SHORT NOTE

Correlating sugarcane productivity in Halfa, Sennar and Kenana sugar cane schemes to time course and annual rainfall

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Sugarcane (*Saccharum officinarum* L.) has a long growing season, normally 15 to 16 months and is grown between latitudes 35° north and south of the equator (Abdel Wahab, 2009). There is shortage of information about sugarcane in the Sudan (Abbas and El-Hag, 2013). According to Abdel Wahab(2009), knowledge about water relations is fundamental to improved crop management in these regions. In fact, all sugar growing schemes in the Sudan were established in the arid and the semi-arid zones. In these zones, irrigation is costly (Mohamed, 2013). An important aspect of sugar cane management is the correct irrigation in terms of interval and amount. The objective of this study was to highlight some aspects of sugarcane productivity in relation to the time course and annual rainfall in three of the sugar schemes in the Sudan; Halfa, Sennar and Kenana, with the purpose of further improvement in their productivities.

Halfa lies in an arid climate, with the coordinates 15.32° north and 35.6° east. The mean annual rainfall for the period 1975-2004 is about 228.3mm/annum, with a standard deviation of 117.5 and a standard error of 21.4. The maximum annual rainfall was 543mm and the minimum was 33.4mm. Sennar lies in a semi-arid climate with coordinates13.55° north and 33.62°. The mean annual rainfall in Sennar Sugar Scheme for the period 1979-2014 is 365.3mm, the standard deviation is 102.9, and the standard error is 16.4mm. The maximum rainfall during the period was 580.7mm and the minimum was 174.7mm. Kenana lies in a semi-arid climate at latitude 13.10° north and longitude 32.40° east.The mean annual rainfall in Kenana sugar scheme for the period 1975-2005 is 371.1mm/annum with a standard deviation of 119.7 and a standard error of 23.0. Maximum annual rainfall was 641.9 mm and the minimum was 89.1 mm.

The data used consisted of annual rainfall for the periods of the study for the concerned areas and the annual productivity of both cane and sugar in each of the schemes. The data were obtained from the various schemes for the specified periods. Excel statistical package was used to correlate productivities to annual rainfall and time course.

Figure1a, b and c shows the time course of annual rainfall in the three schemes for the periods concerned. The trends were negative in both Halfa and Sennar, with a higher correlation coefficient for Sennar, while Kenana rainfall showed a rather positive trend with time. The decreasing trends in both schemes confirm many findings that Sudan rainfall was decreasing during the second half of the last century (Mohamed, 1998). Rainfall decreased in Sennar by about 2.5 mm/year on average between 1979 and 2014. In Halfa, it decreased by about 2 mm/year, and showed a big drop during the eighties while it increased in Kenana by about 3 mm/year on average. Figure2a, b and c shows the time course of cane productivities in the three schemes. The correlations were on average highly significant, in particular those of Sennar and Kenana, and the highest correlation significance and the lowest standard error were those of Sennar. Cane productivity increased steadily in the three schemes, with the highest slope for Kenana and Sennar and the lowest in Halfa. Each of the figures tells a unique story of progress. The details of Halfa figure show almost a sine wave function, with steeper peaks and crests. In fact, a lot of useful information can be obtained from each of these figures, for example about the periods of advance and periods of retreat, factors involved and so on. Figures3a,

b and c show the time courses of sugar production for the three schemes. Almost similar trends to those of cane were observed. However, in Halfa sugar productivity showed weaker correlation with time and lower significance compared to that of cane, while retaining the same shape of the trend. Both Sennar and Kenana showed stronger correlation and higher significance compared to those of cane. Sennar and Kenana sugar productivities increased steadily at rates of 0.06 and 0.09 tons/feddan each year compared to about 0.01 ton /feddan in Halfa.

Figure 4a, b and c shows the correlation between annual rainfall and the productivities of cane in the three schemes. Both Halfa and Sennar showed negative correlations, while Kenana showed a rather positive correlation. The correlation for Sennar is negative, strong and significant at P= 0.04, while those for Halfa and Kenana are week but useful indicators. The negative correlation may mean that the rainfall was utilized in these schemes, while the positive sign of Kenana may mean the contrary.

