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The Effect of Two Stored Sorghum Varieties Composition and Grain Coat Hardness to Feeding by Khapra Beetle and Lesser Grain Borer

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Abstract:
Insect pests of stored products cause much damage to stored sorghum grains. Considerable losses were recorded at Renk county, Upper Nile State, Southern Sudan and the surrounding areas. This study was conducted in the period of six months (January,2009-July,2009),to evaluate the effect of sorghum grain composition and seed coat hardness to feeding by Khapra beetle and lesser grain borer. The laboratory results showed that Fetterita cultivar had higher percentage of proteins (14%) and fat(2.43%) content than Gadamalhamam, while Gadamalhamam contained more crude fiber(6.90%) than Fetterita(5.53%),: This may partly explain why Gadamalhamam was more resistant to infestation by both the Khapra beetle(*Trogoderma granarium*) and Lesser grain borer(*Rhyzopertha dominica*) than Fetterita. The results also revealed that there was a positive relationship between coat hardness of the grain and degree of grain resistant to infestation by insect pests. The percentage weight loss of infested Fetterita grain was (14.4%) while, that of Gadamalhamam was (8.1%), and the degree of the seed coat resistance of Fetterita was (2.88kg/mm), while that of Gadamalhamam was (3.12kg/mm).

Keywords: Sorghum, Grains hardness, Feeding, Khapra beetle, Lesser grain borer.

Introduction:

Sudan is mainly an agricultural country where various crops are grown both by irrigation and rainfall. Renk County is one of northern upper Nile state counties of southern Sudan. Renk is considering as one of the largest agricultural production areas in Southern Sudan and a key producer of sorghum and other grains. FAO estimated world-wide annual losses in store products as 10% of all the stored grains. During storage, grains are liable to attack by insects, rodents, birds, mites and micro-organisms which cause direct and indirect damage that result into loss of weight and changes in natural components. About 13 million tons of grain loss is due to insects (Wolpert, 1966). Sorghum is the staple food in many countries including the Sudan (Shazali and Ahmed, 1998). It is the staple food in most regions of this country. It contains a reasonable amount of proteins, ash, carbohydrates, oil and fiber (Drich and Pran, 1987). Sorghum is the staple food of most inhabitants of southern Sudan, except in the Zande area where cassava and eleusine are the staple food. "Fetterita" a sorghum cultivor is grown on commercial basis in the central rain lands, especially in Renk in Upper Nile (Badal, 1999). The biological agents commonly responsiblefor deterioration of stored grains are insects, fungi, mites, rodents and birds (Promeranz, 1992). Rodents and birds cause extensive damage to both standing crops and stored products, but damage to stored grains is greatest (Hall, 1970). Insects cause direct damage as a result of consumption of grain kernels, thus affecting viability and nutritive value of the seeds. They may also change the chemical composition of the infested commodity and contaminate it with their broken appendages and metabolic bi-products. The moisture content of grains and other factors have direct effect on the degree of susceptibility of stored grains to attack by insects. Moisture for example is the most important factor inducing fungal growth which leads to the deterioration of stored grains within a short time (Promeranz, 1992 and Igbal, *et al*., 1996). Hall (1970) reported that grain size, physical properties (e.g. hardness) composition and nutritive value also influence the development of stored grain insects. White (1975) found that, susceptible cultivars had thicker pericarp with conspicuous quantities of starch granules present in the mesocarp layer while the resistant varieties generally had thinner pericarp and seed coat. Hardness has been frequently suggested as a factor in resistance of cereal grain to stored product insects. Manee Choti (1974) measured relative hardness by the penetrating point method, and measuring the impression made by a diamond point under 1 kg weight on different sorghum cultivars. In East Africa, Dogget (1970) found a positive relationship between the low level of damage to sorghum grains by weevils and the thickness of the corneous endosperm layers. Also small grains escape damage more often than large ones. Grains composition is also a major factor in resistance to insects. The infestation of 39 sorghum varieties and hybrids under laboratory condition revealed that host resistance, grain tannin content, and grain hardness were not strongly correlated, but that the weevil activity was positively correlated with grain volume and number of emerging weevils (Ramalho et al., 1977).

The Objective of this Study was:

To evaluate the effect of two sorghum varieties (Gadamalhamam and Feterrita) composition and seed coat hardness to feeding by the khapra beetle (*Trogoderma granarim*) and lesser grain borer (*Rhythopertha* dominica).

