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PROPERTIES CHANGE OF RICE STRAW RESIDUES DUE TO DECOMPOSITION AND MOISTURE CONTENT

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ABSTRACT

A way to bury the rice straw in the soil is the decomposed rice straw internodes to prevent the black cloud which caused high pollution in Cairo every year. The mechanical and physical properties of straw residues from cereal crops left on the soil are affected by decomposition rate and moisture content during inter-cropping period. In this research, the study was carried out the relationship between physical characteristics and mechanical properties of mature rice straw as a function of decomposition and moisture content. The mechanical properties of rice straw residues such as shearing and bending stress were evaluated. Physical properties of ground samples such as moisture content, humid, mean diameter, length and thickness of rice straw internodes were determined. The ear internodes had the lowest mass per unit length and the highest density because of its smaller diameter and stem wall thickness. The difference in maximum force and energy required for failures among internodes is due to their mass per unit length and cross-sectional area. The higher Young's modulus and maximum bending stress of the ear internodes found to be due to its higher properties of hemicelluloses. Bending and shear strengths decreased by 70% and 80% respectively with decomposition due to the loss of mass. Rice straw moisture had opposite effects on bending and shearing strengths. The maximum bending stress decreased by 54% and the shear stress increased by 83%. As both decomposition and moisture greatly modify the mechanical properties of straw. These two factors should be taken into account in the management of straw after harvest.

INTRODUCTION

The move of Ministry of Agriculture is intended to help overcome the annual rice straw burning problem, the main cause of the seasonal Black Cloud (fig. 1). Unless it is recycled, rice straw is a major health and environmental hazard, according to Egyptian Environmental Affairs Agency (EEAA) officials. Egyptian farmers using traditional presses (Saroukh) to press rice straw in a bales every year. Rice is one of the most abundant field crop residues in Egypt which represents about 3.5 million tons of rice straw every year roughly 91% of total biomass (Nour, 2000). Utilization of rice crop residues as an energy source, will serve to reduce consumption of fossil fuels, thereby reducing the emission of greenhouse gases to the environment. Biomass stores energy during the process of photosynthesis.

Feasible use of biomass for chemical and energy production is highly dependent on its handling characteristics. Often, densification processes are required to improve transportation and storage properties and improve the cost of low bulk density feedstock. Knowledge of mechanical properties of biomass feedstock is essential before efficient designs of compression and densification systems can be achieved.

This energy (renewable) can be recovered by the combustion process or by conversion into usable form such as ethanol, bio-oils, or producer gases (Twidell, 1998). Crop residues have low bulk densities and thus have low volumetric heating values. Therefore, handling and storage are major obstacles in bio-based energy production. The bulk density of loose straw and bagasse is around 40 kg/m³; the highest bulk density of unprocessed biomass is around 250 kg/m³ for some wood residues (Demirba s, 2001). Conversion of low bulk density biomass into a densified form improves handling, transportation and storage of these materials. The conversion process includes size reduction and densification of ground materials under various process variables. Among the many advantages of densified bio-fuels are: a) the amount of dust produced is minimized; b) the fuel is free flowing, which facilitates material handling and the rate of flow control; c) the energy density is increased, easing storage and transportation; and, d) uniformity and stability permit more efficient combustion control (Samson *et al.*, 2000).

In Egypt, rice straw may be removed from the field, incorporated into the plowed layer, or used as a mulch. The quantity of straw, and the size and strength of the pieces can interfere with tillage and sowing operations. This can be detrimental to the establishment of the following crop, particularly in the case of direct drilling. The mechanical properties of straw, its deformability and resistance to cutting by the teeth or disks of agricultural tools, are particularly important for the quality of tillage and sowing operations. The mechanical properties of straw can vary with water content (i.e., since the last rainfall) and degree of decomposition (i.e., the time since harvesting). Both water content and degree of decomposition depend on the date of the agricultural operation. Consequently, additional information on the mechanical properties of straw, and the way these properties change after harvest, can improve the choice of dates for chopping, burying or sowing.

Most studies on the mechanical properties of plants have been done for development using failure criteria (force, stress or energy) or the modulus of elasticity and rigidity for wheat. On the other hand, there have been few studies on the changes that take place in the mechanical properties of rice straw residues during field decomposition. Studies have focused on plant anatomy, lodging processes, harvest optimization, animal nutrition, and industrial applications (Ames *et al.*, 1995; Crook and Ennos, 1996). The strength of wheat stems increases with maturity (O'Dogherty *et al.*, 1995). It varies with the variety and the position on the stem. Crook and Ennos, (1994) and O'Dogherty *et al.* (1995) found a lower Young's modulus for the ear internode, while Skubisz (1980) obtained the opposite results. The moisture of the wheat stem affects shear strength, particularly in the range of 0-15% wet basis (O'Dogherty *et al.*, 1995). There is a need for complementary information on the changes in mechanical properties of rice straw that occur after harvesting so as to improve straw management: choice of dates for chopping, burying and sowing, and the advantages of chopping or burying before sowing. This study examines the mechanical properties of un-decomposed and decomposed stem internodes as a function of their moisture content. The study focused on tile mechanical behavior of the rice straw ear internodes, the effect of moisture on bending, and the effect of decomposition on its mechanical properties by using two test methods (bending and shearing) to study the deformability of the straw and its resistance to cutting.

