Variations in the Anatomical Structure of *Ailanthus excelsa* Wood with Height on the tree and Radial Distance from the pith

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Abstract: Microscopic slides were prepared from 12 locations on ailanthus trees representing three height levels and 4 radial locations at each height level with different distances from the pith. The slides included cross sectional slides and slides for macerated fibers. These slides were examined under the microscope and analyzed using stereological techniques to look for any variations or trends in the anatomical properties with height on the tree and radial distance from the pith. The results were analyzed statistically using analysis of variance and Duncan's Multiple Range test. Results revealed that the average fiber length decreased gradually from top height to bottom height. There were no significant differences in the volume fractions of cell components (cell walls and lumens) between different heights except for fiber lumen and parenchyma lumen, both of which showed a gradual decrease from top height to bottom height. There were no significant differences in volume fractions of different cell components between different zones (radial distance from the pith) except for vessel walls and Parenchyma lumens. With regards to volume fractions of the cell types, the volume fractions of vessels decreased from top height to bottom height, and also decreased from zone 1 to zone 3 and then increased in zone 4. With regards to cell dimensions, average vessel diameters decreased from top height to bottom height. They also decreased from zone 1 to zone 3 and then increased at zone 4- the same trend as for vessel volume fraction. Average fiber diameter increased from zone 1 to zone 4, but no trend was observed between heights. On the other hand, average parenchyma diameter showed the same trend as the vessel diameters with height- decreased from top height to bottom height. It also increased from zone 1 to zone 3 and then decreased in zone 4. Double cell wall thickness, on other hand, increased from top height to bottom height and also from zone 1 to zone 4.

Key Words: Wood structure, Variation trends, Stereological analysis

Introduction

Wood is a natural renewable resource. Its biological origin makes it such a variable material that man has very little control over its properties. It is produced by thousands of tree species grown around the world. In temperate zones the number of different tree species growing is relatively limited. However, in the tropics the number of species is in the thousands. For example, while in North America there are only a little over 100 tree species growing, in the Amazon River valley in Brazil about 3000 species have been identified. In some other parts of the world, such as the Malayan peninsula, more than 6000 wood producing tree species are believed to be native (Ifu *et al*,1978). The importance of such a study stems from the fact that almost all woodProper-ties and its utilization are affected by itsanatomical structure, and that wood being a natural material is very variable. Each tree species produces wood with characteristic structure and properties. In practice, these structural properties are used for wood identification. However, variability within a single species due to growth conditions, geographic origin, age and other characteristics of the tree make structural consistency less than ideal. Even within a single tree the structure of wood at the base of the trunk may be quite different from wood coming from branches. The most apparent differences between woods are in microstructure (Bowyer and Smith, 2003). All hardwoods or broad leaf species contain two systems of cells. These are longitudinal and transverse elements. The longi-tudinal elements include vessel, fibers, tracheids and parenchyma cells. While the transverse elem-ents include rays all those elements are identifiable under the microscope. The relative size and size distribution of those anatomical elements are species specific, but they may also be influenced by the environ-ment in which the tree was growing. In addition, there is an almost infinite variety of possible arrangements of the microstructural elements within the structure. Nonetheless, all these micro-structural features may be expre-ssed in some numerical form to allow quantitative characterization of the structure of wood (Nasroun, 1978).

Structural differences among woods lead to differences in physical and mechanical properties. It is generally accepted that the physical and mechanical properties of material depend on those of its components, and knowledge of the overall structure enables behavior of the whole to be predicted from that of its components (Desch and Dinwoodi, 1996): (Nasroun, 2005). Even within the same tree, anatomical structure and cell dimension may vary. The objective of this investigation is to study anatomical variations of ailanthus wood with tree height and across the trunk with radial distances from the pith. Previous studies on other species showed considerable variations in trends of anatomical properties with these zones.

Materials and Methods

The material used in this study was ailanthus wood (*Ailanthus excelsa*). It was collected from trees growing in Abojayly forest gerif land, Senar State. The sample trees were selected randomly, felled and three 20- cm discs were obtained from the tree – one from the base of the tree, one from top height and one from the middle of the tree.

Cross-sectional parameters

Sectioning blocks were taken from different locations of an ailanthus tree. These locations comprised three heights, bottom, mid and top heights. The bottom height disc was from 20 cm. above the ground level; mid height (2.5meters) above the ground and top height (4.5meters) above ground level. Disks were cut from each of these levels. From each disk samples were taken from four radial positions (zones) with different distances from the pith. Zone one being the outer most zones. This added up to three height levels and 4 radial zones making 12 locations. Cross- sectional microscopic slides were prepared from all these location using sliding micro-tome. These slides were analysed using stereological techniques looking for any variations in some anatomical properties between these locations. Slides were project-ted from a set up in the Faculty of Forest, University of Khartoum. The set up consisted of a microscope fitted with a camera and connected to a computer. The wood sections were projected from the microscope stage, through the camera onto the computer monitor (screen). A 16 - point square grid (12x12cm) was superimposed onto the projected image on the computer screen. The grid consisted of four horizontal lines intersecting with four vertical lines resulting in 16 intersection points which represented the test points. This is the set up for the stereological analysis for wood structure.

On each location a random point count (Pp) procedure was carried out on cell walls and lumens of fibers, vessels and parenchyma. This aimed at obtaining volume fractions for each component and cell type. Other counts made in the same fields included the numbers of intersection of horizontal test lines with boundaries of vessels, parenchyma, and fibers per unit length of test line (P_L) and the number of cells per unit test area (NA). The parameters calculated from the means of these counts were:

-Cross-sectional cell dimensions which were obtained using the following formulae:

-Ce diameter ($\bar{d}$)

$$\bar{d} = \frac{\bar{P}_L}{2\bar{N}_A} \quad (1)$$

-Fiber lumen diameters (LD)

$$LD = \sqrt{\frac{4 P_{P\,lumen}}{\Pi N_A}} \quad (2)$$

-Double cell wall thickness for fibers (DCWT)

$$DCWT = \bar{d} - LD \quad (3)$$

Fiber length

Thin layers or chips from the same locations as above were macerated using nitric acid of 60% concentration. This was allowed to boil in water bath four 5 minutes washed by distilled water and stained by safranine for one hour, immersed in alcohol for 5 minutes and washed by water.

The macerated material was shaken thoroughly to complete the separation of fibers which were mounted on glass slides using zayalin. The number of slides added up to 48 slides to represent all heights and zones. The slides were then displayed from the microscope through a camera onto computer screen using the same set up mentioned above. The 48 slides were selected system-atically to represent all heights and zones. The following stereological parameters were obtained: the number of points of intersection the horizontal test lines made with fiber boundaries per unit length of test line (PL) and the number of fibers per unit test area (NA).

From the means of these two stereological parameters fiber length (FL) was calculated from the following equation:

$$FL = \pi PL/2NA \quad (4)$$

Analysis of variance was carried out using SAS statistical software to determine any significant variations among the three levels of height and the four radial zones in all structural parameters.

Results and Discussion

Fiber Length

Table 1 shows the variation of fibers length with height and zone. The average fiber length, in the last column, decreased from the top height to bottom height. The fiber length at top height was 1.33mm while that at the bottom height was 1.25mm. The average fiber length for different zones decreased from zone 4 to zone 2 and then increased at zone 1. The highest value was 1.34 for zone one while the lowest value was for zone two (1.22mm). This does not agree with results obtained by Nasroun (1978) with other species, where there was a clear decrease of fiber length from outer zone to the inside. The same investigation showed no clear trend for the variation of fiber length with height. Taylor (1967), on the other hand, observed a steady decrease in fiber length with increased height. There was a lot of contradiction between the results of previous studies with respect to trends on these two directions. This is why this kind of study is being repeated from time to time. This was especially true for this study, because although the sizes of trees were large enough for use, there was an appreciable proportion of juvenile wood, which is not mature wood and has different properties. This makes it essential to make sure that the trees to be investigated must be mature enough.

Table 1 Variation of fiber length mm with height and zone

Heights	Fiber length with height and zone(mm)*				
	Zone1	Zone2	Zone3	Zone4	Averages
Top height	1.34	1.34	1.31	1.34	1.33
Mid height	1.4	1.22	1.38	1.11	1.28
Bottom height	1.3	1.12	1.16	1.42	1.25
Averages	1.34	1.22	1.28	1.29	

*Zone is the radial distance from the pith, 1 being the outer most while 4 is the inner-most zones**.**

Volume fractions for cell components

Table 2 shows the effect of height on volume fractions of different cell components was shown in table 2 Results showed that there were no significant differences in the volume fractions of cell components between the three heights except for fiber lumen and parenchyma lumen, which showed significant differences betw-een heights. However, vess-el walls showed a gradual decrease in volume fraction from top height to bottom height. The highest value was (0.08773) at top height, followed by 0.0783 for mid height and 0.0597 for bottom height. The vessel lumen also decreased gradually from top height to bottom height. The highest value was 0.1800 for the top height followed by 0.0940 for mid height and 0.0909 for the bottom height. The fiber wall showed no significant difference or any trend with height, while fiber lumen showed a significant decrease from top to bottom height. A significant difference was noted between top height and bottom height, but none of them was significantly different from mid height. A similar trend was obtain-ed with parenchyma lumen, but with signifi-cant difference between bottom height and the other two levels.

The effect of zone on volume fractions of different cell components was shown in Table3. Results indicated that there were no significant differences between zones in all cell compon-ents except vessel wall and parenchyma lumen. However, Parenchyma lumen did not show any trend with zones; vessel wall decreased significantly from zone 4 to zone two and then increased in zone one without a significant difference from others.

Table 2. Effect of height on volume fraction of different cell components

Heights	Volume fractions for different cell components					
	Vessel wall	Vessel lumen	Fiber wall	Fiber lumen	Parenchyma wall	Parenchyma lumen
Top height	0.08773 A	0.1800 A	0.1999A	0.1641A	0.1609A	0.1142A
Mid height	0.0783 A	0.0940 A	0.1945A	0.1601AB	0.1813A	0.1018A
Bottom height	0.0597 A	0.0908 A	0.2212A	0.1313B	0.1609A	0.0673B

Means with the same capital letter down the columns are not significantly different at p = 0.05.

Table 3.Effect of zone on volume fractions of different cell components

Zone*	Volume fractions for different cell components					
	Vessel wall	Vessel lumen	Fiber wall	Fiber lumen	Parenchyma wall	Parenchyma lumen
1	0.08563AB	0.10017 A	0.2014A	0.15277A	0.17490A	0.06063C
2	0.05447 B	0.1044 A	0.2270A	0.18153A	0.17077A	0.13630A
3	0.06903 AB	0.08357 A	0.18116A	0.13763A	0.20190A	0.07937CB
4	0.09190 A	0.10230 A	0.1912A	0.13557A	0.18987A	0.10430AB

Means with the same capital letter down the columns are not significantly different at p=0.05.
*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone

Volume fractions of cell types

The effect of height and zone on volume fraction of vessels as depicted by Table 4 which revealed that there was a gradual decrease in the average volume fraction, as seen in the last column, from the top height to bottom height; however, there was a gradual decrease in average volume fraction from zone 1 to zone 3 and increase in zone 4. There were no significant differences betw-een zones at mid height and bottom heights, while volume fractions showed significant differences between zones at top height. The highest volume fraction (0.2505) was obtained in zone 4. While the lowest value was at zone 3 mid heights with no trend.

Table 5 shows the effect of height and zone on volume fraction of fibers. Was shown in Table 5 indicated that there were no significant differences in volume fraction of fibers between the three heights in all zones. Likewise the volume fractions of fibers showed no significant differences between zones at all heights. The highest volume fraction (0.4255) was obtained at zone 2 at top height, while the lowest value was at zone 4 bottom height. For height averages the highest volume fraction was at top height followed by bottom height. The effect of height and zone on volume fraction of parenchyma cells as shown in table 6 indicates that there was a gradual increase in volume fraction from zone 1 to zone 3 and then dropped in zone 4 at top height. The volume fraction at mid and bottom heights showed significant differences, but no trend was observed. The highest values (0.3995) was obtained at mid height zone 2 and the lowest value (0.1940) was obtained at mid height zone1.

Table 4. Effect of height and zone on volume fraction of vessels

Heights	Volume fraction for different zones *				
	Zone1	Zone2	Zone3	Zone4	Average
Top height	0.2066Aab	0.1567Ab	0.1691Ab	0.2505Aa	0.1947
Mid height	0.1753Aa	0.1758Aa	0.1442Aa	0.1815ABa	0.1684
Bottom height	0.1755Aa	0.1443Aa	0.1445Aa	0.1506Ba	0.1537
Average	0.1858	0.1590	0.1526	0.1942	

Means with the same capital letter down the columns and the same small letter across columns are not significantly different at p=0.05
*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone.

Table 5 Effect of height and zone on volume fraction of fibers

Volume fraction for different zones *					Heights
Average	Zone4	Zone3	Zone2	Zone1	
0.3641	0.3557Aa	0.3251Aa	0.4255Aa	0.3501Aa	Top height
0. 3420	0.3193Aa	0.3251Aa	0.3876Aa	0.3263Aa	Mid height
0.3528	0.3055Aa	0.3062Aa	0.4135Aa	0.3863Aa	Bottom height

Means with the same capital letter down the columns and small letter across rows are not significantly different at p=0.05.
*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zones.

Table 6. Effect of height and zone on volume fraction of parenchyma cells

Volume fraction for different zone *					Heights
Average	Zone4	Zone3	Zone2	Zone1	
0.2763	0.2316Ba	0.3187Aba	0.2840Ab	0.2627Aab	Top height
0.2851	0.3030Ab	0.2440Acb	0.3995Aa	0.1940Ac	Mid height
0.2735	0.3479Aa	0.2811Aab	0.2256Ab	0.2499Aa	Bottom height

Means with the same capital letter down the column are not significantly different at p = 0.05
*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is inner-most.