Material and Methods:

The experiments were conducted during a period of 6 months (from January 2009 – July 2009) at lab of Zoology and Entomology, Upper Nile University and completed in laboratory of Crop Protection in Department of Entomology, College of Agriculture, and Khartoum University. Insects were collected from stored sorghum at four localities within Renk County (11.6´N-32.8´N), Geigar (11.8´E/32.7´N), and Guwzrum (11.6´W/33´N, Gelhak (11.4´E/32.7´N) and wadacona (11.7´E/32.8´W), Upper Nile State, South Sudan About half kilograms (500 grams) of each of the two sorghum cultivars (Fetterita and Gadamalhamam) were randomly collected and each kept in about 16 big glass vials (8 for each cultivar), and the 8 glass vials were also divided into four for each cultivars. Then 16 (sixteen) adult of two insect (10:6, female to male) were introduced into the two groups using hand lens, fine hair brush and needle. Each vial was covered with a piece of cloth tied with a rubber band.

The losses in weight due to infestation by the khapra beetle and lesser grain borer were determined by weighting 500 grain of each cultivar before introducing a known number of insect, (weight at zero time) and then samples were taken monthly until the end of experiment. The net weight loss due to the feeding of khapra beetle and the lesser grain borer were obtained by subtracting the final weight from the initial weight of the grains after adjusting for losses occurring in the control treatments. The (%) weight loss of grains was calculated by "count and weight" method described by Harris and Lindblad, (1978) applying the following equation:

$$\% \text{ weight loss} = \frac{N_d (W_u - W_d) \times 100}{W_u (N_d + N_u)}$$

where:

W_u=Weight of undamaged grains.

N_u=Number of undamaged grains.

W_d=Weight of damage grains.

N_d=Number of damage grains.

Through this formula, losses in each cultivars type were estimated.

Determination of the Main Constituents of Sorghum Grains:

Moisture content: Five grams of seed from each cultivar (Gadamalhamam and Fetterita) were weighted in a clean dish using sensitive balance. The dish was kept in an oven at 105C overnight. The dish was kept in a desicator until the contents reached room temperature when it was weighted, then the dish was heated in the oven for two hours and reweighted. This was repeated until a constant weight was obtained, the loss in weight was calculated as percent of the weight of the sample and considered as the moisture content, using the Association of Official Analytical Chemist (AOAC) method (2000).

$$\text{Moisture content\%} = \frac{W_1 - W_2}{\text{Sample weight}} \times 100$$

Where:

W_1= weight of sample +crucible before oven dry.

W_2= weight of sample +crucible after oven dry.

Ash content: The ash content was determined according to the AOAC methods (2000) using muffle furnace. Five grams of each sample were weighted and repeated in triplicate into porcelain crucibles, which were ignited, cooled in a desicator and weighted and placed in a cool electric muffle furnace. The temperatures were between (550C-600C) until ashes carbon free (2-3hours), then the ash crucibles were transferred directly into a desicator, then cooled for 30 minutes and weighted immediately. The ash content was determined using the equation:

$$\text{Ash content \%} = \frac{W_1\text{-}W_2 \times 100}{\text{Moist sample weight}} \times \frac{100}{100 - m}$$

Where:

W_1= Weight of crucible with dried ash.

W_2= Weight of empty crucible.

M= Moisture percentage of the sample.

Crude fiber: Crude fiber was determined according to AOAC (1984). About 5 grams of grains were weighted to which 150 ml of H_2SO_4 (conc. 7.3 ml/l) were added then heated and kept boiling for 30 minutes, and then filtered. The residue was washed three times with hot water, then 150 ml of pre-heated KOH (12.89 gm/l) were added and boiled for 3 minutes and then filtered. The residue was washed three times with hot water and then dried under suction and placed in an oven at 150°C overnight and then weighted. The residue was ashed in muffle furnace at 550°C for three hours till a light grey ash was formed then weighed.

$$\text{Crude fiber (\%)} = \frac{W_1 - W_2}{S} \times 100$$

Where:

S= Original weight of sample.
W_1= Weight of sample before ignition.
W_2= Weight of sample after ignition.

Protein content: The protein content of sorghum grain samples was determined by the Kjeldahl method as described by AOAC (1990). Ten(10) ml of each grain sample were weighted and kept into a clean dry Kjeldahl flask, to which 0.4 gram of $CuSO_4$ and concentrated H_2SO_4 (25 ml) were added. The flask was heated until a clear solution was obtained and then allowed to cool.

The digested sample was poured into a volumetric flask (100 ml) and diluted with distilled water. Then 15 ml of 40% NaOH was added and distilled, the ammonia evolved was received in 10 ml of (2%) boric acid plus three drops of indicator (bromocresolgreen + phenolphthalein red).