Fig. 1: On the road to Cairo, sources of black cloud are easily noticed

MATERIALS AND METHODS

Straw treatment

Un-decomposed straw was defined as straw stored after harvest in dry condition. Straw was dried to constant weight by placing internodes in a ventilated oven at 35°C for 24 h. Drying at 35°C prevented changes in the mechanical properties of the straw due to chemical reaction between cell wall component at higher temperature (Cone *et al.*, 1996).

Decomposed straw was obtained by placing internodes in plastic boxes in two layers between silt loam soil aggregates (2 ~ 3 mm diameter). Each box contained 48 internodes and 500g wet soil. Boxes containing soil and straw were placed in a dark incubator at 25°C ± 2 °C for one month. The boxes were opened every two days to prevent oxygen depletion.

Moisture conditioning of rice straw

The biomass feedstock utilized in this study was rice straw. Wet straw was obtained by placing the internodes between two pieces of water-saturated cotton until the weight was constant (48 h). This method resulted in no free water in the hollow tube and minimized the leaching of soluble components. The straw stem was kept in a refrigerator below 5 °C during moistening to prevent de-composition by microorganisms. Different internodes moistures were obtained by placing moistened internodes in a ventilated oven at 35°C for different lengths of time. Moisture content of rice straw sample was determined according to ASAE standard S358.2 for forages (ASAE 2005). A sample of 25g was oven dried for 24 h at 105 ± 3 °C. The moisture content was reported in percent wet basis. Rice straw was found to have a moisture content below the desired range, and was therefore conditioned to 11-12% wet basis (wb) by adding a pre-calculated mass of water using Equation 1.

$$M_w = m_i\,(M_{wf} - M_{wi}) \,/\, (1 - M_{wf}) \qquad (1)$$

where:

M_w = mass of water added to sample (g)
m_i = initial mass of sample (g)
M_{wf} = final desired moisture content of sample
M_{wi} = initial moisture content of sample

Rice straw and chop size

Rice straw were obtained from Rice Mechanization Project experimental farm at Meet Eldeeba, Kafr Elsheikh Governorate. The rice straw were collected with care and it was 11.8 % (wb) of average moisture contents. The collected rice straw were tested directly after combine harvesting on 2007 season.

The whole plant of rice stalks were chopped manually (by scissor) to the size of 25 mm to 50 mm and determined according to the ASAE standard S424.1 (ASAE, 2001) for chopped forage materials. A sample of 4 liter biomass was taken and sieved manually by professional female farmers at Kafr Elsheikh. The material was screened for 5 minutes and the mass retained on each screen was weighed to determine the geometric mean size of the chopped material.

Mechanical properties of rice straw

The mechanical properties of straw were assessed using two tests, shearing test and a three-point bending test. The shear stress was measured in double shear using a shear box made of two fixed parallel metal plates and a third close-fitting plate which can slide freely located at Mechanic Department Lab., Faculty of Engineering, Cairo University, Egypt.

Shearing and bending strength

Shear stress was applied at the midpoint of internodes by moving the mobile plate. During the bending test, the internode was placed on two rounded metal supports 50 x 10^{-3} m apart and loaded midway between the supports with a blunt blade driven by the movable support. The loading rates in both tests were constant at 0.17 x 10^{-3} m/s. The force applied was measured by a gauge (Bourdon Sedeme, Models XF 200N in bending and XC 500 N in shearing).The number of observations was 4 to 8 depending on the internodes position. Figure 2 shows examples of force recorded during shearing and bending tests with the distance covered by the movable support. The mechanical criteria considered were failure criteria (maximum force, maximum stress, energy required for failure and Young's modulus. Maximum shear stress is defined by the ratio between the force applied and the cross-sectional area (Gere and Timoshenko, 1997).