Cell Dimensions

The effect of height and zone on vessel diameter was shown in Table7. The averages indicate that there was a decrease in vessel diameter from top height to bottom height. Averages for zones showed decease in diameter from zone 1 to zone 3 follow by increase in zone 4. This is the same trend as for vessel volume fraction. The highest value (0.2283mm) was in zone 1. This trend agrees with results obtained by Nasroun (1978). Zone1 is sapwood area where vessels are active in transporting water from root to crown and so they will be saturated with water and expanded to maximum limit. The bottom height had smallest vessel diameter may be because it has a bigger portion of heartwood which consists of dead shrinking cells. Table 9 shows the effect of height and zone on fiber lumen diameter. The height averages (last column) indicated no trend; while zone averages (bottom row) show an increase in diameters from zone 1 to zone 4. The lowest fiber diameters were at zone 1 and 2. This was opposite to vessel diameters, which were highest at these zones. This may be due to the fact that fibers may have been compressed by the expanded vessels at these zones.

Effect of height and zone on the diameter of fiber lumen (Table9) revealed that the zone averages indicated that there was a very gradual decrease from zone 1 to zone 4. The height averages increased from top to mid height and then dropped. The effect of height and zone on double cell wall thickness for fibers as shown in table 10 indicated that there is a gradual increase from top height to bottom height. Zone averages showed a gradual increase from zone 1 to zone 4, the same trend as fiber diameter. The effect of height and zone on parenchyma diameter is shown in table11. The height averages in the last column indicate that there was a gradual increase in diameter with the tree height. The highest value was obtained at top height (0.1728mm). The zone averages increased from zone 1 to zone 3 and then dropped. This also agrees with result obtained by Nasroun (1978).

Table 7.Effect of height and zone on vessel diameter (mm)

Vessel diameter for different zones (mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.2557	0.1713	0.2048	0.3038	0.3430	Top height
0.2025	0.2625	0.1822	0.1792	0.1861	Mid height
0.1692	0.1841	0.1500	0.1868	0.1560	Bottom height
	0.2059	0.1790	0.2232	0.2283	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone.

Table 8 Effect of height and zone on fiber diameter (mm)

Fiber diameter for different zones (mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.2349	0.2201	0.2760	0.2315	0.2123	Top height
0.2669	0.3482	0.2210	0.2648	0.2415	Mid height
0.2564	0.2422	0.2562	0.2375	0.2897	Bottom height
	0.2701	0.2510	0.2458	0.2478	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone.

Table 9 Effect of height and zone on the diameter of fiber lumen

Diameter of fiber lumen for different zones (mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.1163	0.1099	0.1256	0.1294	0.1005	Top height
0.1202	0.1177	0.1155	0.10007	0.1479	Mid height
0.0896	0.0750	0.0843	0.0747	0.1247	Bottom height
	0.1008	0.1084	0.1013	0.1243	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner

Table 10 Effect of height and zone on double cell wall thickness of fibers (mm)

Double cell wall thickness for different zones (mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.1186	0.1101	0.1504	0.10211	0.1177	Top height
0.1494	0.2305	0.1054	0.1684	0.0936	Mid height
0.1667	0.1671	0.1719	0.1628	0.1650	Bottom height
	0.1693	0.1425	0.1444	0.1234	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone.

Table 11. Effect of height and zone on parenchyma diameter (mm).

Parenchyma diameter for different zone(mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.1728	0.1845	0.1539	0.1799	0.1730	Top height
0.1639	0.1975	0.1654	0.2006	0.0921	Mid height
0.1268	0.1756	0.2567	0.2071	0.2280	Bottom height
	0.1977	0.2327	0.1958	0.1643	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone

Conclusions

Although not significantly different volume fraction of fiber wall increased gradually from top height to bottom height, in agreement with the fact that wood density is highest at the bottom of the stem. Vessel diameter averages were highest at zone1 which is the sapwood area where vessels are active in transporting fluids and thereby expanded. Average vessel diameters also decreased from top height to bottom height which consists of a bigger proportion of heartwood with dead compressed vessels.

References

Ifju, G, J, P. Chimelo and T.H Nasroun. (1978). Structure property relations for wood and wood products Proceeding of *Iner-American Symposim on Wood Engineering*, Brazil.

Bowyer, J. L. and Smith, R. I. (2003). *The nature of wood and products*. University of Minnesota,U.S.A.

Nasroun, T.H. (1978**)** *Quantitative microstr-uctural characteristics of seven tropical hardwoods and their relationship to paper making properties*. Ph.D thesis, Virginia State University, U.S.A.

Desch, H. E and J.M. Dinwoodie (1996) *Timber Structure, Properties, Conversion, and Use*. Macmillan Press Ltd 306 pp.

Nasroun, T.H. (2005) *Wood Properties and Technology*. Dar Alam AlKutub, Riyadh, Saudia Aribia 304 pp (Arabic).

Taylor, F. W. (1967). Variation in size and prop-erties of wood elements in popular trees. *Wood Science and Technology***.** **2** : 153 – 163.

الإختلافات في التركيب التشريحي لخشب الإيلانسس مع الإرتفاع على الشجرة والبعد عن النخاع

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المستخلص

تم إعداد شرائح مجهرية من 12 موقع على الشجرة تمثل ثلاثة مستويات إرتفاع وأربعة مواقع قطرية في كل مستوى إرتفاع تختلف في بعدها عن النخاع. و شملت الشرائح مقاطع عرضيه وشرائح للألياف المحررة. وتم تشخيص وتحليل هذه الشرائح باستخدام التقانه الاسترولوجيه لمعرفه الاختلافات التشريحيه على مستويات الارتفاع والبعد القطرى عن النحاع. اظهرت النتائج ان هناك انخفاضاً تدريجيا فى طول الالياف من المستوى الأعلى إلى المستوى القاعدى للشجرة.. لم تكن هناك فروق معنويه فى نسب مكونات الخلايا المختلفه(جدر وفراغات خلويه) بين مستويات الارتفاع الثلاثه إلا فى حاله فراغات الالياف و فراغات البرانشيمامع وجود إنخفاض فى الحالتين من مستوى الإرتفاع الاعلى إلى الإرتفاع القاعدى. كذلك لم تكن هناك فروق معنويه فى مكونات الخلايا مع البعد القطرى عن النخاع عدا جدر الأوعيه وفراغات البرانشيما. اما عن نسب انواع الخلايا المختلفه فقد أوضحت النتائج ان متوسطات نسبه الأوعيه قد تناقصت تدريجيا" من القمه إلى القاعده. وأظهرت النتائج ايضا أن قطر الأوعيه تناقص تدريجياً من مستوى الإرتفاع الاعلى الى مستوى الارتفاع القاعدى. كما اظهرت النتائج انخفاض متوسطات نسب الأوعيه فى الاتجاه القطرى من الموقع(1) (الابعد عن النخاع) الى الموقع (3) ثم إزدادت النسبه فى الموقع (4). ولم يظهر قطر الالياف أي توجهات خاصه مع الإرتفاع او الاتجاه القطرى. واظهرت النتائج ان قطر البرانشيما إنخفض تدريجيا" من مستوى الارتفاع الأعلى الى مستوى الإرتفاع القاعدى كما إزداد فى الإتجاه القطرى من الموقع 1 الى الموقع 3 ثم عاد وانخفض فى الموقع 4.

Critical Period of Weed Interference in Sesame (*Sesamum indicum* L.) in Dongola Locality, Northern State, Sudan

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Abstract: A field experiment was conducted at Altraa village, Sherg Elneel Unit, Dongola Locality, Northern State, Sudan, during two consecutive summer seasons of 2010 and 2011 to determine yield loss in sesame (*Sesamum indicum* L.) inflicted by weeds and to identify the critical period for weed interference. Sesame, cultivar Promo, was sown on 23 June in both seasons. A set of weeding regimes comprised of 12 treatments was arranged in randomized complete block design, with four replicates. The crop was kept weed-free for the first 2, 4, 6, 8 or 10 weeks after crop sowing and then remained weedy till harvest or kept weedy for the same periods and then remained weed-free till harvest. Weed free and weedy treatments till harvest were included as controls for comparison. Combined analysis of both seasons indicated that unrestricted weed growth significantly reduced sesame seed yield by 53.2% compared to weed free full season treatment. Seed yield decreased as the weed infestation period increased. Number of leaves/plant was significantly reduced by 58.93% under full season weed infestation. The same trend was observed for the first capsule height from the soil surface, plant height, and number of branches/plant. The critical period of weed competition was found to be between 2-6 weeks after crop planting.

Key words: The critical period, Weed competition.

Introduction

Sesame (*sesamum indicum* L) belongs to the Family Pedaliaceae. It is one of the most important vegetable oils and cash crops in the Sudan. It ranks third in area after sorghum and millet. It draws its importance from the fact that it is a food crop, raw material for industry, feed for livestock, as well as a leading export crop. Sesame is grown mainly in the rainfed sector under traditional and mechanized farming systems. However, the cultivated area and yield fluctuated from season to another due to variation in the production factors. Sudan is the second in volume of sesame exports as it cultivats 80% and 40% of the sesame area in the Arab world and African continent, respectively (Mohamed *et al*., 2008 and Abdel Rahman *et al*., 2009). Weeds constitute a serious obstacle in sesame production. They interfere with the utilization of land and water resources and thus adversely affect human welfare (Mukhtar and Elamin, 2011). Weeds are the major constraint to crop production in all cultivated areas in Sudan. Unrestricted weed growth promotes soil degradation in cultivated lands and reduces yield of the main crops by 50-100 % (Hamada, 2000). A critical period for weed competition (CPWC) is defined as the period in the crop growth cycle during which weeds must be controlled to prevent unacceptable yield losses. Controlling weeds based on CPWC is the most appropriate way to optimize weed control.

With the aid of CPWC it is possible to make decisions on the need for and timing of weed control and to control weeds only when required (Abdelmarouf, 2004 and Mukhtar and Hamada, 2011). The two approaches commonly used to determine the CPWC are i) the crop is kept free from weeds until a certain time, after which weeds are allowed to grow and ii) weeds are allowed to grow from the beginning to a certain time, after which they are removed until the end of the growing season (Mukhtar, 2006). If approach i) is followed, there is a minimum time limit called minimum time point weed free (MTPWF), until which the crop must be kept weed-free from the beginning of growth to avoid crop losses from weeds emerging thereafter. If approach ii) is followed, there is a maximum time limit, called maximum time point under weed infestation (MTPWI), after which the crop must be kept free from weeds emerging with crop to prevent competition causing yield loss. The time interval between (MTPWF) and (MTPWI) is defined as the CPWC (Mahgoub, 2002).

In Sudan, sesame received little attention and the available information is inadequate especially in the area of weed competition. The present study was, therefore, conducted to assess the magnitude of yield losses in sesame due to weed infestation and determine the critical period for weed competition.

Materials and Methods

A field experiment was conducted for two consecutive summer seasons of 2010 and 2011 at Altraa village, Sherg Elneel Unit, Dongola Locality, Northern State, Sudan. The area is located within latitudes 16° and 22° N, and longitude 20° and 32° E. It is true desert with extremely high temperatures and radiation in summer, low temperature in winter, scarce rainfall and high wind speed. The mean maximum and minimum temperatures are 36.8 and 19.5°C, respectively. The climate is hyper arid with a vapour pressure of 10.8 mb and a relative humidity less than 20% (Mukhtar, 2012).

The soil of the area is sandy clay loam, with 57.34% sand, 19.83% silt and 22.50% clay (Damirgi and Al-agidi, 1982). The land was ploughed, disc harrowed, leveled and divided into plots. A set of weeding regimes comprised of 12 treatments was arranged in randomized complete block design, with four replicates. The crop was kept weed-free for the first 2, 4, 6, 8 or 10 weeks after crop sowing and afterward remained weedy till harvest or kept weedy for the same periods and then remained weed- free till harvest. Weed free and weedy treatments till harvest were included as controls for comparison. Plot size was 5×4.2 m. Each plot was consisted of seven ridges, each five meters long. Sesame, cultivar Promo, was sown on 23 June in both seasons.Three seeds per hole were planted in ridges 60 cm apart and 20 cm between holes, on the ridges. The seedlings were later thinned to one plant per hole. Urea at 48 kg /fed was applied at thinning. In the weed free full season treatment, weeds were removed frequently by repeated hand weeding to keep the crop free from weeds till harvest. However, in the weedy full season treatment weeds were left to grow, unrestrictedly, with the crop until harvest. Irrigation water was applied at 7-10 days interval depending on temperature and other environmental conditions. The insecticide, Morisban, was applied to control the heavy infestation of termites in both seasons.

At 10 weeks from sowing, 5 plants were randomly selected from the two inner ridges in each plot. First capsule height from the soil surface, plant height, number of branches/plant and number of leaves/plant were determined. At harvest capsules from ten randomly selected plants in each treatment were cut, air dried and used for determination of yield characters including, number of capsules/plant, number of seeds/capsule and 1000 seeds weight. Plants from the inner 2 ridges (4×1.2 m.) was harvested in each plot, air dried, threshed, weighted and the total seed yield calculated.

The procedure described by Gomez and Gomez (1984) was used to estimate the combined analysis of variance (ANOVA), carried out on data obtained using the statistical analysis system (SAS) computer package for SAS Institute Inc., 1990, to detect significant effects among the treatments and populations. Mean squares for treatments or populations were calculated. Simple statistics including mean, standard deviation, standard error and coefficient of variation (C. V. %) were also calculated.