According to Binbol *et al* (2006), too much rainfall during time of planting and establishment stage was detrimental for the sugar cane setts and for the young plants, respectively, and therefore, rainfall was negatively correlated to sugar cane yield in Nigeria. However, as reported by Samui *et al* (2003), higher rainfall of about 800 mm contributed positively to increasing the yield of sugar cane in Uttar Pradesh. Sugar productivity on the other hand, was less affected by annual rainfall compared to cane productivity and particularly in Halfa which showed a rather positive correlation, which may need to be investigated. The correlations were positive and week for both Halfa and Kenana, but negative and strong for Sennar, and significant at P=0.02. Sugar productivity decreased with increasing rainfall in Sennar.

Figure 5a, b and c shows the correlations between the productivities of sugar and cane for each of the schemes. The correlations are highly linear and the significances are very high in particular that for Sennar. The figures show an attempt to predict, on relatively longer periods, the production of sugar from the productivities of both sugar and cane as can be seen from the equations on the figures. The equations show that an average productivity of sugar is obtainable from that of cane for each of the schemes. Figure5b for Sennar shows the highest correlation and the highest ratio which is about 0.1, while both Halfa and Kenana gave a ratio of about 0.09.

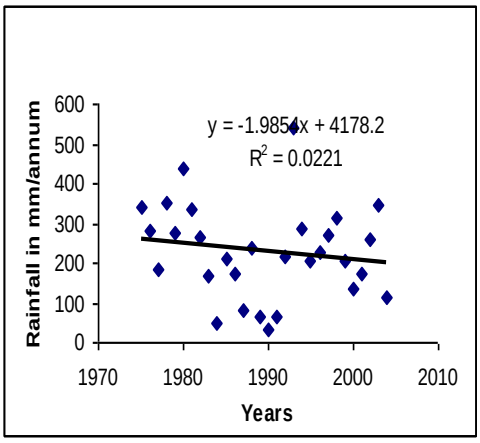

Fig.1a.Rainfall *vs.* years in Halfa Scheme.

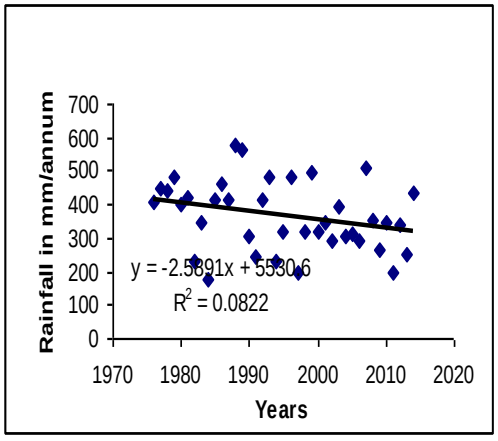

Fig.1b.Rainfall *vs.* years in Sennar scheme.

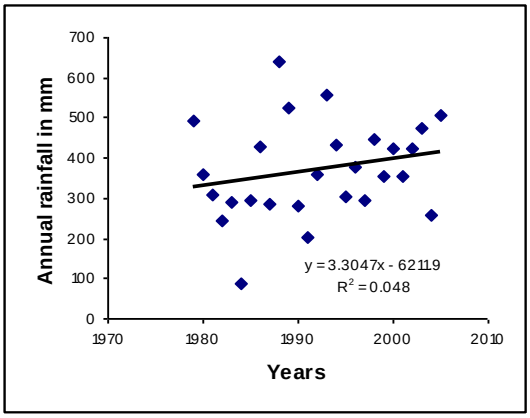

Fig.1c.Rainfall *vs.* years in Kenana scheme.

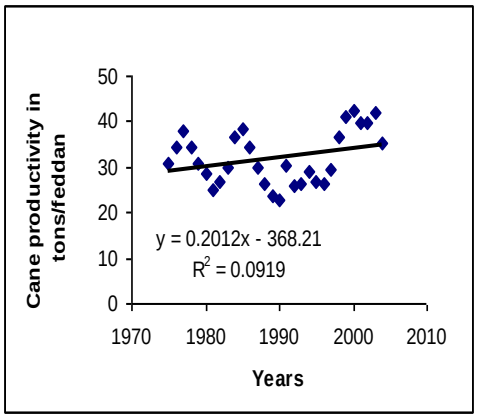

Fig 2a. Cane productivity *vs.* years in Halfa scheme.