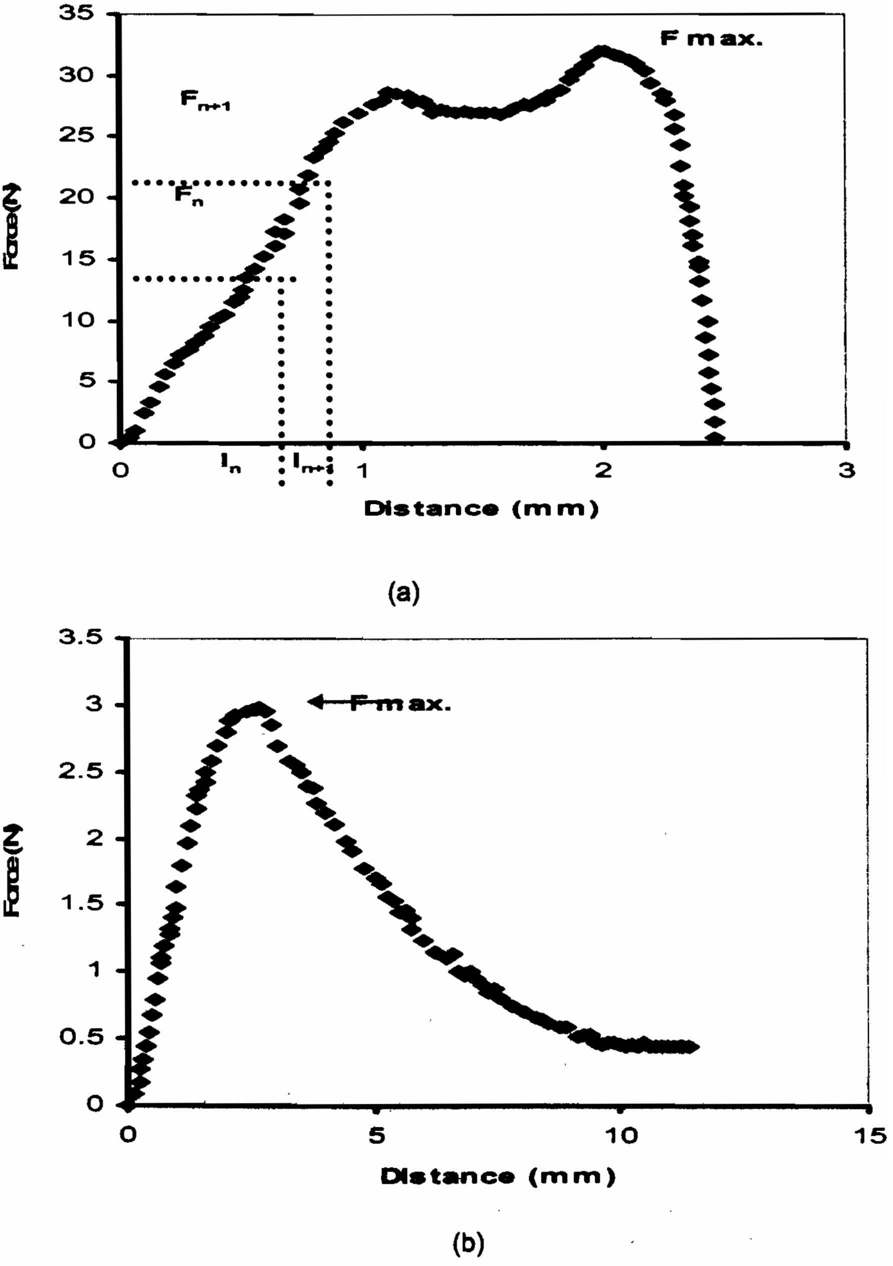

Fig. 2: Force versus distance covered by the movable support during shearing (a) and bending (ب).

Maximum shear stress was calculated by the following equation:

$$\tau_{max} = F_{s,max} / 2A \qquad (2)$$

Where:

τ_{max} = maximum shear stress (MPa)
$F_{s,max}$ = maximum shearing force (N)
A = cross-sectional area (mm^2)

Maximum bending stress is defined by Gere and Timoshenko, 1997 as follows:

$$\sigma_{max} = (F_{b,max} * r_{out} * L) / 4\, I_b \qquad (3)$$

Where:

σ max = maximum bending stress (MPa)
$F_{b,max}$ = maximum bending force (N)
r_{out} = outer radius of the internode (mm)
L= the distance between the two metal supports (mm)
I_b = the second moment of area of tubular cross-section and calculated as follows:

$$I_b = \pi\, (r^4_{out} - (r_{out} - e)^4) / 4$$

Where:

e=thickness of the wall stem

The energy required for shearing and bending stresses (W) which is the area under the curve (Figure 2) was calculated by integrating F over the distance covered by the movable support until failure (l_f):

$$W = \int F.\, dl = \sum (l_{n+1} - l_n) * ((F_{n+1} + F_n) / 2)$$

The elastic modulus or Young's modulus (E) was calculated from the expression obtained from Crook and Ennos (1994).

$$E = [\{L^3 (dF / dl)\} / 48] / I_b$$

Where:

L = distance between the two metal supports
dF / dl = origin slope of the curve between F and the distance covered by the movable support
I_b = second moment of area of tubular cross-section

RESULTS AND DISCUSSION

1- Mechanical properties changes of rice straw

1-1 Effect of un-decomposed and dry rice straw internodes

Young's modulus and maximum stress in bending and shearing varied as a function of the position of the internode on the stem (table 1). The first internode (ear internode) had the highest responses (statistically significant at 0.05 level in bending), while the three other internodes were quite smaller. As the Young's modulus is reduced when internode moisture increased, this contradictory effect of stem position may be explained by the change in moisture between internodes.

Table 1: Mechanical properties of rice straw internodes as a function of decomposition and moisture.

Mechanical properties	IN. 1	IN. 2	IN. 3	IN. 4
n	12	12	12	12
Un-decomposed dry internodes				
E (GPa)	3.5	2.8	2.4	3.0
σ (MPa)	24.9	15.9	13.0	15.2
τ (MPa)	4.9	4.4	4.2	4.1
F_b (N)	3.0	5.3	5.7	5.0
F_s (N)	26.8	51.2	51.1	44.1
W_b (MJ)	3.0	4.8	5.0	3.6
W_s (MJ)	35.4	112.2	104.8	82.5
Decomposed dry internodes				
E (GPa)	0.8	0.7	0.8	0.8
σ (MPa)	6.8	4.6	5.1	5.3
τ (MPa)	1.1	0.9	1.1	1.2
F_b (N)	0.6	1.1	1.6	1.7
F_s (N)	5.6	9.5	9.8	15.1
W_b (MJ)	0.9	1.4	1.8	1.7
W_s (MJ)	7.6	15.0	14.3	32.0
Un-decomposed wet internodes				
E (GPa)	2.6	1.8	1.4	1.3
σ (MPa)	10.3	8.2	6.6	6.2
τ (MPa)	10.2	8.8	7.3	6.0
F_b (N)	1.0	1.9	2.0	2.3
F_s (N)	55.7	97.7	90.5	95.1
W_b (MJ)	0.9	2.0	2.1	2.6
W_s (MJ)	80.3	120.4	130.3	155.5
Decomposed wet internodes				
E (GPa)	0.4	0.4	0.5	0.6
σ (MPa)	2.1	2.3	2.5	3.1
τ (MPa)	1.4	1.8	2.3	2.4
F_b (N)	0.2	0.7	0.6	1.1
F_s (N)	8.6	19.4	24.7	37.5
W_b (MJ)	0.7	3.5	3.1	6.4
W_s (MJ)	7.4	25.3	38.1	57.6