Results and Discussion

The weed flora in the experimental site consisted of grassy and broad-leaved weeds. The dom-inant weed species were *Cynodon dactylon* (L.) pers., *Sorghum arundinaceum*. (Dew.) Stapl, *Convolvulus arvensis* L., *Malva palvi-flora* L., *Cyperus rotundus* L., *Datura stram-onium* L., *Eruca sativa* Mill., *Sonchus oleraceus* L., *Amaranthus graecizans* L., *Tribulus terrestris* L., *Cassia italica* (Mill.) Lam. Ex Steud., *Desmostachya bipinnata*, *Tephrosia apollinea* (Del.) DC, *Echinochloa colona* (L.) Link, *Aerva javanica* (Burm. f.), *Euphorbia aegyptiaca* Boiss., *Calotropis procera* (Ait.) Ait. f., *Ipomoea cordofana* Choisy, *Lotus arabicus* L., *Rhynchosia memn-onia* (Del.) cooke, *Dactyloctenium aegyptium* (L.) Beauv, *Sporobolus pyramidatus* (Lam.) Hitchc., *Portulaca oleracea* L., *Corchorus olitorius* L., *Citrullus lanatus* and *Hyoscyamus reticulates*. Sesame is a plant which is extremely sensitive to weeds competition because it emerges more slowly than weeds. Weed competition for water, nutrients and light is one of the major factors limiting the yield of sesame as its seedling grows slowly during the first four weeks making it a poor competitor at earlier stages of crop growth (Bennett and Conde, 2003). Combined analy-sis of both summer seasons indicated that unrestricted weed growth significantly reduced sesame seed yield by 53.2% compared to weed free full season treatment (Table 1). This is in line with the finding of Grichar et al. (2011) who reported that, unrestricted weed growth could lead to high losses ranging from 65% to 95% in sesame crop yield. Also, similar results were reported by Zubair *et al.,* (2011) who showed that, insufficient weed control during early growth period of sesame causes yield reduc-tion between 35% to 70%. These results could be attributed to the presence of weeds which compete with the crop for essential mineral nutrients, water and light which reduce plant growth and decrease sesame yield.

Results of this investigation revealed that sesame seed yield increased when the duration of weed infestation period decreased. This supports the work of Grichar *et al.,* (2011) who reported that, sesame seed yield reduction by weeds was directly related to the duration of weed interference. The reduction in sesame seed yield due to weeds interference occurred mainly through reduction in yield components including number of capsules/plant, number of seeds/capsule and 1000 seed weight (Table 1).

The CPWC in sesame was between 2 and 6 weeks after crop planting (Table 1). This is in agreement with results obtained by Singh *et al*., (1993) and Mizan (2011) who reported that the CPWC in sesame was between 15 and 45 days after sowing. Moreover, the result was in line with that of Mizan *et al*. (2009) and Zubair *et al*., (2011) who showed that the CPWC in sesame was between 10 and 45 days after emergence.

However, the result obtained from this work is at variance with that of obtained by Grichar *et al*. (2001) who showed that, the CPWC in ses-ame is more than 50 days after seedling emergence. This is expected, because the CPWC is influenced by several factors incl-uding weed species, density or ground covered by weeds, the environment, plant density, time of weed competition, soil fertility and crop cultivar (Mahgoub, 2002 and Mukhtar *et al*., 2007). Growth parameters were adversely affected by weed competition. Number of leaves/plant was significantly reduced under full season weed infestation. The same trend was observed for the first capsule height from the soil surface, plant height, and number of branches/plant (Table 2).

It is evident that a weed-free period starting from 2nd to 6th week after sowing is necessary to provide high seed yield. To attain a weed-free environment in sesame, pre or post-emergence herbicides, mechanical and hand weeding during this period should be timed and adjusted to the critical period of weed competition only. In this, way use of persistent soil acting herbicides could be avoided and weed control treatments minimized.

Conclusions

Sesame seed yield decreased as the duration of the weed, period increased.

The reduction in sesame seed yield due to weeds interference was mainly through reduction in number of capsules/plant and number of seeds/capsule.

Combined analysis of both seasons indicated that unrestricted weed growth accounted for 53.2% loss in sesame seed yield.

The CPWC in sesame was between 2 and 6 weeks after crop planting.

Table 1: Effect of weed interference on seed yield and yield components during both seasons, combined

Treatments	Number of capsules/plant	Number of seeds/capsule	1000 seed weight (g)	Seed yield (kg/fed.)
Weed-free for 2 weeks 2	113.04a	51.90a	3.00a	261.60b
Weed-free for 4 weeks	133.05a	51.36a	3.50a	381.44a
Weed-free for 6 weeks	121.63a	49.00ab	3.30a	388.70a
Weed-free for 8 weeks	122.99a	47.84ab	3.50a	379.30a
Weed-free for 10 weeks	122.85a	51.58a	3.25a	362.30a
Weedy for 2 weeks	126.42a	47.01ab	3.00a	390.80a
Weedy for 4 weeks	123.43a	46.00b	2.50a	234.20b
Weedy for 6 weeks	105.03ab	47.30ab	3.50a	214.40b
Weedy for 8 weeks	106.45ab	49.30ab	3.25a	212.70b
Weedy for 10 weeks	93.40b	43.42b	3.50a	219.40b
Weed free full season	144.77a	54.94a	3.50a	411.33a
Weedy full season	55.90c	33.20c	3025a	192.50b
C.V%	20.16	07.53	24.05	27.85
S.E.±	9.02	0.29	0.41	24.93

-Means with the same letters in a column are not significantly different at 0.05 level of probability according to DMRT.

Table 2: Effect of weed interference on plant growth parameters during both seasons, combined

Treatments	First capsule height from soil surface (cm)	Plant height (cm)	Number of leaves/ plant	Number of branches/plant
Weed-free for 2 weeks 2	122.70a	164.70a	277.90a	9.80b
Weed-free for 4 weeks	120.80a	160.55a	258.80a	8.80b
Weed-free for 6 weeks	126.50a	167.50a	282.20a	9.90b
Weed-free for 8 weeks	122.80a	157.60a	284.70a	12.30a
Weed-free for 10 weeks	122.20a	161.10a	266.50a	11.90a
Weedy for 2 weeks	113.85a	157.10a	385.90a	15.20a
Weedy for 4 weeks	119.40a	157.90a	291.10a	12.30a
Weedy for 6 weeks	106.05a	137.90b	309.20a	8.20b
Weedy for 8 weeks	107.25a	137.15b	305.40a	8.40b
Weedy for 10 weeks	105.70a	129.60b	256.80a	10.30b
Weed free full season	129.70a	163.10a	367.20a	15.40a
Weedy full season	107.70a	148.70b	150.80b	7.50b
C.V%	8.47	9.53	29.80	42.33
S.E.±	6.06	6.51	35.97	2.24

-Means with the same letters in a column are not significantly different at 0.05 level of probability according to DMRT.

References

Abd Elrahman A. E; Saif Eldin, M. E and Faisal,E. A. (2009). Performance of Sesame (*Sesamum indicum* L.) genotypes under irrigation condition in Northern Sudan. *University of Khartoum Journal of Agricultural Sciences*, **17**(3): 333-343.

Abdel marouf, A. M. E. (2004). *Chemical weed control in faba bean (Vicia faba L.) using two foliar-applied herbicides*. M. Sc. Thesis. University of Khartoum, Sudan.

Bennett, M.K. and Condé, B. (2003). Sesame Recommendations for the Northern Territ-ory. Agnote **657**: 1-4.

Damirgi, S.M. and Al-agidi W. K. (1982). Soil Structure Types. Glossary of soil science Terms. P: 130-137.

Gomez, K. A. and Gomez, A. A. (1984). *Statistical Procedures for Agricultural Research, 2nd. Edition*. John Wiley and Sons, Inc. New York.

Grichar, J. W.; Dotray, A. P. and Ray Langham, D. (2011**).** Weed control and the use of herbicides in sesame production. Texas Agricultural Sesaco Corporation. pp: 41-72.

Grichar, W. J.; David, C. S.; Kevind, B.; Brent, A. B.; Charles R. S. and Dudley T. S. (2001). Sesame (*Sesamum indicum* L.) tolerance and weed control with soil-appl-ied–herbicides. *Crop production* ***20***: 389-394.

Hamada, A. A. (2000). Weeds and weed management in Sudan. *Journal of Weed Science Technology*, **45**(2): 131- 136.

Mahgoub, B. M. (2002). *Determination of Critical Period for Weed Competition in Maize (Zea mays L.) as influenced by Nitrogen Fertilizer Uptake and Chemical Weed Control*. Ph. D. Thesis, University of Khartoum, Sudan.

Mizan A.; Gebrmedhin, W. and Sharma, J.J. (2009). Sesame crop versus weeds: When is the critical period of weed control. *African Crop Science Conference Proceedings,* **9**: 591-593.

Mizan, A. (2011). Estimation of critical period for weed control in sesame (*Sesamum indicum* L.) in Northern Ethiopia. *Ethiopa Journal Applied Science Technolgy*, **2**(1): 59- 66.

Mohmed, E. A.; El Jack, A. A. and El Ahmadi, A. B. (2008). Implications of genotype x environment interaction in sesame (*Sesam-um indicum* L.)evaluation program. Sudan Journal of Agricultural Research, **11**: 35-44.

Mukhtar, A. M. (2006). *Weeds in maize-(Zea may s L.) (importance and control) with special reference to the North State of Su dan*. Ph. D. Thesis. Sudan University of of Science & Technology, Sudan.

Mukhtar, A. M.; Eltahir, S. A.; Siraj O. M. and Hamada, A. A. (2007). Effect of weeds on growth and yield of maize (*Zea mays* L) in Northern State, Sudan. *Sudan Journal Agricultural Research*, **8**: 1- 7.

Mukhtar*, A..M. (2012).* Weed survey on wheat in the Northern State, Sudan*. University of Khartoum Journal of Agricultural Sciences,* **20**(1): 26-43.

Mukhtar, A.M. and Elamin, S.E. (2011). Effect of some soil-applied herbicides on growth, yield and weed control in faba bean (*Vicia faba* L.). *University of Dongola Journal for Scientific Research*, **1**: 255 – 268.

Mukhtar, A.M. and Hamada, A. A. (2011). Weeds in maize (*Zea mays* L*.)* (Survey, competition and control) in Dongola area, Northern State, Sudan. *University of Dongola Journal for Scientific Research*, **1**: 371 – 397.

Singh, A. K.; Singh, R. P.; Singh, R. A. and Singh, C. M. (1993). Effect of time of weed removal on growth and yield of pigeon pea and sesame grown in association. *Ind-ian Journal of weed science*. **25**(8):12-16

Zubair, I.; Asif, T.; Muhammad, A.; Naeem,A.; Farhan, A. A.; Asghar, A. and Muhammad, M.M. (2011). Effect of Weed crop competition period on weeds and yield and yield components of sesame (*Seseamum indicum* L.)**.** *Paksitan Journal Weed Science Research.* **17**(1): 51-63

تأثير الحشائش على نمو وإنتاجية السمسم (.Sesamum indicum L) بمحلية دنقلا–الولاية الشمالية–السودان

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المستخلص

أجريت هذه التجربة بقرية الترعة، وحدة شرق النيل، محلية دنقلا، الولاية الشمالية، السودان، خلال موسمين صيفيين متعاقبين للعامين 2010 و2011) لتقويم الفقد فى إنتاجية السمسم (.*Sesamums indicum* L) الناجم من الحشائش وتحديد الفترة الحرجة لمنافسة الحشائش. تمت زراعة السمسم فى 6/23 فى الموسمين الصيفيين. شملت التجربة 12 معاملة صممت بإستخدام التصميم العشوائى الكامل بأربع مكررات. تمت إزالة الحشائش من المحصول لفترة 2، 4، 6، 8 أو 10 أسابيع بعد الزراعة وبعد ذلك ترك المحصول موبوءاً بالحشائش حتى الحصاد أو ترك موبوءاً لنفس الفترات وبعد ذلك ترك خالياً من الحشائش حتى نهاية الموسم. المعاملات الخالية من الحشائش والموبوءة بها حتى الحصاد تم تضمينها كشواهد للمقارنة. أشار التحليل المشترك للموسمين إلى أن منافسة الحشائش حدت معنوياً من إنتاجية السمسم بنسبة 53.2% مقارنة بالمعاملة الخالية من الحشائش طول الموسم. هذا وقد إنخفضت إنتاجية بذور السمسم بزيادة فترة منافسة الحشائش. منافسة الحشائش طول الموسم أدت إلى نقص معنوى فى عدد أوراق النبات بنسبة 58.93%. وقد لوحظ نفس التأثير مع إرتفاع أول كبسولة من سطح التربة، إرتفاع النبات و عدد الفروع فى النبات. الفترة الحرجة لمنافسة الحشائش تراوحت بين الأسبوع الثانى والسادس بعد زراعة المحصول.

Effect of Dietary Fenugreek Seeds (*Trigonella foenum*) as Natural Feed Addition on Broiler Chicks Performance

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Abstract: The objective of this study is to evaluate the effect of fenugreek seeds as natural feed additive in broiler diets. A total of 160 unsexed one-day Ross chicks were used in this study, the broiler chicks were divided randomly into four experimental groups, each experimental group included 40 chicks in four replicates (10chicks/replicate). The first experimental group represent the control and fed basal diet, while the other groups (from 2 to 4 received the basal diets) supplemented with fenugreek at 0.5% ,1.0% and 1.5% of diet respectively. The experimental groups were nearly equal in the live body weight at the start of the experiment. The experiment was extended up to 6 weeks of age. The results showed that the:-Live body weight at 6 weeks old, body weight gain, feed conversion ratio and protein efficiency ratio were significantly improved for chicks fed diets supplemented at o.5% or 1.5% as compared to control diet. -Higher values were obtained in average feed consumption for the groups fed with 1.5% while the lower values were recorded in groups fed diets with 0.5% and 1.0% during whole experimental period. Significant improvements in efficiency of energy utilization values in average feed consumption were recorded for the groups fed diets with o.5 and 1.5% during the experiment period.