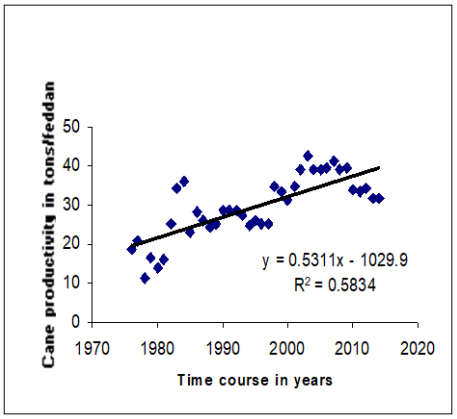

Fig.2b.Cane productivity *vs.* years in Kenana scheme

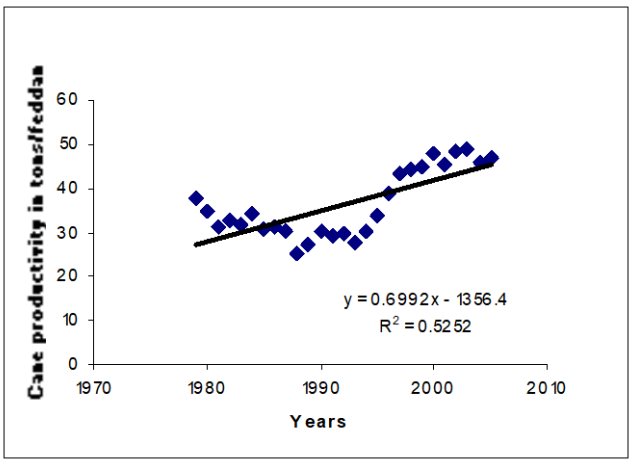

Fig.2c.Cane productivity *vs*. years in Sennar scheme.

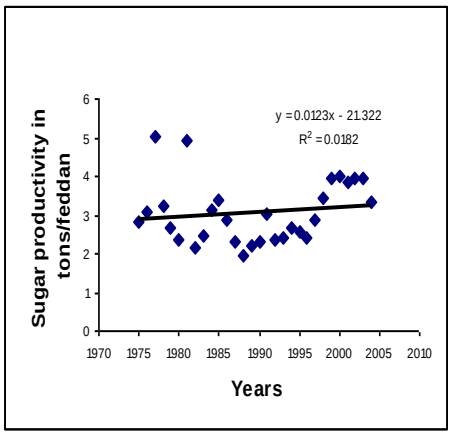

Fig.3a. Sugar productivity *vs*. years in Halfa scheme

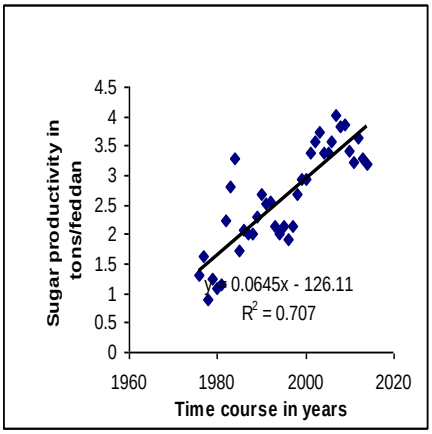

Fig.3b. Sugar productivity *vs.* years in Sennar scheme.