Notes: n: observation number, IN: Internodes, E: Young's modulus in bending, σ: maximum bending stress, τ: maximum shear stress, F_b: maximum bending force, F_s: maximum shear force, W_b: bending energy, W_s: shearing energy.

The greater Young's modulus and maximum bending stress of the first internode may be due to its high density (table 2). Covariance analysis of the effect of Young's modulus and maximum stresses were performed as a function of stem position (variable) and specimen density (covariate). The effect of density was significant for the three mechanical properties (fig. 3), but with low coefficients of multiple determination for Young's modulus and maximum bending stress (table 3). In this case, internode position remained significant, indicating a difference in the structure of the first internode and the others. Chemical analysis showed that, first internode had the lowest proportions of cellulose and lignin, and the highest proportion of hemicelluloses (table 4). Therefore, the proportion of hemicelluloses reflects differences in the strength of internodes.

Table 2: Physical properties of rice straw internodes as a function of decomposition and moisture.

Physical properties	IN. 1	IN. 2	IN. 3	IN. 4
N	12	12	12	12
Un-decomposed dry internodes				
Length (mm)	250	168	100	67
Diameter (mm)	2.5	3.7	3.7	3.3
Thickness (mm)	0.32	0.51	0.61	0.61
Area(mm^2)	2.8	5.3	6.6	5.2
ML (g/m)	0.6	1.2	1.3	1.3
Specimen density	0.3	0.2	0.2	0.2
Decomposed dry internodes				
Mass loss (g/g)	0.45	0.42	0.38	0.39
Thickness (mm)	0.41	0.61	0.62	0.71
Area(mm^2)	2.51	5.01	5.42	6.51
ML (g/m)	0.42	0.72	0.73	0.82
Specimen density	0.2	0.1	0.1	0.1
Un-decomposed wet internodes				
Water content(g/g)	1.53	1.62	1.62	1.83
Thickness (mm)	0.41	0.61	0.71	0.82
Area(mm^2)	2.71	5.12	6.12	7.31
ML (g/m)	0.72	1.01	1.12	1.42
Specimen density	0.3	0.2	0.2	0.2
Decomposed wet internodes				
Mass loss (g/g)	0.44	0.42	0.38	0.37
Water content(g/g)	3.0	3.7	2.4	2.7
Thickness (mm)	0.4	0.6	0.6	0.8
Area(mm^2)	2.8	5.7	5.3	7.2
ML (g/m)	0.4	0.7	0.7	0.8
Specimen density	0.2	0.1	0.1	0.1

Notes: n: observation number, IN: internodes, thickness: stem wall thickness, ML: mass per unit length, area: cross sectional area.

In spite of having the highest maximum stresses, the first internode required lower maximum forces for shearing and bending (table 1). This can be linked to the physical properties of the internodes. The first internode had lower mass per unit length and cross-sectional area due to its smaller diameter and wall thickness, as found by Huber (1991). Covariance analysis of the effect of maximum force and energy were performed as a function of stem position (variable), mass per unit length, and cross-sectional area (covariates). The effects of mass per unit length or cross sectional area were significant (table 3). Higher coefficients of multiple determination were observed using the covariate mass per unit length than the covariate cross-sectional area (table 3), although these two covariates were positively correlated (r = 0.71). Internode position remained significant in several cases (table 3), but as illustrated in figure 3, these effects were always small. The coefficient of multiple determination was higher in bending than in shearing (table 3, fig. 4). This may be due to that bending concerns the whole internode, while shearing concerns a section of the internode, which is probably more sensitive to any in homogeneity of the natural cellular material.

The effect of the position of the internodes on the stem on force in bending and shearing was mainly due to the physical properties of the internodes. The difference in the stress and Young's modulus of the first internode and the others is probably due to the chemical composition, and particularly to the proportion of hemicelluloses. Lastly, the bending test was more sensitive to the structure of the stem than was the shearing test.