Key words: *Fenugreek , Broiler and Performance* **.**

Introduction

Large number of feed additives available for inclusion in animal and poultry diets to improve animal performance. However, the use of chemical products especially hormones and antibiotics, may cause unfavourable side effects. Moreover, there is evidence indicating that this products could be considered as pollutants for human and threaten their health on the long-run. Attempts to use the natural materials such as medical plants could be widely accepted as feed additives to improve the efficiency of feed utilization and animal productive performance (Aboul-Fotouh *et al* .,1999).It was found that Fenugreek seeds is rich in protein, fat, total carbohydrates and minerals such as calcium, phosphorus, iron, zinc and magnesium (Gupta *et al*, 1996). Moreover Fenugreek benefits the digestive system (Sahalian, 2004).The objectives of this study is to investigate the effect of fenugreek addition at different levels (o.5%, 0.1% and 1.5%) into broiler diets on growth performance.

Materials and Methods:

Experimental chicks and diets:

The present study was carried out at department of animal production, Faculty of Agriculure, Sinnar University, Abu Naama. Total of 160 unsexed one-day-old Ross chicks
were used . The broiler chicks were divided randomly into four experimental groups. Each experimental group included 40 chicks in four replicates (10 chicks/replicate).The first experimental group represents the control and fed basal diets (table 1), the groups from 2 to 4 received the basal diets supplemented with fenugreek at different levels of 0.5, 1.0 and 1.50% of diet, respectively. The experimental birds were nearly equal in the live body weight at the start of the experiment. The experiment was extended up to 6weeks of age. The experimental period included two feeding phases (starter and finisher periods). The basal diets were 23% and 18% CP and 3100 and 3200kcal ME/kg diet of the starter and finisher respectively (table 1). Experimental diets were formulated to meet the nutrient

requirements of the broiler chicks (NRC,1984). Feed and water were supplied adlibitum during the experimental periods. Chicks were grown in brooders with raised wire floors and exposed to 24 hours of constant light (12 hrs on day light and the rest on artificial lighting, using 40 watt bulbs.). All chicks were kept under the same environmental and hygienic conditions. Individual body weight was recorded at one day, th, five and six weeks of age. Live weight, body weight gain, feed consumption, feed conversion ratio, protein efficiency ratio were recorded during the experiment period.

Statistical analysis:

The data obtained from the growth study was subjected to analysis of variance according to Steel and Torrie (1980), using a completel randomized design. The significance between treatments means determined using Duncan's (1955) multiple range test (DMRT).

Table (1): Percent Ingredients of experimental diets .

Ingredients	Starter diet(%)				Finisher diet (%)			
	0	0.5	1.0	1.5	0	0.5	1.0	1.5
Sorghum	66.5	66.5	66.5	66.5	67.00	67.00	67.00	67.00
Wheat bran	15.8	15.3	14.8	14.3	15.00	14.50	14.00	13.50
Sesame cake	05.0	05.0	05.0	05.0	07.00	07.00	07.00	07.00
Fish meal	09.0	09.0	09.0	09 .0	06.50	06.50	06.50	06.50
Lysine	00.6	00.6	00.6	00.6	00.05	00.05	00.05	00.05
Methionine	00.1	00.1	00.1	00.1	00.02	00.02	00.02	00.02
Sesame oil	02.2	02.2	02.2	02.2	03.13	03.13	03.13	03.13
Lime stone	00.4	00.4	00.4	00.4	00.90	00.90	00.90	00.90
Fenugreek	00.	00.5	01.0	01.5	00.00	00.50	01.00	01.50
Salt	00.4	00.4	00.4	00.4	00.40	00.40	00.40	00.40

Results and Discussion:

Chemical composition of fenugreek:

The chemical composition of fenugreek was showed in table (2) according to A.O.A.C (1990).

Table (2): Chemical Composition of fenugreek (FK) seed.

Item (%)	Fenugreek
Moisture	7.15
Dry matter	92.85
Organic matter	33.03
Crude protein	16.51
Ether extract	9.49
Total ash	7.15
NFE	33.82
ME(kcal/kg)	38.52

Live body weight and body weight gain:

Values of live body weight (LBW) and body weight gain (BWG) of the chicks fed on the experimental diets are shown in table (3) and table (4) respectively .There were significant differences in initial live body weight among different experimental groups. Significant increases in live body weight and body weight gain at 0-2, 2-4 and 4-6 weeks of the treated groups with fenugreek incomparison to control diet.

The obtained results are in agreement with that of El-Gharmy *et al*., (2004) who found that, addition of fenugreek chickens at 1.5% level had significantly ($p\leq 0.05$) heavier live body weight and body weight gain than those fed on control diet ,similarly, Morsy (1995) reported that there was a significant improvement in live body weight and body weight gain of Hubbard broiler chicks fed 500g fk/ton diet while no significant differences in live body weight and body weight gain were found for birds fed 1000g Fk/ton diet compared to the control diet at 6 weeks of age. Azooz (2001) reported that addition of FK at levels 1 and 1.5% diets (23% CP) containing two levels of metabolizable energy (3000 and 3200 kcal/kg) respectively, had no significant effect on body weight gain, while supplementation of FK to low energy diets (2800kcal/kg) up till 2% increased significantly ($p\leq 0.05$) body weight gain as compared with control diet.

Table (3): Effect of dietary Fenugreek on broiler live body weight and body weight gain/bird

Age	live body weight (gm) Fenugreek level			
	0%	0.5%	1%	1.5%
1day	43.20±o.66	43.67±o.70	43.21±o.76	43.52±o.68
2weeks	724.5±15.8 ^{b}	748.5±10.4^{ab}	762.6±11.6 ^{a}	748.1 ±8.5^{ab}
4weeks	1546.5±44.3 ^{b}	1628.2±32.6 ^{a}	1546.4±25 ^{b}	1616.7 ±19.1 ^{a}
6weeks	2191.7±72.5 ^{c}	2364.3b±50.7 ^{b}	2293.8^{c}±41^{b}	2461.3 ±33.5 ^{a}

Age	body weight gain (gm/day) Fenugreek level			
	0%	0.5%	1%	1.5%
2weeks	48.64±15.7 ^{b}	50.34 ±10.3 $^{a\,b}$	51.38±11.6^{a}	50.32±8.4 $^{a\,b}$
4weeks	58.70 ±34.8 ^{b}	62.83 ±27.0 ^{a}	55.98 ±18 ^{a}	62.00 ±15.4 ^{c}
6weeks	46.10±38.3 ^{c}	51.15±40.3 ^{b}	52.42 ±25.4 ^{b}	57.90 ±27.7 ^{a}

Means with similar letters with in the same row are not significantly different.
± SE

Feed consumption and feed conversion ratio:

Values of feed consumption (FC) and feed conversion ratio (FCR) of day old broiler chicks fed on experimental diets are shown in table (4). Birds fed 1.5%fenugreek recorded the highest values but birds given 0.5and 1% recorded the lowest values as compared to control group, this may be due to the change in the taste of feed, as reported by Stukie (1986) who indicated that, birds have a sense of taste. The best feed conversion ratio was obtained by birds given 0.5 FK diets while the lowest was obtained by the control group, similar trend was observed by Abdel – Latif ., *et al* (2002) in Japanese quail when reported that adding FK to the control diet at a level of 1000g Fk/ton diet improved feed conversion ratio while feed consumption values were declined. Morsy (1995) showed that no significant ($p\geq 0.05$) differences in feed consumption and feed conversion ratio when broiler chicks fed diets containing 500 or 1000g FK/ton as compared with control diets. Azooz (2001) found that no significant (p≥0.05) differences in FC and FCR between birds fed 1, 1.5, or 2% and control diet.

Table (4): Feed consumption and feed conversion ratio/bird

	Feed consumption (gm/day)			
	Fenugreek level			
Age	0%	0.5%	1%	1.5%
1day	59.60 ±79.8^{ab}	52.88 ±79.8 ^{a}	54.63 ±98^{ab}	58.00±54.0^{ab}
2weeks	99.60±158$^{a\ b}$	93.95 ±71 ^{b}	94.55 ±157$^{a\ b}$	101.04 ±177 ^{a}
4weeks	99.63 ±57^{b}	95.37 ±3.2^{b}	99.37 ±302 ^{b}	99.97 ±5.5 ^{b}
6weeks	118.10 ±111.3 ^{b}	107.97 ±35.5 ^{c}	110.8 ±114.9 ^{b}	115.78±121.7 ^{a}

	Feed conversion ratio			
	Fenugreek level			
Age	0%	0.5%	1%	1.5%
2weeks	1.96 ±0.08 ^{a}	1.72 ±0.04^{bc}	1.81 ±0.06^{abc}	1.76 ^{bc}±0.03^{bc}
4weeks	1.47 ^{a} ±0.05	1.30 ±0.03^{ab}	1.38±0.04^{ab}	1.42 ±0.02^{ab}
6weeks	1.87 ±0.10 a	1.73 b±0.11 b	1.98 a ±0.12a	1.86 a ±0.11 a

Means with similar letters are not significantly different.
± SE

Protein efficiency ratio and efficiency of energy utilization:

Results presented in table (5), showed that supplementation of fenugreek to broiler chicks significantly (p≤ 0.05) improve protein efficiency ratio values compared with the un-supplemented diets, there was no significant differences (p≥ 0.05) in efficiency of energy utilization values between chicks fed the different levels of FK compared with the control diet. Moreover significant (p≤ 0.05) improvements in efficiency of energy utilization for chicks fed diets containing 0.5 and 1.5% of fenugreek.

Table (5): Protein efficiency ratio and efficiency of energy utilization/bird

Age	Efficiency 0f energy utilization (EEU)			
	Fenugreek Level			
	0%	0.5%	1%	1.5%
2weeks	5.99±0.31	5.53±0.36	6.33±0.39	5.96±0.34
4weeks	7.96±0.88	7.00±0.47	6.28±0.25	7.16±0.52
6weeks	6.24±0.26[a]	5.53±0.12[bc]	5.84±0.20[abc]	5.49±0.09[bc]

Age	Protein efficiency ratio (PER)			
	Fenugreek level			
	0%	0.5%	1%	1.5%
2weeks	2.69±0.13[b]	2.92±0.20[a]	2.54±0.15[b]	2.70±0.16[b]
4weeks	2.16±0.14[b]	2.68±0.04[a]	2.67±0.10[a]	2.77±0.07[a]
6weeks	2.23±0.08[d]	2.55±0.06[bcd]	2.40±0.08[a]	2.47±0.04[abc]

Means with similar letters are not significantly different.
± **SE**

Conclusion and Recommendation:

Supplementation of fenugreek had significant effect for broiler chicks in live body weight, body weight gain, feed conversion ratio, protein efficiency ratio, feed consumption and efficiency of energy utilization.

Further Study is recommended for using fenugreek in layers rations.

References:

Abdel –latif,S.A;Faten.A.A.Ibrahim A. A and EL-kaiaty A. M. (2002). Effect of feeding dietary thyme, black cumin. Dianthus and fennel on productive and some metabolic responses of growing Japanese quail. Egypt poult.sci, 22(1): 106-125.

Aboul-Fotouh,GE; Shehat S.M.and Abdel-Azeem S. N. (1999). Effect of some medicinal plants as feed additives on performance of growing sheep.Egyptian j.Nutrition and feeds, 2(2):79-87.

Association of official Analytical chemists (A.O.A.C) 1990.Official methods of analy-sis, 15th edition, Washington, USA.

Azooz, H.M.M. (2001). Effect of hot pepper and fenugreek seeds supplementation on broiler diets Ph.D.Thesis.Faculty of Agric., Cairo university,Egypt.

Duncan,D.B(1955).Multiple range and multi-ple F test Biometrics,11:1-42

El-Gharmy,A.A;H.M.Azooz and A. T. El-Yamny (2004).Effect of hot pepper and fenugreek seeds supplementation to low energy diets Muscovy ducklings perfor-mance. Egypt. poult. Sci; 23(111):613-627.

Gupta,K;k.k.Thakral;S.k.Arora and M. l. Chowdhary (1996).Structural carbohy-drate and mineral seeds. Indian Coca Arecenut and species J, 20:120.

Morsy, M.M.A.(1995). The use of fenugreek (Trigonella foenum graecum), clove (Syzgium Aromaticum) in broiler nutrition as feed additives.M.Sc. Thesis, Fac. Of Agric, Alexandria Univ, Egypt.

NRC: 1984. National Research Council. Quail. In; Micro-livestock –Little known small animals with a promising future. Nation Academy Press. Washington D.C. PP. 147-155.

Sshalian,M. D.(2004).Diosgenin,a steroid sapo-nins of Trigonella foenum graecum (feungreek),inhibits azoxymethane-induced aberrantcrypt foci formation in HT-29 human colon cancer cells.prev.2004 Aug;13(8):8

Steel,G. D. R. and H. J. Torrie (1980).Principles and procedures of statistical Biometrical approach.p.633. 2nd.University of Wisconsin.

Stukie,P. D.(1986).Avian physiology.4th Ed. Published by Springe Verlag, NewYork, USA.