The distillation was continued until the volume in the flask was 75 ml then the flask was removed.

The distillate was then titrated with 0.1 HCl until the end point (red color) was obtained. The protein content was calculated using the following equation:

Protein (%) = T x 0.1 x 0.014 x 100/W x 100

Where:
T=Reading of titration.
W=Weight of original sample.

Fat content: Fat content was determined according to the AOAC Method (1990). Five grams from each sample were wrapped in a filter paper, placed in a thimble, covered by a piece of absorbent cotton, and placed in an extraction tube. Fifty ml of the solvent (hexane BP 60-70°C) was added to the apparatus. The extraction was carried out for 45 minutes before the solvent was recovered from the oil. The flask was oven dried for 30 min at 103 ± 2°C then cooled and re-weighted. The oil content was calculated according to the following equation:

$$Fat\% = \frac{W_2 - W_1}{\text{Weight of sample}} \times \frac{100}{100-M} \times 100$$

Where:
W_1=Weight of empty flask.
W_2=Weight of the flask with oil.
M=Moisture percentage of the sample.

Determination of Grain Hardness: Test of grain hardness of each cultivars was made by a hardness tester model (No. 174886) made by Seiskusho LTD Din Japan. One hundred (100) sound unbroken kernels of each cultivar were selected randomly from seeds kept under different room conditions. Each kernel was placed in the tester and pressed by winding the tester handle until the breakage of the kernel. The pressure in kg used to break each kernel was recorded and the mean weight in kg used break the kernel of each cultivar was taken as a measure of hardness.

Results:

When seeds of each of the two sorghum cultivars were infested with both the khapra beetle and lesser grain borer, Fetterita was the most susceptible and the loss in seed weight increased with the increase in time following infestation. When the two varieties infested by khapra beetle, the mean weight loss of Feterrita was (5.74%) and (2.87%) of Gadam alhamam when stored for six months (Table 1). Where lesser grainborer caused (8.22%) for feterrita and (4.30%) of Gadam alhamam (Table 2).

Table 1: Monthly mean weight loss of two sorghum cultivars infested by the khapra beetle during a period of six months

Months	Gadam alhamam			Mean of weight loss of infested grain (g)	Feterrita			Mean of weight loss of infested grain (g)
	Weight loss of infested grains (g)				Weight loss of infested grain (g)			
January	1.50	0.30	0.30	0.70	0	0.40	0.20	0.20
February	0.30	2	1.10	1.13	1.20	1	1.10	1.10
March	3.20	1.10	2.15	2.15	5.90	7.40	4.60	5.97
April	4.70	2.60	2.60	3.30	6	10.50	7.50	8
May	7.30	0.20	5.50	4.33	9.80	11.60	4.49	8.63
June	6.60	5.40	4.80	5.60	11.30	12.40	7.89	10.53
Mean				2.87				5.74

Table 2: Monthly mean weight loss of two sorghum cultivars infested by the Lesser grain borer during a period of six months

Months	Gadam alhamam			Mean weight loss of infested grain (g)	Feterrita			Mean weight loss of infested grain (g)
	Weight loss of infested grains (g)				Weight loss of infested grain (g)			
January	0.20	0	0.20	0.13	0.10	0	0.50	0.20
February	0.10	0.5	0.30	0.30	0.90	1.40	3.30	1.87
March	2.70	3	1.30	2.33	2.30	8.80	7.60	6.23
April	5.40	6.10	4.60	5.37	10.20	11.20	11.40	10.93
May	8.30	8.40	6.50	7.73	13	13.30	14.20	13.50
June	10.60	9.60	9.60	9.93	14.60	17.70	17.40	16.57
Mean				4.30				8.22

The proximate composition of the two sorghum cultivars (Gadam alhamam and Feterrita) as shown in Table (3) reflect that protein (14%) and fat(2.43%) content of Feterrita were higher than in Gadam alhamam (10.50%) and (2.07%) respectively, while the crude fiber of Gadam alhamam(6.90%) was higher than that of Feterrita (5.53%). At the same time there were no differences in moisture and ash content between the two cultivars. The grain of the two cultivars have similar quantities of Ca, Mg and Na but they differ very much with respect to the quantities of K which are (0.37%) and (0.03%) respectively.