Table 3: Statistical analysis of the change in mechanical properties

Mechanical properties	**Covariate**	**Slope**	**S.D**	**IN. 1**	**IN. 2**	**IN. 3**	**IN. 4**	**R^2**
Un-decomposed dry internodes								
E (GPa)	Density	4.91	1.72	2.42	1.82	1.61	2.01	0.16
σ (MPa)	Density	20.71	7.52	21.63	13.02	10.82	12.12	0.15
τ (MPa)	Density	17.91	2.42	0.92	0.62	0.73	0.33	0.55
F_b (N)	ML	5.72	0.3	-1.2	-1.5	-1.6	-2.5	0.89
F_s (N)	ML	41.7	6.5	1.2	0.9	2.3	-3.7	0.49
W_b (MJ)	ML	6.1	0.7	-1.5	-2.4	3.0	-4.2	0.62
W_s (MJ)	ML	100.8	11.9	-29.1	-12.3	-16.0	-35.6	0.63
F_b (N)	Area	0.5	0.1	1.6	2.9	2.4	2.3	0.39
F_s (N)	Area	5.1	1.1	14.4	23.7	20.0	19.4	0.35
W_b (MJ)	Area	0.72	0.11	1.12	1.42	0.22	0.01	0.40
W_s (MJ)	Area	11.42	2.23	5.33	48.32	32.83	25.13	0.38
Decomposed dry internodes								
E (GPa)	Density	3.63	0.81	0.31	0.33	0.42	0.42	0.33
σ (MPa)	Density	0						
τ (MPa)	Density	7.81	1.62	-0.32	-0.21	-0.12	0.21	0.37
F_b (N)	ML	3.42	0.3	-0.7	-1.11	-0.71	-0.72	0.81
F_s (N)	ML	22.5	3.2	-4.32	-6.43	-4.92	-2.5	0.54
W_b (MJ)	ML	3.22	0.61	-0.41	-0.71	-0.41	-0.62	0.42
W_s (MJ)	ML	37.92	7.03	-9.33	-12.0	-10.5	-2.6	0.41
F_b (N)	Area	0.23	0.13	0.13	0.13	0.32	0.52	0.47
F_s (N)	Area	1.41	0.41	2.22	2.32	3.12	7.81	0.25
W_b (MJ)	Area	0.31	0.11	-0.11	-0.21	-0.22	-0.21	0.62
W_s (MJ)	Area	2.62	0.82	1.13	1.43	1.83	12.9	0.21

Notes: ML for mass per unit length, S.D. for standard deviation and Area for cross sectional area significant at ($P < 0.05$) .

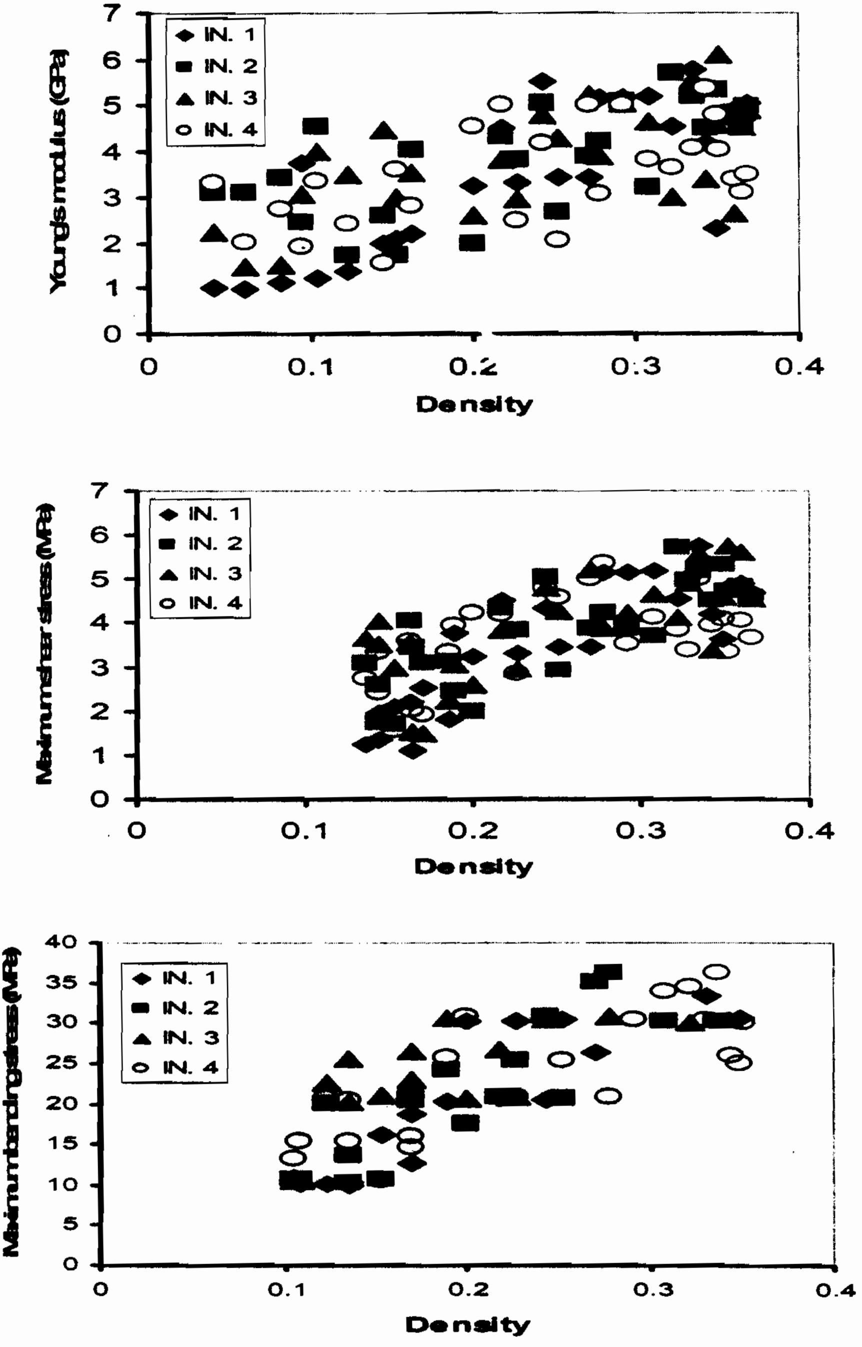

Fig. 3: Relation between mechanical stresses and density of un-decomposed and dry rice straw internodes (IN).

