogen source, rate and foliar application on yield and fruit quality in order to formulate a fertilizer program for sweet oranges in the area.

Table 7 shows type and quantity of organic manure which is added to the fruiting orange tree. Most of the farmers (78.3%) added sheep manure and 45.8% of them add 10kgs/tree/year. Elhassan *et al.* (2005) reported that sheep manure increased Foster grapefruit yield significantly over the control because it improved soil structure and soil-plant-water relationships.

The nutritional status of orange trees can be determined using leaf analysis. Orange leaf standards showing deficient, low, optimum, and excess levels of the essential nutrient levels are available (Salus, 2002). The use of leaf analysis as a method to determine fertilizer needs is not practiced by the farmers in the River Nile State and all of the farmers surveyed indicated that they did not use leaf analysis to diagnose the nutritional status of their trees.

Table 7. Type and quantity of organic manure added to fruiting orange trees in the River Nile State (2010).

Parameter	Frequency	Percent
Type of manure :		
Sheep	94	78.3
Chicken	21	17.5
Cow	5	4.2
Quantity of manure (kg/tree/year) :		
0.5	16	13.3
1.0	18	15.0
5.0	23	19.2
10.0	55	45.8
20.0	8	6.7

CONCLUSION

In conclusion, this study shows the improper cultural practices for sweet orange production which are followed in the River Nile State. Low yielding sweet orange cultivars were dominant in the area, most of citrus orchards use flat irrigation, which is not recommended and most of farmers use excess amounts of nitrogen fertilizers. Extension services are highly needed for improvement of yield and quality of sweet oranges in the River Nile State.

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الوضع الراهن لحدائق البرتقال (*Citrus sinensis* L.) في ولاية نهر النيل، السودان

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الخلاصة

إنتاجية البرتقال في السودان لا تغطي الاحتياجات المحلية، وحالياً يتم استيراد البرتقال من مصر وإيران وجنوب إفريقيا لتغطية الطلب المتزايد عليه. هنالك حاجة لدراسة العوامل التي تؤدي إلى الإنتاجية المتدنية لأشجار البرتقال في واحدة من أهم الولايات لإنتاج البرتقال في السودان. يهدف هذا البحث إلى دراسة وتقويم العمليات الفلاحية المختلفة التي تؤثر على إنتاجية البرتقال في ولاية نهر النيل. أوضح الاستبيان الذي أجري مع 120 مزارع برتقال في مشاريع الكتياب والزيداب وقندتو إلى أنّ 75.8% من المزارعين يمتلكون حدائق برتقال أقل من 2.9 هكتار. الأصناف المزروعة والسائدة في تلك المنطقة أصناف برتقال ذات إنتاجية قليلة وهي سناري وبلدي وهاملين ونوري 16. نسبة 96.7% من أشجار البرتقال مطعومه على أصل النارنج كما أن 85.8% من الشتول يتم تطعيمها في المشاتل الخاصة بإستخدام طعوم مأخوذة من أمهات غير معتمدة موجودة في المشاتل الخاصة. كل حدائق البرتقال تزرع معها أنواع أخرى من الفاكهة بنسبة 100% إضافة إلى أن 80.8% منها يتم ريها بواسطة الري السطحي. لا يوجد برنامج تسميدي ثابت. نوع وكمية السماد الكيميائي والعضوي مختلف بين المزارعين. لا تتم إضافة سماد ورقي على الأشجار وهنالك أعراض نقص في معظم الحدائق للزنك والحديد والمنجنيز. يوصى بتفعيل الخدمات الإرشادية لتحسين الإنتاجية والجودة للبرتقال في ولاية نهر النيل.