أثر إضافة الحلبة علي أداء الدجاج اللاحم

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المستخلص

الهدف من هذه الدراسة هو تقييم الحلبة كمضاف غذائي طبيعي في علائق كتاكيت التسمين. استخدم في هذه الدراسة عدد 160 كتكوت روس عمر يوم غير مجنس. وزعت الكتاكيت عشوائيا الي لأربع معاملات الأولى هي المجموعة المقارنة (الكنترول) بينما المعاملات الأخرى تحتوي على بذورالحلبة بمستويات مختلفة(5،% , 1،5%)على التوالي.متوسط اوزان الجسم للمعاملات التجريبية كان متساوي تقريبا في بداية التجربة . استمرت التجربة لمدة 6 اسابيع وأوضحت النتائج أن زيادة معنوية في متوسط وزن الجسم الحي و الزيادة الوزنية المكتسبة و تحسن ملحوظ في معدل التحويل الغذائي والكفاءة النسبية للبروتين للمعاملات المضاف اليها النسب 5،% أو 1،5 % مقارنة بالقياسية. سجلت الكتاكيت المغذاة على علائق بها 1،5% أعلى متوسط استهلاك للغذاء و كان اقل متوسط للغذاء للعلائق 5، %, 1% أثناء فترة التجربة. على علائق بها 5، %, 1% وجد تحسن ملحوظ في قيم كفاءة الاستفادة من الطاقة للكتاكيت المغذاة .

Effect of Slope of Grain on Modulus of Rupture and Modulus of Elasticity of Sunt (*Acacia nilotica*) Wood Grown in Blue Nile State, Sudan

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Abstract: This investigation dealt with the effect of grain angle on modulus of rupture (MOR) and modulus of elasticity (MOE) of sunt wood grown in Blue Nile State. Static bending test was carried out on samples with five different grain angles including zero angle i.e. clear wood with straight grain. From test results MOR and MOE were calculated for each slope of grain. Four grades were selected arbitrarily and suitable strength ratios were assigned to these grades. From the test results and using the strength ratios chosen, the MOR was calculated for each grade. Analysis of variance and Duncan's Multiple Range test were carried out, looking for the level of significance of the variations in MOR and MOE between the different grain angles. Regression analysis was also carried out for establishing relationships between each of MOR and MOE as dependent variables and grain angles as independent variables for estimating grain angles for different grades.. The values of MOR for each grade (MORg) were substituted in the model relating MOR to slope of grain to find the slope of grain for each grade. Highly significant differences were found between MOR for the different slopes of grain ($P < 0.0001$). Significant differences were also obtained between MOE for the different slopes of grain ($p = 0.0086$). Regression analysis resulted in a model for estimating MOR from the slope of grain or vice versa. The model is as follows:
MOR = 1986-3697.6×SG .Where: SG = slope of grain,
The model for MOE was as follows:
MOE = 173580 – 189299 × SG
Slopes of grain for first, second, third and forth grades were: 1/10, 1/6, ¼ and 1/3 respectively.
Key words: Mechanical properties, Stress grading, Structural wood

Introduction

A good understanding of material is a key to efficient utilization and sound engineering design. Timber is such a versatile material that its success lies partly in its attractive appearance, high strength-to-weight ratio and its workability, and partly in its availability at a competitive price (Nasroun, 1982). Although many of its traditional uses have been replaced by man-made plastics and fiber-composites, timber still remains a competitive material in many applications (Desch and Dinwo-odi, 1996). The importance of this study lies in the fact that we use small clear specimens for determining wood strength, for getting true comparison between strength of different timbers. But clear wood does not represent timber used for structural purposes which is of large sizes and contains strength-reducing defects. These strength reducing defects include: slope of grain, knots and checks.

The effect of these defects on strength must be determined and the strength of small clear specimens must be reduced according to the size of defect. This is the bases for stress grading of timber which is performed according to some grading rules. These rules define a number of grades (first, second, third grades) and assign different sizes of defects which should not be exceeded for each grade. Then a suitable strength ratio is defined for each grade (Nasroun, 2005); (Bowyer and Smith, 2003).

Formulation of stress grading rules of timber is based on the number and magnitude of some natural defects such as slope of grain, knots and checks. This investigation delt with the effect of grain angle on (MOR) and (MOE) of sunt wood grown in Blue Nile State. This is going to be the basis for visual grading of structural timbers as indicated in (BS 5756: 2007).

Materials and Methods:

Sunt (*Acacia nilotica*) wood from Blue Nile State riverine plantations was the material used for this investigation. It is an extremely variable species. The tree is 2.5-14 m high.

Bark on trunk is rough, fissured, grey brown or blackish; young branchlets are almost glabrous to sub tomentose. Stipules spinescent up to 8 cm long, straight, sometimes reflexed. Ant galls and other prickles absent (Elamin, 1990) . The wood is hard and heavy with high mechanical properties. It is used mainly for heavy construction and for railway sleepers. It is also very durable against wood destroying fungi and insects.

In this investigation planks of sunt wood were selected randomly from three trees. The planks were resawn into boards 5 cm thick. From each board sticks 3cm wide, with different grain angles were marked and cut. The marking of the slope of grain was made by a scribe as described in (BS 5756: 2007). The sticks were then planed to the cross-sectional dimensions of the standard bending specimen (20X20mm) and cross cut to pieces with the standard length (300mm). Static bending samples were prepared with five different grain angles including zero angle i.e. clear wood with straight grain. The slopes used included 1in 16, 1in 12, 1in 8, and 1in 6 (which means 1/16, 1/12, 1/8 and 1/6) It was a hard job trying to measure the slope of grain visually in the absence of new sophisticated facilities. It was measured twice before cutting the samples to length and before starting testing, the prepared samples were tested in static bending according to a modified British Standard (B.S.373, 1986). Small clear specimens were used for the control (without defects). The standard size of the static bending specimen is 20×20×300 mm. The tests were carried out on a universal testing machine.

From each test specimen the following data was recorded: maximum load at failure, load at proportional limit and deformation at proportional limit. The tests were carried out by a universal testing machine. From the obtained data MOR and MOE were calculated for each slope of grain according to the following equations

$$MOR = 3PL/2bd^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where:

MOR = modulus of rupture in kg/cm².

P is the maximum load at failure, in Kg
L is the length of span, in cm
b is the width of the test specimen, in cm
d is the depth, in cm

$$MOE = P'L^3/4\Delta' bd^3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where

MOE = modulus of elasticity in kg/cm²
P' is the load in Kg, at the limit of proportionality
L is the span, in cm
Δ' is deflection, in cm at the limit of proportionality
b is width, in cm
d is depth, in cm

Statistical Analyses

The experiment was of a completely randomized design with five levels of grain angle and 20 replicates for each angle. Analysis of variance and Duncan's Multiple Range Test were carried out, looking for the level of significance of variations in MOR and MOE between the different grain angles.

Regression analysis was also carried out for establishing relationships between MOR and MOE as dependent variables and grain angles as independent variables and estimating a grain angle for each grade. The relationship between grain angle and MOR was established for short duration ultimate stress.

Determination of slopes grain for selected grades

This was carried out for MOR only since MOE is not a stress. The first step was to select and name a number of grades and assign a reasonable strength ratio to each grade. The selection of these two parameters was arbitrary and depends on the quality of timber available in the country. The sawn timber produced from sunt plantations along the Blue Nile was considered of reasonable quality. This affected the choice of four grades with reasonable strength ratios.

The next step was to calculate the MOR for each grade (MORg) by multiplying the mean MOR obtained for clear wood ($\bar{X}$) by the strength ratio (as a ratio not in percentage). The final step was to find the slope of grain corresponding to each MORg value from the relationship established between MOR and slope of grain as shown by the model and the curve obtained from the regression analysis. This sequence for partial stress grading using grain angle can be summarized in the following:

First grade: Strength ratio (%) = 80

MORg (Kg/cm²) = X¯ × 0.8

Second grade: Strength ratio (%) = 65

MORg (Kg/cm²) = X¯ × 0.65

Third grade: strength ratio (%) = 50

MORg (Kg/cm²) = X¯ × 0.5

Fourth grade : strength ratio (%) = 40

MORg (Kg/cm²) = X¯ × 0.4

Where:

MORg = MOR for different grades

X¯ = Mean MOR for clear wood

The slope of grain for each grade was calculated by applying MOR for the different grades (MORg) to the regression model relating MOR to slope of grain.

Results and Discussion

Variation of MOR and MOE with slope of grain

Table (1) shows the effect of slope of grain on MOR and MOE and the separation of means. The table shows a continuous decrease in MOR with increased slope of grain. As expected the highest value was for clear wood (zero slope of grain) with significant differences from all other slopes of grain. This was followed by MOR's for 1/16, 1/12 and 1/8 with no significant differences between them but significantly different from the other two slopes of grain.

MOE also showed a continuous decrease with increased slope of grain. This decrease was not significant between the first four slopes of grain, also the MOE' s for the last three slopes of grain were not significantly different. The only significant differences were between MOE's of clear wood and 1/16 slope of grain, on one hand, and 1/6 slope of grain on the other. This also shows that MOR is more sensitive to changes in slope of grain than MOE

Table (1) .The effect of slope of grain on MOR and MOE

Slope of grain	Modulus of rupture MOR (kg/cm²)	Modulus of elasticity MOE (kg/cm²)
Straight grain	1992.3 a	171818 a
1/16	1750.8 b	163954 a
1/12	1642.2 b	156129 ab
1/8	1582.1 b	154805 ab
1/6	1345.1 c	138376 b

Means with the same letters down the columns are not significantly different

Table (2). shows the ANOVA table for MOR. The table shows highly significant differences in MOR between the different slopes of grain ($P < 0.0001$).

Table (2). ANOVA table for MOR.

Source of variation	Degrees of freedom	Mean of square	Pr > F
Slope of grain	4	1120771.88	< 0.0001
Error	95	114666.54	

Table (3). shows the ANOVA table for MOE. It reveals significant differences in MOE for the different slopes of grain ($p = 0.0086$). This p–value shows that MOE is not as sensitive to changes in slope of grain as MOR

Table (3). ANOVA table for MOE

Source of Variation	Degree of freedom	Mean square	Pr > F
Slope of grain	4	3101843300	0.0086
Error	95	856156618	

The relationship between slope of grain and MOR.

Regression analysis resulted in the following model for estimating MOR from the slope of grain or vice versa. The model is as follows:

MOR = 1986-3697.6×SG ………………. (3)
Where
SG = slope of grain
$R^2 = 0.2846$
The model is highly significant ($P < 0.0001$) but with a rather low R^2 value. as indicated above.

Relationship between slope of grain and MOE.

Regression analysis showed that the following model can be used to predict MOE values from the slope of grain or vice versa. The model is as follows:
MOE = 173580 – 189299 × SG …………….. (4)
Where
SG = slope of grain
R^2 = o. 1221
Again a significant model but with a low R^2 value. The low value of R^2 in both models is due to the enormous variability of wood as a natural material especially our hardwoods. This variability seemed to have masked some of the effect of slope of grain on MOR and MOE. The trends of MOR and MOE with slope of grain shown by the Multiple Range Test can also be seen from the slope of the regression line which is steeper in case of MOR than for MOE.

Slopes of grain for different grades

Determination of slopes of grain for different grades followed the procedure and steps indicated in Table (4). It began by selecting a number of grades and giving them names. The number of grades selected depended on the quality of wood available from sunt plantations. In our case four grades were selected namely: first, second, third and fourth. The second step was to assign a strength ratio to each grade. This choice was also arbitrary depending on quality of wood available. As the quality of timber produced from sunt plantation along the Blue Nile is of reasonable quality as compared to wood obtained from natural forests, we selected reasonably high strength ratio's. The strength ratio is the ratio of the strength of timber with defect to the strength of the same timber without defect (clear sample). Stress of defected timber (MORg) was calculated by multiplying mean MOR obtained for clear wood by the strength ratio for each grade (as a ratio not percentage) for example for first grade the MORg = 1992.3 × 0.8 = 1593.8.

The last row in Table 4 shows the slope of grain corresponding to each grade as calculated from equation 3 above.
Slope of grain for different grades:
MOR (g) = 1986 - 3701×SG

SG = (1986 – MOR (g))/3701
SG (1) = (1986 – 1593.8)/3701 = 0.10 = 1/10
SG (2) = (1986 – 1295)/3701 = 0.18 = 1/6
SG (3) = (1986 – 996.2)/3701 = 0.26 = ¼
SG (4) = (1986 – 796.2)/3701 = 0.32= 1/3

Table (4). Slope of grain for different grades

Grade	First	Second	Third	Fourth
Strength ratio	80%	65%	50%	40%
Stress(MORg) Kg/cm²	1593.8	1295.0	996.2	796.2
Slope of grain	1 in 10	1 in 6	1 in 4	1 in 3

The slopes of grain obtained in this investigation were rather high compared with those obtained by (Wilson, 1921) for some softwoods. This is due to the homogeneity of softwoods compared to the complex structure of our hardwoods and the enormous variability mentioned above. They were also higher than the permissible limits given in BS 5756: 2007 for tropical hardwoods, but they were comparable to permissible limits for tropical hardwoods with interlocked grain. This suggests that the samples used in this investigation might have had interlocked grain in some parts. Again the same standard showed that the permissible limits given for grade 2 general structural temperate hardwoods were comparable to the limits obtained from this investigation.

Conclusions

- MOR and MOE were significantly reduced by increased slope of grain.
- It appeared that the wide variation in the ultimate bending stresses among the 20 specimens tested for each grain angle affected the relationship between MOR and MOE on one side and slope of grain on the other by reducing R^2 values.
- The small size of sample (20 pieces for each grain angle) also contributed to the same above effect.
- MOE was less sensitive to changes in slope of grain than MOR

Recommendation

A further study is needed with a much larger sample size to eliminate the negative effect of wood variability on the results.

References

Bowyer, J. L. and Smith, R. I. (2003).*The nature of wood and wood products.* University of Minnesota, U.S.A.