1-2 Effect of decomposed and dry rice straw internodes

The mean degree of decomposition was about 0.40 g/g for all internodes (table 2), Cellulose was the cell wall component most accessible to microorganisms and its quantity was reduced to 50% during decomposition (table 4), In contrast, the quantity of lignin was unchanged during decomposition. All the mechanical properties of decomposed internodes were lower than those of un-decomposed internodes (table 1) in shearing. Young's modulus and maximum bending stress decreased by 70%, while the maximum shear stress decreased by 77%. The geometry of the internodes (thickness and cross-sectional area) was not affected by decomposition (table 2). During decomposition, the proportion of lignin increased and the proportion of hemicelluloses remained constant, while the mean proportion of cellulose in the four internodes was significantly reduced from 0.60 to 0.53 g/g (table 4). Therefore, the decrease in internode strength by decomposition was related to a decrease in the proportion of cellulose. This confirms the importance of the cellulose for mechanical properties. The coefficient of multiple determination after covariance analysis between straw strength and physical characteristics was generally lower for decomposed internodes than for un-decomposed internodes (table 3). The slopes of the relationships between mechanical criteria and the covariates mass per unit length, cross-sectional area or specimen density were significantly lower for decomposed internodes than for un-decomposed internodes (table 3). The change in the mechanical properties of decomposed internodes was less well explained by their physical characteristics. It is probably due more to the chemical composition of the internodes and to the arrangement of chemical components within their cell walls than to the physical characteristics of the internodes.

The effect of internode position on the stem on straw strength was less marked for decomposed internodes than for un-decomposed ones (tables 1 and 3). We have shown that the effect of internode position in un-decomposed internodes is linked to the proportion of hemicelluloses. The results show that the proportion of hemicelluloses in the decomposed internodes was not significantly different (table 4), in accordance with the small effect of the internode position in decomposed internodes.

1-3 Effect of wet rice straw internodes

The mean physical characteristics of humid and dry internodes were similar (table 2). The moisture content of decomposed internodes was higher than that of un-decomposed internodes (table 2). Variance analysis indicated that internode moisture on thickness, mass per unit length, cross-sectional area, and specimen density had no significant effect ($P > 0.05$). Internode moisture had significant, but opposite, effects on bending and shearing (table 1). Humid un-decomposed internodes had higher maximum force and stress in shearing (mean increase of 83%), but a maximum force and stress, and Young's modulus in bending (mean decrease of 54%). Consequently, wet internodes are easier to bend, but shearing wet internodes is more difficult, because they are less brittle. It is not only the mechanical properties of the components, but also their arrangement within natural composites, that generate the mechanical properties of the internode. The physical and chemical properties of cellulose, such as elasticity, water retention, and a capacity to swell, are due to its constitution and its structure. Thus, an increase in water content may change hydrogen bonds within and between polymers that may modify the network formed by wall components and hence modify the mechanical properties. The effect of moisture on the mechanical properties of decomposed internodes was similar to its effect on un-decomposed internodes, except for the bending energy, since humid decomposed internodes had a higher energy of bending failure than did dry ones (table 1). This interaction between the effects of moisture and decomposition on mechanical properties was also significant for the effect of the internode stem position. For un-decomposed internodes, the first wet internode had a higher Young's modulus and maximum stresses, lower energy and maximum forces than the other internodes, as in the dry state. In contrast, for the decomposed internodes, the first wet internode had lower or similar Young's modulus and maximum stresses than the other internodes. Consequently, the effect of moisture on internode mechanical properties depends on their chemical composition and the arrangement of the chemical components within their cell wall.

Table 4: Chemical composition of internodes as a function of decomposition.

Chemical composition	IN. 1	IN. 2	IN. 3	IN. 4
n	3	3	3	3
Un-decomposed internodes				
C/N ($g.g^{-1}$)	211.0	360.0	351.0	160.0
Hemicelluloses ($g.g^{-1}$ ND)	0.35	0.32	0.32	0.32
Cellulose ($g.g^{-1}$ ND)	0.58	0.62	0.61	0.61
Lignin($g.g^{-1}$ ND)	0.09	0.09	0.11	0.11
Decomposed internodes				
C/N ($g.g^{-1}$)	39.05	51.06	53.04	57.05
Hemicelluloses ($g.g^{-1}$ ND)	0.18	0.16	0.18	0.16
Cellulose ($g.g^{-1}$ ND)	0.26	0.31	0.32	0.33
Lignin ($g.g^{-1}$ ND)	0.11	0.10	0.11	0.11
Hemicelluloses ($g.g^{-1}$ D)	0.32	0.28	0.29	0.27
Cellulose ($g.g^{-1}$ D)	0.48	0.53	0.52	0.54
Lignin ($g.g^{-1}$ D)	0.18	0.16	0.16	0.17

Notes: chemical analysis was done at Food Technology Research Institute, Agricultural Research Center (Giza, Egypt). IN: internodes, n: observation number, C: carbon, N: nitrogen, D: decomposed and ND: un-decomposed.