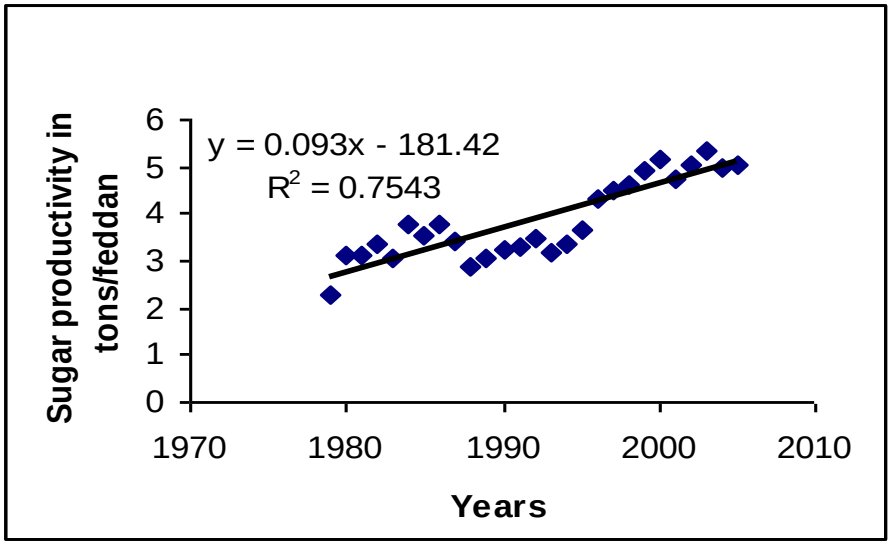

Fig.3c.Sugar productivity *vs.* years in Kenana scheme.

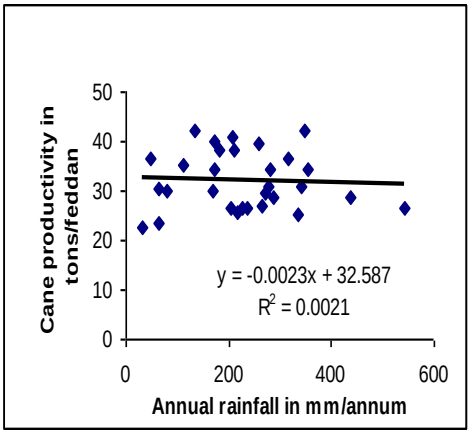

Fig.4a. Cane productivity *vs*. annual rainall in Halfa scheme.

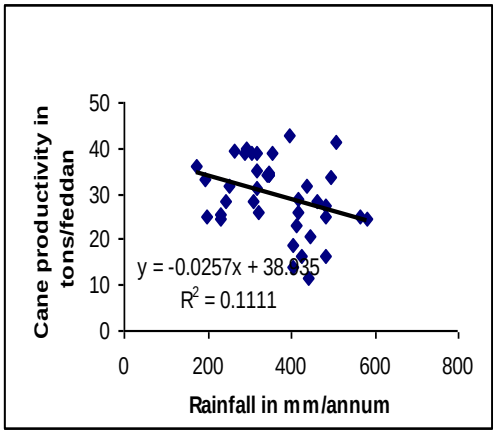

Fig.4b. Cane productivity *vs*. annual rainfall in Sennar scheme.

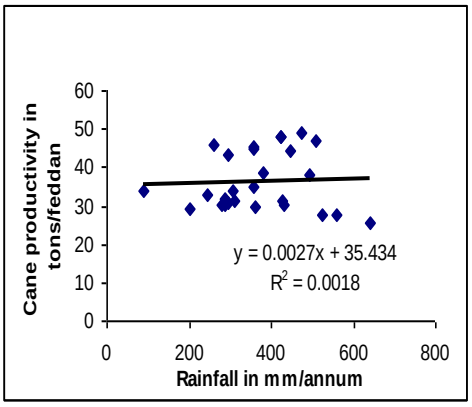

Fig.4c. Cane productivity *vs*. rainfall in Kenana scheme.

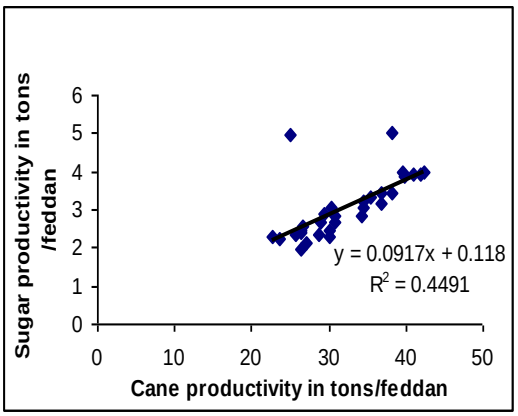

Fig.5a. Sugar productivity *vs*. cane productivity in Halfa scheme.