British Standard BS 5756:(2007) Visual grading of hardwood – Specification. BSI.

BS 373 : 1957 (1986). *Methods of Testing Small Clear Specimens of Timber*. BSI, London.

Desch, H. E. and J. M. Dinwoodie. (1996). *Timber Structure, Properties, Conversion and use* (seventh ed. Revised by Dinwoodie). Macmillan Press Ltd. London.

Elamin, H. M. (1990). *Trees and Shrubs of the Sudan*. Ithaca Press Exeter 484 p

Nasroun, T. H. (2005). *Wood Properties and Technology.* Dar Aalam Alkutub. Riyadh, Saudi Arabia. 304 pp.

Nasroun, T. H. (1982). Specifying local timbers for structures. *Sudan Silva*. **IV (24)** : 38 – 51.

Wilson, T. R. C. (1921). The effect of spiral grain on strength of wood. *Journal of Forestry*. **19**. 740 – 747.

تأثير إنحراف إتجاه الألياف على معامل الانهيار ومعامل المرونة لخشب السنط النامي في ولاية النيل الأزرق – السودان

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المستخلص

إستهدفت هذه الدراسة تحديد تأثير انحراف اتجاه الالياف على معامل الانهيار ومعامل المرونة فى اخشاب السنط النامية فى الغابات النيليه بولاية النيل الازرق. ولتحقيق هذا الهدف تم اجراء اختبار الانحناء الاستاتيكي على عينات من خشب السنط بخمس درجات من انحراف الالياف بمافيها عينات مستقيمة الألياف (لا إنحراف فيها). ،. ومن نتائج الاختبار تم حساب معامل الانهيار ومعامل المرونة لكل درجة من درجات انحراف الالياف وتم إختيار اربعه درجات ة للأخشاب بطريقة إعتباطية. ومقابل كل درجه نسبه قوة تم تحديدها حسب نوعيه الاخشاب المتوفره. وباستخدام نسبه القوه تم حساب معامل الانهيار لكل درجه قوه .. وقد تم تحليل النتائج باستخدام تحليل التباين وتحليل الانحدار الخطي بين كل من معامل الانهيار ومعامل المرونة كمتغيرات تابعة وانحراف اتجاه الالياف كمتغير مستقل. وبتعويض معامل الانهيار لكل درجه قوه فى نموذج الانحدارالخطى الذى يربط معامل الانهيار بانحراف الالياف تم الحصول على درجات إنحراف الالياف لدرجات القوة المختلفه. واظهرت نتائج تحليل التباين فروق معنوية عاليه بين معامل الانهيار لدرجات انحراف الالياف المختلفة ($P<0.0001$). كما أظهرت النتائج أيضاً وجود فروق معنويه بين معامل المرونة لدرجات انحراف الالياف المختلفة ($P=0.0086$) . ومن نتائج تحليل الانحدار الخطي تم استنباط نموذج رياضي يحدد علاقة معامل الانهيار (MOR) بانحراف اتجاه الالياف والنموذج هو $MOR=1986-3697.6\times SG$ حيث SG= درجة انحراف الالياف. وكانت درجات إنحراف إتجاه الالياف للدرجات الأولى والثانية والثالثة والرابعة هي: 1/10 و1/6 و1/4 و1/3 على التوالي. وكان النموذج الرياضي لمعامل المرونة MOE كالآتي $MOE = 173580 – 189299XSG$ حيث SG = درجة إنحراف الألياف.

Importance of Indigenous Browse Species in Improvement of Livestock Feeds in Western Bahr El Ghazal State (Sudan).

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Abstract: The aim of this study was to investigate the importance of indigenous browse species in livestock production in South Sudan. The study was conducted in three villages of River Jur County in Western Bahr El Ghazal State namely "*Marial Bai", "Malwil"* and *"Kubri Kwanye"*. The area has an open to dense woodland savanna with livestock raising and subsistence agriculture being the main livelihood activities. Methodology used to collect data included tree cover assessment mainly density, relative density, height and browse level, to assess browse distribution in the area; in addition to a survey in order to evaluate the browse socio-economic aspect, and laboratory chemical analysis of the browse material to assess their nutritive components. The trees cover assessment indicated high tree density and diversification in the area, with tree density of 138 trees/ha, and relative browse species density of 6 spp./ha, and total tree density of 6 spp./ha. The results obtained in two different seasons, for the browse nutritive components for seven selected species included (*Grewia mollis, Leptadenia lancifolia, lablab* spp*.*, *Marsdenia abyssinica*, *Pterocarpus lucens, Strychnos spinosa and Balanites aegyptiaca*), indicated their relatively high crude protein levels, with averages ranged between 2% in *Grewia mollis* up to 15% in *Marsdenia abyssinica* during the dry season. DM, CF, E.E, and Ash contents ranged between 93.20%-97.50%, 24-62%, 1.60-6.80%, and 4.60-12.66% respectively. The results of the socio-economic survey indicated that, tree utilization for both forage and non-forage uses are important in the area. The respondents were able to identify a total (43) tree and shrub species as useful browse source for livestock. The survey also highlighted the browse species with multipurpose uses and their ethno-veterinary values. Multiple uses of some important browse trees included *Terminelia brownii* and *Hymenocardia acida*, in addition to water scarcity and absence of prescribed grazing system, were identified as most affecting factors that may hamper animals browse utilization in the area. It was concluded from the results of this study that, there is a wide range and diversification of types of trees and shrubs which included many important species with browse value in the area, whereas species with browse value showed to have potential level of nutrients mainly the crude protein. Pastoralist's indigenous knowledge was proved as significant in relation to browse knowledge and utilization. Water shortage particularly during dry season, and lack of prescribed range management, in addition to trees multiple uses, were identified as main problems to browse utilization in the area. The results of this study may be therefore used to direct the management and utilization of the browse resource in the area with the aim of achieving their conservation for improved animal feeding.

Key words: Browse Species, Livestock, Indigenous knowledge, Feed, Management.

Introduction

In the Sudan, natural rangelands contribute to about 77% of the feed available for livestock, while livestock population in the country according to the last census is estimated as 138 million heads (FMAR, 1976). Southern Sudan occupies a total geographical area of 640.000 square km. which is almost one third of the Sudan (Emilio, 2007). According to land use, this vast area is broken down into natural pastures, forests, grazable and other cultivable lands. This area had the largest livestock population estimated as 27% in Sudan and second to the Western region (Fadlalla, 1987).

The tropical woodland savanna, with very rich grasslands and open stand of trees and shrubs, represent the major grazing environment in Southern Sudan. These natural rangelands constitute an important forage source for Sudan livestock, raised particularly by the nomadic and pastoral tribes in the area, and those in Western and Central Sudan. Their livestock depend heavily on forests grazing during bad years and in their seasonal movement between North and South. Abusuwar (2007) reported that, forests in "Upper Nile" represents important grazing resources for pastoralists during summer and are used heavily. Therefore, it was estimated that, in tropical savanna, browse from trees and shrubs, represents animal feed during critical seasons particularly on ranges where grasslands are associated with open stands of trees and shrubs, spaced approximately as far as their heights (Le Houerou, 1980).

Browse is usually the primary and most economical source of nutrients for livestock, particularly meat goats. While it was reported that, goats as natural browsers, have the unique ability to select plants when they are at their most nutritious state, and that, goats which browses, have fewer problems with internal parasites. Pastures tend to be high in energy and protein when in a vegetative stage. As their plants mature, palatability and digestibility decline, thus it is important to rotate pastures so as to keep plants in a vegetative state. During the early part of the grazing season, browse species, composed of shrubs, trees, woody plants and weeds, tend to be higher in protein and energy than ordinary pasture (Schoenian, 2009).

The objectives of this study were therefore, to investigate the importance of the browse resources and their role in livestock production in South Sudan, through identifying the major species, estimating their nutritive components and to document indigenous knowledge of their uses.

Materials and Methods:

Study area

The study was conducted at Marial Bai, Malwil and Kubri- kwanye villages located in River Jur County in Western Bahr el Ghazal State. The three villages are 12, 7 and 6 miles from Wau town the capital city. The area lies in between 7º 53′ N and 25º 52′ E. It receives rainfall ranging from 900-1200mm. per year falling between April and October with short dry spells from mid-February to mid-March. The area is mainly inhabited by the agro-pastoral Dinka and Jur tribes. The key land use system is subsistence agriculture and livestock rising including cattle, goats, sheep and poultry.

Sampling and data collection

The Nearest Individual Method (Matthew *et al.,* 1993) was used to determine the density of trees and shrubs. A plot of standard size of 20x50m (Abusuwar, 2007) was marked on a randomly chosen browsed- site at "*Kubri kwanye"* village. Determination of the browsed plot depended on visual detection of browsing signs along the browsing level (Gaiballa, *et al.*, 2003). The first point was then marked and data for the nearest tree or shrub was determined and recorded included (distance, height, browsing level and tree or shrub name). Trees and shrubs distance from each sampling point was directly counted using a tape meter, while their heights and browsing level were determined using a clinometer readings from a known distance accordingly. This was then repeated until the required number of the sampling points totaling 20 was fulfilled. Similar measurements were repeated as for the assessment of their relative density. This plot was used to represent the study site, as for the other two villages, *Malwil and Kubri-kwanye*, in which the natural vegetation including shrubs and trees species, are homogenous.

Field records and relative part of questions on the survey questionnaire were directed to indicate the types and characteristics of the trees and shrubs included the most common and important species, particularly those with browse value.

A detailed questionnaire was conducted with seventy five (75) households in the three villages to cite the browse species they knew and which represent in their area. Pastoralists' indigenous knowledge on browse and their preference by cattle, sheep and goats was recorded as well as other utilization of browse species. Names of species were given in either Dinka or Luo dialects, then identified by the corresponding scientific names using a textbook (Thirakul, 1984). Average households in each village were about (250), and each was covered with (25) questionnaires, thus representing 10% of the total households respectively. The questionnaire composed up of almost (40) open to closed questions concentrated on tree types, tree animal's relationship, uses and their socio-economic values (Onwuka, *et al*., 1990). During the survey, focused group discussions with livestock keepers were conducted to identify species being considered important as livestock feed or having other outstanding use. Their knowledge on these aspects, particularly these shrubs and trees as potential feed for livestock was recorded. In most cases the respondents were either agro-pastoralists or farmers.

The sampling for chemical analysis was done twice; early in the rainy season in (2008) and late in the dry season in (2009). Species selected were those nominated by the pastoralists within the focused group discussions as best known browse trees and shrubs in the area. These included (*Grewia mollis, Pterocarpus lucens, Balanites aegyptiaca, Leptadenia spp, Lablab, Strychnos spinosa and Marsdenia abyssinica*). One kg. browse material (including leaves, twigs and tender branches) of each sample was collected from its tree or shrub; air dried and sent to Animal Production College Lab. in Khartoum for their chemical analysis.. Results obtained covered dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (E.E), and ash.

Data Analysis

The data from the questionnaire survey were analyzed using the Statistical Package for the Social Sciences (SPSS). Means, showing significance differences at probability level $P < 0.05$ were compared using the Chi-square program. The data from browse trees cover assessment including density, total and relative densities, were analyzed and calculated using the relative standard equation as follows respectively: Total density = (*Total Distances ÷Number of points*); Trees density = (*10.000 ÷ 2(average/species)²* and (*Relative density =species /frequency ÷ Number of trees ×Trees density*). The data from the sampling for nutritive components assessment were chemically analyzed using the (AOAC, 1995) method.

Results and Discussion

The current state of the browse in the study area

The Pastoral Community

The results of the socio- economic survey indicated the status of some of the main aspects that highlight important personal characteristics of the pastoral community including age groups, income, education and gender.

The results indicated that the Dinka and Jur pastoralists have unique indigenous knowledge on browse use in the area. The results indicated that, the knowledge obtained in the survey is significantly reliable as to the maturity of the respondents whom the majority was above 40 to 60 years in age (Table 1). They were able to identify and to name the different tree types as well as those with browse value in the area using their local dialects or common Arabic. The knowledge reported by female respondents on the browse species and their uses was similar to that reported by the male respondents. This finding indicates that women are part in the livestock management activities. This could be attributing to the role livestock resource play in the community. These results are comparable to the findings of Preston, (2008) who stated that, Dinka lifestyle centres on their animals, the roles within the groups, beliefs, systems and the rituals they practice all reflect this.

Table 1. The percentages of age groups among the respondents

Category	Percentages
Less than 20	16%
20- 40 years	29.3%
41- 60 years	44%
Over 61 years	10.6
Df.	**3**
SIG.	***

The browse trees of the area

According to the field survey and feedback of the respondents based on their indigenous knowledge, a total of (43) indigenous browse tree and shrub species were identified representing potential source of browse for their livestock (Table 2). Consequently, they were able to tell the different aspects of their utilization (Table 3).