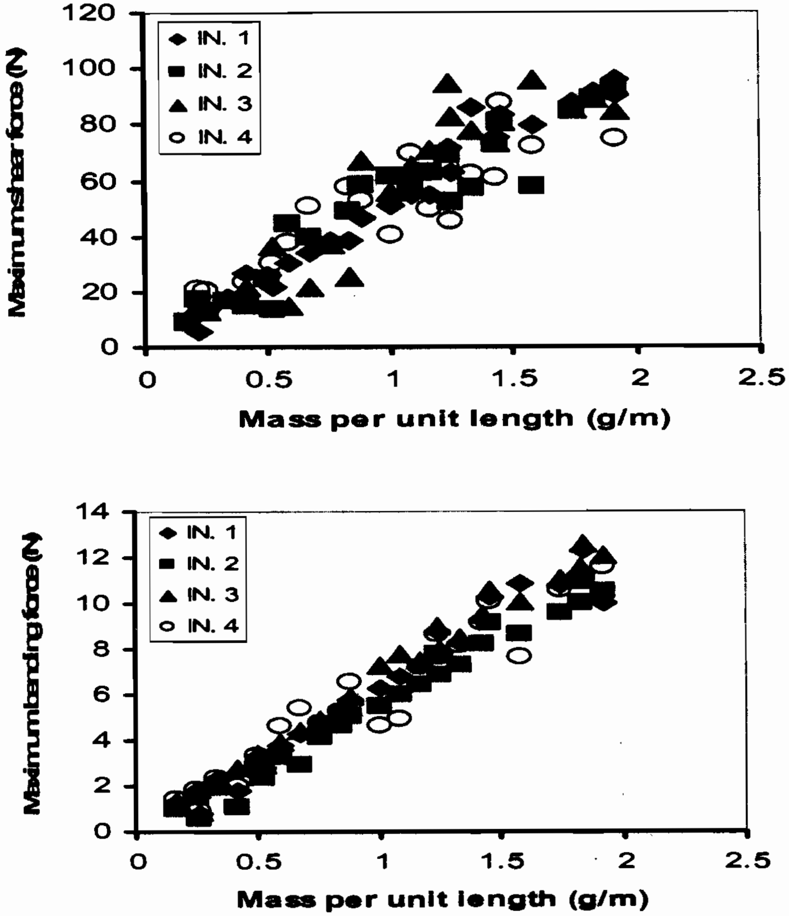

Fig. 4: Relationship between maximum force (shearing and bending) at failure and internode mass per unit length of un-decomposed and dry rice straw internodes (IN).

The changes in the maximum stress in bending and in shearing with the internode moisture (0 to 100% dry basis) are shown in figure 5. There was a threshold relationship between the maximum stress at failure and the internode moisture. The internode moisture did not change maximum forces measured above a threshold value of 20 to 30% (dry basis). Change in straw moisture from the dry state cause changes in the range of mechanical properties, such as the change obtained after extensive decomposition (loss of about 0.40 g g^{-1}). Therefore, the straw moisture at the time of an agricultural operation (chopping, burying or sowing) greatly influences the mechanical properties of the straw. The choice of the date of an agricultural operation, relative to rainfall ,is very important.