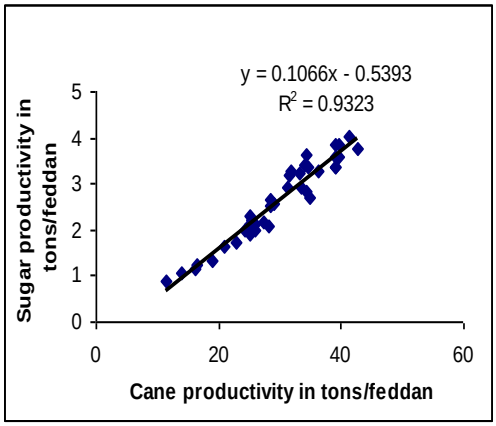

Fig.5b. Sugar productivity vs. cane productivity in Sennar scheme.

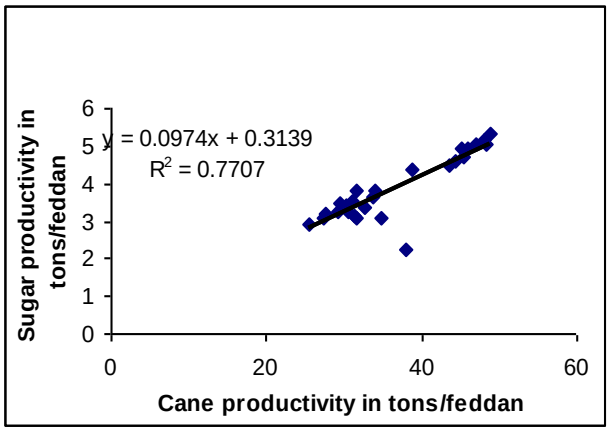

Fig.5c. Sugar productivity *vs*. cane productivity in Kenana scheme.

The following conclusions could be drawn:

- The annual productivity of sugar cane decreased with increase in annual rainfall in both Halfa and Sennar sugar schemes, but rather increased in Kenana scheme.
- The annual productivity of both cane and sugar increased progressively with time in both Kenana and Sennar sugar schemes, but the increase was small in Halfa sugar scheme.
- The ratio of sugar to cane productivities was almost stable with time at 0.09 for Halfa and Kenana and 0.10 for Sennar schemes.
- It is recommended that use should be made of the annual rainfall in both Halfa and Sennar schemes, and that other schemes may benefit from Sennar sugar experience of the higher sugar to cane ratio or index.

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العلاقة بين معدل انتاجية قصب السكر في مشاريع حلفا وسنار وكنانة ومعدل الأمطار السنوي والزمن

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الخلاصة

شملت هذه الدراسة ثلاثة من مشاريع السكر بالسودان وهى حلفا وسنار وكنانة وهدفت الى القاء الضوء على العلاقة بين انتاجية الفدان من القصب والسكر من جهة، ومعدلات الامطار السنوية تقدم الزمن من الجهة الأخرى. تم الحصول على معدلات الامطار للفترات المعنية للمشاريع الثلاثة وكذلك الحصول على معلومات الانتاجية من المشايع المعنية. استخدم برنامج التحليل الإحصائي (Excel) لإيجاد الارتباط بين الانتاجية والعوامل الاخرى. أوضحت الدراسة أن انتاجية الفدان من القصب انخفضت مع ازدياد المعدل السنوي للأمطار في كل من حلفا وسنار وعلى العكس ازدادت في كنانة. وأن انتاجية الفدان من القصب ازدادت مع الزمن وباستمرار في كل من سنار وكنانة و كانت الزيادة طفيفة في حلفا. وأن انتاجية الفدان من السكر ازدادت مع الزمن و باستمرار في كل من سنار وكنانة و كانت الزيادة طفيفة في حلفا. وأن نسبة انتاجية الفدان من السكر للقصب ظلت ثابتة مع الزمن وهى حوالى 0.09 في سنار. ويمكن اجراء المزيد من الدراسة للاستفادة من الامطار في كل من حلفا وسنار 0.1 في كل من حلفا وكنانة وحوالى كما يمكن الافادة من تجربة سنار فيما يتعلق بنسبة السكر الاعلى.