Table 2. Some important indigenous browse species of the study area

Local name	Scientific name	Family
1. Abola (Luo.dia.)	*Annona senegalensis*	Annonaceae
2. Rit (Luo/Din.dia.)	*Anogeissus leiocarpus*	Combretaceae
3. Ushier (Din.dia.)	*Acacia albida*	Mimosoideae
4. Kakamut (Ar.)	*Acacia polyacantha*	Mimosoideae
5. Garad (Ar.)	*Acacia nilotica*	Mimosoideae
6. Akiro (Luo.dia.)	*Albizia amara*	Mimosoideae
7. Bei (Luo.dia.)	*Afzelia africana*	Caesalpinioideae
8. Thau (Luo/Din.dia.)	*Balanites aegyptiaca*	Balanitaceae
9. Abinaj (Luo.dia.)	*Burkea africana*	Caesalpinioideae
10. Dorot (Ar.)	*Combretum glutinosum*	Combretaceae
11. Akud kuda (Luo.dia.)	*Detarium microcarpum*	Caesalpinioideae
12. Dual yat (Luo.dia.)	*Marsdenia abyssinica*	Asclepiadaceae
13. Amboloto (Ar.)	*Entada africana*	Mimosoideae
14. Jumeiz (Ar.)	*Ficus spp.*	Moraceae
15. Apaba (Luo.dia.)	*Grewia mollis*	Tiliaceae

16. Doung (Luo.dia.)	*Gardenia lutea*	Rubiaceae
17. Akanga (Luo.dia.)	*Hymenocardia acida*	Euphorbiaceae
18. Um-shatur (Ar.)	*Kigelia africana*	Bignoniaceae
19. Mahogany (Ar.)	*Khaya senegalensis*	Meliaceae
20. Akuar (Din.dia.)	*Leptadenia lancifolia*	Asclepiadaceae
21. Lablab (Ar.)	*Lablab purpureus spp.*	Papilionoideae
22. Alana (Luo.dia.)	*Pterocarpus lucens*	Papilionoideae
23. Upat (Luo.dia.)	*Piliostigma thonningii*	Caesalpinioideae
24. Homeid (Ar.)	*Sclerocarya birrea*	Anacardiaceae
25.Akwalkwala (Luo.dia.)	*Strychnos spinosa*	Loganiaceae
26. Dorot (Ar.)	*Terminalia brownii*	Combretaceae
27.Chuah (Luo/Din.dia.)	*Tamarindus indica*	Caesalpinioideae
28. Kurnyuk (Ar.)	*Vitex doniana*	Verbenaceae
29. Alemo (Luo.dia.)	*Ximenia americana*	Olacaceae
30. Lang (Luo/Din.dia.)	*Ziziphus spina christi*	Rhamnaceae

(Luo.dia.)= Luo dialect, (Luo/Din.dia)= Luo and Dinka dialects, (Ar.)= Arabic.

According to the respondents, nearly all the domesticated ruminants in the survey area consumed browse species. Browses were utilized in both wet and dry seasons. Certain browse species are deciduous, while others keep leaves late in the dry season. Field investigation showed that, most species are widespread in Jur River and Raga Counties. Both leaves and pods are used by various kinds of livestock and wildlife. It was observed that; the browse identified included a number of legume trees such as *Entada africana, Pterocarpus lucens, Albizzia amara, Prosopis africana, Tamarindus indica* and *Dalbergia melanoxylon*, which respondents described as of good feed source for their animals.

The *Lablab spp., Strychnos spinosa, Grewia mollis, Leptadenia spp., Hymenocardia acida* and *Ziziphus spina christi* were reported by the respondents as the most known browse shrubs, while *Pterocarpus lucens, Balanites aegypti-aca, Combretum glutinosum,* and *Terminelia spp*. are the common browse trees respectively. Comments made by the respond-ents on the use of browse species in the area were comparable in many cases with that of Smith, (1986) on browse use in tropical Africa, These findings are in accordance with Wickens (1969) and Giffard, (1971) who reported the important browse species in the humid tropical West African zone.

The results of this study showed that most of the tree and shrub species found in the area are used in a way or another as feed source by the animals with some being quite reliable source of fruits or edible leaves for human consum-ption. This is similar to the reports by Wickens (1980) who stated that at least 75% of the 7,000 to 10,000 species of trees and shrubs in tropical Africa are used as forage. This may therefore be used as indicator that the browse resource in the area is high compared to other parts of the Sudan.

Table 3. Utilization of some browse species by livestock as assessed by the respondents

Species	Animal species	Edible plant parts
Annona senegalensis	sheep, goats	Leaves, twigs
Anogeisus leiocarpus	sheep, goats	Leaves, flowers
Afzelia africana	Cattle, sheep, goats	Leaves
Butyrospermum paradoxum	Goats	Fruits
Ficus spp.	Cattle, sheep, goats	Leaves, twigs, fruits

Tree Types

The findings of the current study indicated that the majority of the tree species in the area belongs to the families *Mimosoideae*, *Combre-taceae, Caesalpinioideae*, and *Anaca-rdiaceae*. Consequently, field observations revealed that, most of the common browse species identified in the study concentrate in these families (Table 2). These findings are comparable to Toutain (1980) who reported that, from the tree and shrub types of the Sudanian zone, *Piliostigma reticulatum, Isoberlina doka, Tamarindus indica, Entada Africana, Parkia clappertoniana, Terminelia spp., Anogeissus leiocarpus, Pterocarpus lucens, Gardenia lutea, Butyrospermum paradoxum* and many others, are among the common browse species of the tropical savanna in the area. These species were reported by the respondents in the present study as important browse species. Further, similar comments were made by Norton (1994) that the *Caesalpinioideae* and *Mimosoideae* tree fami-lies which contain about 2,800 species each, most are trees of tropical savannah and forests of Africa.

The majority of the tree types encountered during the study appeared to be of the decidu-ous, broadleaf which constitute the main feature of the natural flora in the area. This observation may be a positive indicator of browse availability on natural rangelands in the area.

Distribution

Based on observations and field investigations, findings on trees distribution in the area, indicated that types that are used to a varying degree for browse are naturally widespread within the woodland savanna in the area, in the lower areas, and along the Jur River banks. These areas represent common sites for grazing in the surveyed area. Moreover, around the towns, villages and on farm plots in the surveyed area, most of these species also exist. Acacia species including *Acacia seyal, Acacia sieberana*, *Acacia polyacantha* and *Acacia nilotica* were observed in good stands over the plain areas with wet habitat locally called ‘Toj’ particularly in “*Marial Bai*”. Other common browse shrubs and small trees such as *Hymenocardia acida, Grewia mollis, Annona senegalensis* and *Gardenia lutea* combine high frequency with high local abundance on certain sites, forming predictable coverage that domin-ates several hundred square kilometers of the forest at each site. This finding may indicate a quantitatively available browsing site compared to rangelands with more open and scattered tree stands.

Table (4) summarizes the results obtained for the assessment of trees cover distribution in the area. These results may help to create picture on varying relationships of trees, certain tree species and particularly those with browse nature within the limits of their range to the mass of the other tree species present in the area.

Variations in the Anatomical Structure of *Ailanthus excelsa* Wood with Height on the tree and Radial Distance from the pith

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Abstract: Microscopic slides were prepared from 12 locations on ailanthus trees representing three height levels and 4 radial locations at each height level with different distances from the pith. The slides included cross sectional slides and slides for macerated fibers. These slides were examined under the microscope and analyzed using stereological techniques to look for any variations or trends in the anatomical properties with height on the tree and radial distance from the pith. The results were analyzed statistically using analysis of variance and Duncan's Multiple Range test. Results revealed that the average fiber length decreased gradually from top height to bottom height. There were no significant differences in the volume fractions of cell components (cell walls and lumens) between different heights except for fiber lumen and parenchyma lumen, both of which showed a gradual decrease from top height to bottom height. There were no significant differences in volume fractions of different cell components between different zones (radial distance from the pith) except for vessel walls and Parenchyma lumens. With regards to volume fractions of the cell types, the volume fractions of vessels decreased from top height to bottom height, and also decreased from zone 1 to zone 3 and then increased in zone 4. With regards to cell dimensions, average vessel diameters decreased from top height to bottom height. They also decreased from zone 1 to zone 3 and then increased at zone 4- the same trend as for vessel volume fraction. Average fiber diameter increased from zone 1 to zone 4, but no trend was observed between heights. On the other hand, average parenchyma diameter showed the same trend as the vessel diameters with height- decreased from top height to bottom height. It also increased from zone 1 to zone 3 and then decreased in zone 4. Double cell wall thickness, on other hand, increased from top height to bottom height and also from zone 1 to zone 4.

Key Words: Wood structure, Variation trends, Stereological analysis

Introduction

Wood is a natural renewable resource. Its biological origin makes it such a variable material that man has very little control over its properties. It is produced by thousands of tree species grown around the world. In temperate zones the number of different tree species growing is relatively limited. However, in the tropics the number of species is in the thousands. For example, while in North America there are only a little over 100 tree species growing, in the Amazon River valley in Brazil about 3000 species have been identified. In some other parts of the world, such as the Malayan peninsula, more than 6000 wood producing tree species are believed to be native (Ifu *et al*,1978). The importance of such a study stems from the fact that almost all woodProper-ties and its utilization are affected by itsanatomical structure, and that wood being a natural material is very variable. Each tree species produces wood with characteristic structure and properties. In practice, these structural properties are used for wood identification. However, variability within a single species due to growth conditions, geographic origin, age and other characteristics of the tree make structural consistency less than ideal. Even within a single tree the structure of wood at the base of the trunk may be quite different from wood coming from branches. The most apparent differences between woods are in microstructure (Bowyer and Smith, 2003). All hardwoods or broad leaf species contain two systems of cells. These are longitudinal and transverse elements. The longi-tudinal elements include vessel, fibers, tracheids and parenchyma cells. While the transverse elem-ents include rays all those elements are identifiable under the microscope. The relative size and size distribution of those anatomical elements are species specific, but they may also be influenced by the environ-ment in which the tree was growing. In addition, there is an almost infinite variety of possible arrangements of the microstructural elements within the structure. Nonetheless, all these micro-structural features may be expre-ssed in some numerical form to allow quantitative characterization of the structure of wood (Nasroun, 1978).

Structural differences among woods lead to differences in physical and mechanical properties. It is generally accepted that the physical and mechanical properties of material depend on those of its components, and knowledge of the overall structure enables behavior of the whole to be predicted from that of its components (Desch and Dinwoodi, 1996): (Nasroun, 2005). Even within the same tree, anatomical structure and cell dimension may vary. The objective of this investigation is to study anatomical variations of ailanthus wood with tree height and across the trunk with radial distances from the pith. Previous studies on other species showed considerable variations in trends of anatomical properties with these zones.

Materials and Methods

The material used in this study was ailanthus wood (*Ailanthus excelsa*). It was collected from trees growing in Abojayly forest gerif land, Senar State. The sample trees were selected randomly, felled and three 20- cm discs were obtained from the tree – one from the base of the tree, one from top height and one from the middle of the tree.

Cross-sectional parameters

Sectioning blocks were taken from different locations of an ailanthus tree. These locations comprised three heights, bottom, mid and top heights. The bottom height disc was from 20 cm. above the ground level; mid height (2.5meters) above the ground and top height (4.5meters) above ground level. Disks were cut from each of these levels. From each disk samples were taken from four radial positions (zones) with different distances from the pith. Zone one being the outer most zones. This added up to three height levels and 4 radial zones making 12 locations. Cross- sectional microscopic slides were prepared from all these location using sliding micro-tome. These slides were analysed using stereological techniques looking for any variations in some anatomical properties between these locations. Slides were project-ted from a set up in the Faculty of Forest, University of Khartoum. The set up consisted of a microscope fitted with a camera and connected to a computer. The wood sections were projected from the microscope stage, through the camera onto the computer monitor (screen). A 16 - point square grid (12x12cm) was superimposed onto the projected image on the computer screen. The grid consisted of four horizontal lines intersecting with four vertical lines resulting in 16 intersection points which represented the test points. This is the set up for the stereological analysis for wood structure.

On each location a random point count (Pp) procedure was carried out on cell walls and lumens of fibers, vessels and parenchyma. This aimed at obtaining volume fractions for each component and cell type. Other counts made in the same fields included the numbers of intersection of horizontal test lines with boundaries of vessels, parenchyma, and fibers per unit length of test line (P_L) and the number of cells per unit test area (NA). The parameters calculated from the means of these counts were:

-Cross-sectional cell dimensions which were obtained using the following formulae:

-Ce diameter $(\bar{d})$

$$\bar{d} = \frac{\bar{P}_L}{2\bar{N}_A} \quad (1)$$

-Fiber lumen diameters (LD)

$$LD = \sqrt{\frac{4 P_{P\,lumen}}{\Pi N_A}} \quad (2)$$

-Double cell wall thickness for fibers (DCWT)

$$DCWT = \bar{d} - LD \quad (3)$$

Fiber length

Thin layers or chips from the same locations as above were macerated using nitric acid of 60% concentration. This was allowed to boil in water bath four 5 minutes washed by distilled water and stained by safranine for one hour, immersed in alcohol for 5 minutes and washed by water.

The macerated material was shaken thoroughly to complete the separation of fibers which were mounted on glass slides using zayalin. The number of slides added up to 48 slides to represent all heights and zones. The slides were then displayed from the microscope through a camera onto computer screen using the same set up mentioned above. The 48 slides were selected system-atically to represent all heights and zones. The following stereological parameters were obtained: the number of points of intersection the horizontal test lines made with fiber boundaries per unit length of test line (PL) and the number of fibers per unit test area (NA).

From the means of these two stereological parameters fiber length (FL) was calculated from the following equation:

$$FL = \pi PL/2NA \quad (4)$$

Analysis of variance was carried out using SAS statistical software to determine any significant variations among the three levels of height and the four radial zones in all structural parameters.

Results and Discussion

Fiber Length

Table 1 shows the variation of fibers length with height and zone. The average fiber length, in the last column, decreased from the top height to bottom height. The fiber length at top height was 1.33mm while that at the bottom height was 1.25mm. The average fiber length for different zones decreased from zone 4 to zone 2 and then increased at zone 1. The highest value was 1.34 for zone one while the lowest value was for zone two (1.22mm). This does not agree with results obtained by Nasroun (1978) with other species, where there was a clear decrease of fiber length from outer zone to the inside. The same investigation showed no clear trend for the variation of fiber length with height. Taylor (1967), on the other hand, observed a steady decrease in fiber length with increased height. There was a lot of contradiction between the results of previous studies with respect to trends on these two directions. This is why this kind of study is being repeated from time to time. This was especially true for this study, because although the sizes of trees were large enough for use, there was an appreciable proportion of juvenile wood, which is not mature wood and has different properties. This makes it essential to make sure that the trees to be investigated must be mature enough.