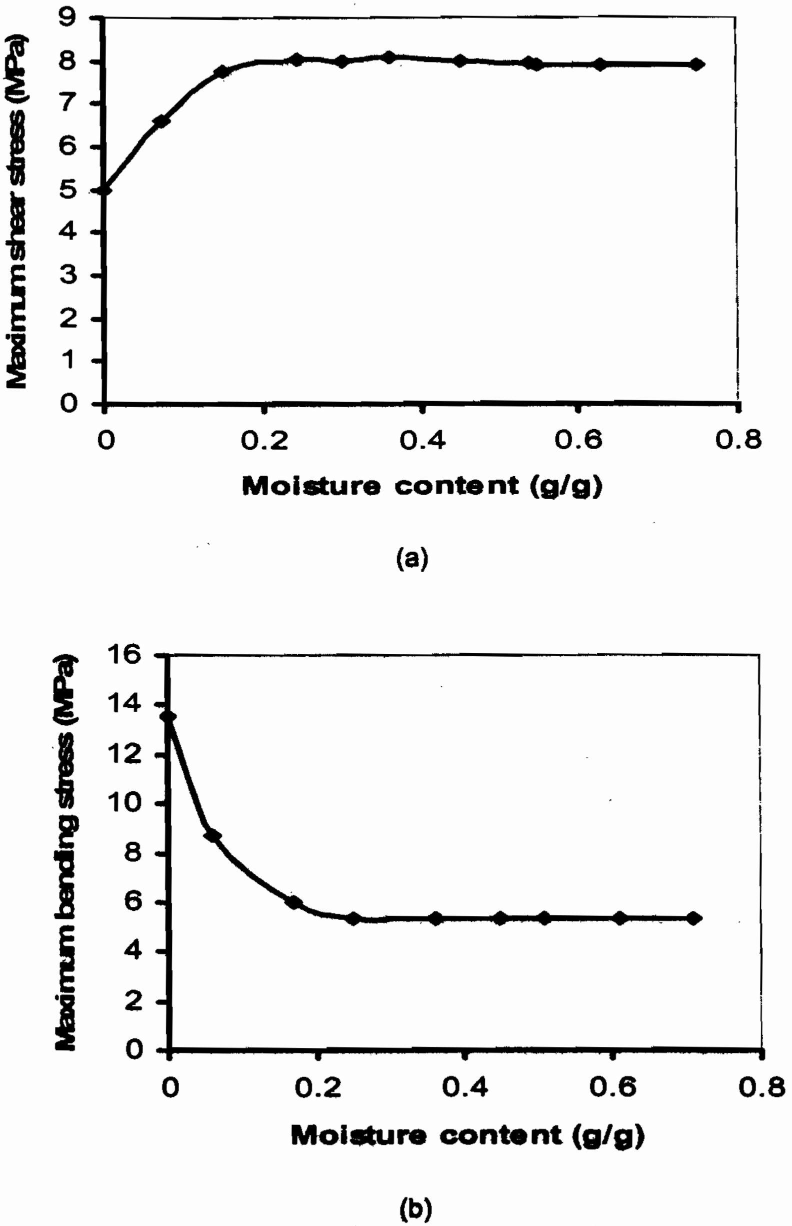

Fig. 5: Effect of internode moisture on maximum force, shearing (a) and bending (b) required for failure of the third rice straw internode.

CONCLUSION

Study was measured the shear strength of rice straw to determine its resistance to cutting, and its bending strength to determine its deformability, as a function of the position of the internodes on the stem, decomposition, and moisture. The ear internode was weaker than the three other internodes. A loss of mass of 40% by decomposition caused a decrease in the shearing and bending strength of rice straw internodes that was related to the decrease in the proportion of cellulose during decomposition. A change of from zero to 20 to 30% (dry basis) in straw moisture from the dry state affected mechanical properties of the straw, with opposing effects on shearing and bending. An increase in straw moisture led to an increase in the shear strength and a decrease in the bending strength. The moisture content of rice straw is changed faster by rainfall than is the decomposition rate. Therefore, from a practical point of view, the choice of the date of an agricultural operation (chopping, burying or sowing) is very important for the response of straw to agricultural tools (size of straw pieces after chopping, quality of straw burying after tillage, quality of seed placement after sowing).

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التغير الحادث فى خواص بقايا قش الأرز والراجع الى التحلل والمحتوى الرطوبة

ابراهيم السيد البطاوى و مصطفى عبدالكريم على
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ان دفن بقايا قش الارز فى التربة بعد عملية الحصاد يعتبر طريقة فعالة لمنع حدوث السحابة السوداء فى سماء مصر نتيجة حرق قش الأرز والتى تتسبب هذة السحابة فى حدوث نسبة عالية من التلوث البينى. كما أن الخواص الميكانيكية والفيزيائية لبقايا القش المتبقى بعد عملية الحصاد والناتج من بعض المحاصيل الحقلية وجدت انها تتأثر بمعدل التحلل وكذلك المحتوى الرطوبى للقش خلال الفترة ما بين زراعة محصول وحصاد اخر.

فى هذا البحث تم دراسة العلاقة بين الخواص الميكانيكية والطبيعية لقش الأرز (الناتج بعد عملية الحصاد) كدالة لعملية التحلل وكذلك المحتوى الرطوبى. وعليه تم اجراء التجربة فى محافظة كفر الشيخ بمنطقتى ميت الديبة وقلين نظرا لوجود نسبة زراعة أرز عالية فى هذة المحافظة.

تم حساب وتقييم الخواص الميكانيكية لقش الأرز موضوع الدراسة والتى تتمثل فى اجهادات اللى والقص كما تم ايضا حساب وتقدير الخواص الطبيعية لقش الأرز والتى تتمثل فى المحتوى الرطوبى – الرطوبة النسبية – متوسط قطر عود القش – وكذلك الطول والسمك.

وقد اثبتت الدراسة أن العقلة الأولى (التى تلى السنبلة مباشرة) لها أقل كتلة فى وحدة الطول وأكبر كثافة وذلك لصغر قطرها.

وأوضحت الدراسة أيضا أن أكبر معامل يانج (نسبة الاجهاد المسلط الى الانفعال الحاصل ضمن حد المرونة) وأقصى اجهاد لى لعقلة السنبلة (العقلة التى تلى السنبلة مباشرة) ترجع الى نسبة الهيميسيليلوز العالية فى هذة العقلة. كما أن اجهادات اللى والقص قلت بنسبة ٧٠% , ٨٠% على الترتيب أثناء عملية التحلل بينما وجد أن المحتوى الرطوبى له تأثير عكسى على هذة الاجهادات حيث وجد أن أقصى اجهاد لى قل بنسبة ٥٤% وأقصى اجهاد قص زاد بنسبة ٨٣% .

وعليه فيجب الاهتمام جيدا بهذان العاملان (الخواص والرطوبة) وأخذهما فى الاعتبار بعد عملية الحصاد مباشرة ليس فقط لمحصول قش الأرز ولكن أيضا لبقايا قش المحاصيل الأخرى.