Table 1 Variation of fiber length mm with height and zone

Heights	Fiber length with height and zone(mm)*				
	Zone1	Zone2	Zone3	Zone4	Averages
Top height	1.34	1.34	1.31	1.34	1.33
Mid height	1.4	1.22	1.38	1.11	1.28
Bottom height	1.3	1.12	1.16	1.42	1.25
Averages	1.34	1.22	1.28	1.29	

*Zone is the radial distance from the pith, 1 being the outer most while 4 is the inner-most zones.

Volume fractions for cell components

Table 2 shows the effect of height on volume fractions of different cell components was shown in table 2 Results showed that there were no significant differences in the volume fractions of cell components between the three heights except for fiber lumen and parenchyma lumen, which showed significant differences betw-een heights. However, vess-el walls showed a gradual decrease in volume fraction from top height to bottom height. The highest value was (0.08773) at top height, followed by 0.0783 for mid height and 0.0597 for bottom height. The vessel lumen also decreased gradually from top height to bottom height. The highest value was 0.1800 for the top height followed by 0.0940 for mid height and 0.0909 for the bottom height. The fiber wall showed no significant difference or any trend with height, while fiber lumen showed a significant decrease from top to bottom height. A significant difference was noted between top height and bottom height, but none of them was significantly different from mid height. A similar trend was obtain-ed with parenchyma lumen, but with signifi-cant difference between bottom height and the other two levels.

The effect of zone on volume fractions of different cell components was shown in Table3. Results indicated that there were no significant differences between zones in all cell compon-ents except vessel wall and parenchyma lumen. However, Parenchyma lumen did not show any trend with zones; vessel wall decreased significantly from zone 4 to zone two and then increased in zone one without a significant difference from others.

Table 2. Effect of height on volume fraction of different cell components

Heights	Volume fractions for different cell components					
	Vessel wall	Vessel lumen	Fiber wall	Fiber lumen	Parenchyma wall	Parenchyma lumen
Top height	0.08773 A	0.1800 A	0.1999A	0.1641A	0.1609A	0.1142A
Mid height	0.0783 A	0.0940 A	0.1945A	0.1601AB	0.1813A	0.1018A
Bottom height	0.0597 A	0.0908 A	0.2212A	0.1313B	0.1609A	0.0673B

Means with the same capital letter down the columns are not significantly different at p = 0.05.

Table 3.Effect of zone on volume fractions of different cell components

Zone*	Volume fractions for different cel onents					
	Vessel wall	Vessel lumen	Fiber wall	Fiber lumen	Parenchyma wall	Parenchyma lumen
1	0.08563AB	0.10017 A	0.2014A	0.15277A	0.17490A	0.06063C
2	0.05447 B	0.1044 A	0.2270A	0.18153A	0.17077A	0.13630A
3	0.06903 AB	0.08357 A	0.18116A	0.13763A	0.20190A	0.07937CB
4	0.09190 A	0.10230 A	0.1912A	0.13557A	0.18987A	0.10430AB

Means with the same capital letter down the columns are not significantly different at p=0.05.
*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone

Volume fractions of cell types

The effect of height and zone on volume fraction of vessels as depicted by Table 4 which revealed that there was a gradual decrease in the average volume fraction, as seen in the last column, from the top height to bottom height; however, there was a gradual decrease in average volume fraction from zone 1 to zone 3 and increase in zone 4. There were no significant differences betw-een zones at mid height and bottom heights, while volume fractions showed significant differences between zones at top height. The highest volume fraction (0.2505) was obtained in zone 4. While the lowest value was at zone 3 mid heights with no trend.
Table 5 shows the effect of height and zone on volume fraction of fibers. Was shown in Table 5 indicated that there were no significant differences in volume fraction of fibers between the three heights in all zones. Likewise the volume fractions of fibers showed no significant differences between zones at all heights. The highest volume fraction (0.4255) was obtained at zone 2 at top height, while the lowest value was at zone 4 bottom height. For height averages the highest volume fraction was at top height followed by bottom height. The effect of height and zone on volume fraction of parenchyma cells as shown in table 6 indicates that there was a gradual increase in volume fraction from zone 1 to zone 3 and then dropped in zone 4 at top height. The volume fraction at mid and bottom heights showed significant differences, but no trend was observed. The highest values (0.3995) was obtained at mid height zone 2 and the lowest value (0.1940) was obtained at mid height zone1.

Table 4. Effect of height and zone on volume fraction of vessels

Heights	Volume fraction for different zones *				
	Zone1	Zone2	Zone3	Zone4	Average
Top height	0.2066Aab	0.1567Ab	0.1691Ab	0.2505Aa	0.1947
Mid height	0.1753Aa	0.1758Aa	0.1442Aa	0.1815ABa	0.1684
Bottom height	0.1755Aa	0.1443Aa	0.1445Aa	0.1506Ba	0.1537
Average	0.1858	0.1590	0.1526	0.1942	

Means with the same capital letter down the columns and the same small letter across columns are not significantly different at p=0.05
*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone.

Table 5 Effect of height and zone on volume fraction of fibers

Volume fraction for different zones *					Heights
Average	Zone4	Zone3	Zone2	Zone1	
0.3641	0.3557Aa	0.3251Aa	0.4255Aa	0.3501Aa	Top height
0. 3420	0.3193Aa	0.3251Aa	0.3876Aa	0.3263Aa	Mid height
0.3528	0.3055Aa	0.3062Aa	0.4135Aa	0.3863Aa	Bottom height

Means with the same capital letter down the columns and small letter across rows are not significantly different at p=0.05.
*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zones.

Table 6. Effect of height and zone on volume fraction of parenchyma cells

Volume fraction for different zone *					Heights
Average	Zone4	Zone3	Zone2	Zone1	
0.2763	0.2316Ba	0.3187Aba	0.2840Ab	0.2627Aab	Top height
0.2851	0.3030Ab	0.2440Acb	0.3995Aa	0.1940Ac	Mid height
0.2735	0.3479Aa	0.2811Aab	0.2256Ab	0.2499Aa	Bottom height

Means with the same capital letter down the column are not significantly different at p = 0.05
*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is inner-most.

Cell Dimensions

The effect of height and zone on vessel diameter was shown in Table7. The averages indicate that there was a decrease in vessel diameter from top height to bottom height. Averages for zones showed decease in diameter from zone 1 to zone 3 follow by increase in zone 4. This is the same trend as for vessel volume fraction. The highest value (0.2283mm) was in zone 1. This trend agrees with results obtained by Nasroun (1978). Zone1 is sapwood area where vessels are active in transporting water from root to crown and so they will be saturated with water and expanded to maximum limit. The bottom height had smallest vessel diameter may be because it has a bigger portion of heartwood which consists of dead shrinking cells. Table 9 shows the effect of height and zone on fiber lumen diameter. The height averages (last column) indicated no trend; while zone averages (bottom row) show an increase in diameters from zone 1 to zone 4. The lowest fiber diameters were at zone 1 and 2. This was opposite to vessel diameters, which were highest at these zones. This may be due to the fact that fibers may have been compressed by the expanded vessels at these zones.

Effect of height and zone on the diameter of fiber lumen (Table9) revealed that the zone averages indicated that there was a very gradual decrease from zone 1 to zone 4. The height averages increased from top to mid height and then dropped. The effect of height and zone on double cell wall thickness for fibers as shown in table 10 indicated that there is a gradual increase from top height to bottom height. Zone averages showed a gradual increase from zone 1 to zone 4, the same trend as fiber diameter. The effect of height and zone on parenchyma diameter is shown in table11. The height averages in the last column indicate that there was a gradual increase in diameter with the tree height. The highest value was obtained at top height (0.1728mm). The zone averages increased from zone 1 to zone 3 and then dropped. This also agrees with result obtained by Nasroun (1978).

Table 7.Effect of height and zone on vessel diameter (mm)

Vessel diameter for different zones (mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.2557	0.1713	0.2048	0.3038	0.3430	Top height
0.2025	0.2625	0.1822	0.1792	0.1861	Mid height
0.1692	0.1841	0.1500	0.1868	0.1560	Bottom height
	0.2059	0.1790	0.2232	0.2283	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone.

Table 8 Effect of height and zone on fiber diameter (mm)

Fiber diameter for different zones (mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.2349	0.2201	0.2760	0.2315	0.2123	Top height
0.2669	0.3482	0.2210	0.2648	0.2415	Mid height
0.2564	0.2422	0.2562	0.2375	0.2897	Bottom height
	0.2701	0.2510	0.2458	0.2478	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone.

Table 9 Effect of height and zone on the diameter of fiber lumen

Diameter of fiber lumen for different zones (mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.1163	0.1099	0.1256	0.1294	0.1005	Top height
0.1202	0.1177	0.1155	0.10007	0.1479	Mid height
0.0896	0.0750	0.0843	0.0747	0.1247	Bottom height
	0.1008	0.1084	0.1013	0.1243	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner

Table 10 Effect of height and zone on double cell wall thickness of fibers (mm)

Double cell wall thickness for different zones (mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.1186	0.1101	0.1504	0.10211	0.1177	Top height
0.1494	0.2305	0.1054	0.1684	0.0936	Mid height
0.1667	0.1671	0.1719	0.1628	0.1650	Bottom height
	0.1693	0.1425	0.1444	0.1234	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone.

Table 11. Effect of height and zone on parenchyma diameter (mm).

Parenchyma diameter for different zone(mm)*					
Average	Zone4	Zone3	Zone2	Zone1	Height
0.1728	0.1845	0.1539	0.1799	0.1730	Top height
0.1639	0.1975	0.1654	0.2006	0.0921	Mid height
0.1268	0.1756	0.2567	0.2071	0.2280	Bottom height
	0.1977	0.2327	0.1958	0.1643	Average

*zone is the radial distance from the pith, zone 1 being the outer most while zone 4 is the inner-most zone

Conclusions

Although not significantly different volume fraction of fiber wall increased gradually from top height to bottom height, in agreement with the fact that wood density is highest at the bottom of the stem. Vessel diameter averages were highest at zone1 which is the sapwood area where vessels are active in transporting fluids and thereby expanded. Average vessel diameters also decreased from top height to bottom height which consists of a bigger proportion of heartwood with dead compressed vessels.

References

Ifju, G, J, P. Chimelo and T.H Nasroun. (1978). Structure property relations for wood and wood products Proceeding of *Iner-American Symposim on Wood Engineering*, Brazil.

Bowyer, J. L. and Smith, R. I. (2003). *The nature of wood and products*. University of Minnesota,U.S.A.

Nasroun, T.H. (1978**)** *Quantitative microstr-uctural characteristics of seven tropical hardwoods and their relationship to paper making properties*. Ph.D thesis, Virginia State University, U.S.A.

Desch, H. E and J.M. Dinwoodie (1996) *Timber Structure, Properties, Conversion, and Use*. Macmillan Press Ltd 306 pp.

Nasroun, T.H. (2005) *Wood Properties and Technology*. Dar Alam AlKutub, Riyadh, Saudia Aribia 304 pp (Arabic).

Taylor, F. W. (1967). Variation in size and prop-erties of wood elements in popular trees. *Wood Science and Technology***. 2** : 153 – 163.

الإختلافات في التركيب التشريحي لخشب الإيلانسس مع الإرتفاع على الشجرة والبعد عن النخاع

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المستخلص

تم إعداد شرائح مجهرية من 12 موقع على الشجرة تمثل ثلاثة مستويات إرتفاع وأربعة مواقع قطرية في كل مستوى إرتفاع تختلف في بعدها عن النخاع. و شملت الشرائح مقاطع عرضيه وشرائح للألياف المحررة. وتم تشخيص وتحليل هذه الشرائح باستخدام التقانه الاسترولوجيه لمعرفه الاختلافات التشريحيه على مستويات الارتفاع والبعد القطرى عن النحاع. اظهرت النتائج ان هناك انخفاضاً تدريجيا فى طول الالياف من المستوى الأعلى إلى المستوى القاعدى للشجرة.. لم تكن هناك فروق معنويه فى نسب مكونات الخلايا المختلفه(جدر وفراغات خلويه) بين مستويات الارتفاع الثلاثه إلا فى حاله فراغات الالياف و فراغات البرانشيمامع وجود إنخفاض فى الحالتين من مستوى الإرتفاع الاعلى إلى الإرتفاع القاعدى. كذلك لم تكن هناك فروق معنويه فى مكونات الخلايا مع البعد القطرى عن النخاع عدا جدر الأوعيه وفراغات البرانشيما. اما عن نسب انواع الخلايا المختلفه فقد أوضحت النتائج ان متوسطات نسبه الأوعيه قد تناقصت تدريجيا" من القمه إلى القاعده. وأظهرت النتائج ايضا أن قطر الأوعيه تناقص تدريجياً من مستوى الإرتفاع الاعلى الى مستوى الارتفاع القاعدى. كما اظهرت النتائج انخفاض متوسطات نسب الأوعيه فى الاتجاه القطرى من الموقع(1) (الابعد عن النخاع) الى الموقع (3) ثم إزدادت النسبه فى الموقع (4). ولم يظهر قطر الالياف أي توجهات خاصه مع الإرتفاع او الاتجاه القطرى. واظهرت النتائج ان قطر البرانشيما إنخفض تدريجيا" من مستوى الارتفاع الأعلى الى مستوى الإرتفاع القاعدى كما إزداد فى الإتجاه القطرى من الموقع 1 الى الموقع 3 ثم عاد وانخفض فى الموقع 4.