Table 3: Proximate composition (%) of two sorghum cultivars (Feterrita and Gadam alhamam)

Variety	Protein	Moisture	Ash	Fat	Crude fiber	Ca	Mg	K	Na
Feterrita	14	5.24	1.43	2.43	5.53	0.20	0.27	0.03	0.03
Gadam alhamam	10.50	5.35	1.50	2.07	6.90	0.25	0.30	0.37	0.02

In Table (4), it showed that there was negative relationship between the percentage loss in weight and grain hardness. When the grain hardness of fetterita were (2.88kg/mm), the percentage weight losses were (14.35%), where grain hardness of Gadamalhamam were (3.12kg/mm) and the weight loss were (8.05%).

Table 4: Relationship between hardness and percentage loss of grain weight caused by khapra beetle and lesser grain borer after six months of storage

Variety	% loss in grain (Wt)	Grain hardness (kg/mm)
Feterrita	14.35	2.88
Gadamalhamam	8.05	3.12

Discussion:

The most important stored products insect pests in Renk area are khapra beetle and lesser grain borer. This result had been supported by El Amin (1990), who mentioned that *Trogoderma granarium* (Everts.) and *Rhyzopertha dominica* (F.) were the main insect pests of sorghum grains in Sudan. Bacon (1948) and Darling (1954) reported that the most important stored grain insects in northern and central Sudan, which include Renk county are khapra beetle and lesser grain borer.Susceptibility of stored sorghum grains to infestation depends to a large extent on the physical and chemical composition of the grains. Thus, grain size, hardness digestibility, moisture content, starch and protein content play an important role in this aspect when the two cultivars (Gadam alhamam and Feterrita), were compared. The results showed some differences in their chemical and physical composition. Feterrita for instance contained more crude protein than Gadam alhamam, but the later had greater ash content. Feterrita also had more fat content than Gadam alhamam. Similar results were reported by other researches (Victor, 1978; Ibrahim, 2001; Torres *et al*., 1993). The two cultivars also differ with regard to moisture content and seed coat hardness. Gadam alhamam seeds had harder seed coat and then more tolerant than Feterrita to infestation by the khapra beetle and lesser grain borer. This finding confirms results obtained by Ibrahim (2001) who found a decrease in weight of infested grain with an increase in seed coat hardness suggesting a positive correlation between resistances to insect damage and seed coat hardness. Indeed; Fadlemula and Horber (1984) claimed that hardness was closely correlated with resistance.

Conclusion:

-The sorghum cultivar (Gadam alhamam), has shown relatively high resistance to infestation by the khapra beetle and lesser grain borer. Thus, it is recommended for prolonged storage than other varieties cultivated in the area.

-Extension and advising services must be available to educate the farmers about the problems of stored products insect pests and modern storage practices.

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تاثير اثنين من اصناف مكونات الذرة الرفيعة وصلابة غلاف الحبة للتغذية بواسطة خنفساءالكابرا وثاقبة الحبوب الصغرى

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المستخلص

تسبب افات المخازن اضرارا بالغة على حبوب الذرة الرفيعة المخزونة وقد سجلت خسائر كبيرة فى مقاطعة الرنك بولاية اعالى النيل - جنوب السودان والمحليات الد جاورة لها. اجريت هذه الدراسة لفترة ستة اشهر (يناير 2009 - يوليو 2009) وذلك بغرض تقييم تاثير مكونات الحبوب وصلابة الغلاف للاصابة بواسطة خنفساء الكابرا وثاقبة الحبوب الصغرى . اجريت هذه الدراسة في مقاطعة الرنك ولاية شمال اعالي النيل جنوب السودان . دلت النتائج المعملية ان الصنف فترية‌ة يحتوي على نسبة عالية من البروتين والدهون من الصنف قدم الحمام ، بينما الصنف قدم الحمام يحتوي على نسبة عالية من الالياف (.90 %)من الصنف فتريتة(.53 %)،هذا قد يفسر جزئياً ان الصنف قدم الحمام اكثر مقاومة بالاصابة بالحشرتين خنفساء الكابرا (*Trogoderma granarium*) وثاقبة الحبوب الصغرى(*Rhythopertha dominica*) من الصنف فتريتة ،ايضاً اظهرت النتائج ان هناك علاقة موجبة بين قوة غلاف الحبة ودرجة مقاومتها بالاصابة بالافات الحشرية . النسبة المئوية لفقد الوزن في صنف فترتية(14.4 %) بينما في الصنف قدم الحمام (8.1 %) وذلك لان درجة قوة غلاف حبة الفتريتة تساوي (2.88 كيلوجرام/ ملمتر) بينما تساوي قوة غلاف حبة قدم الحمام (3.12 كيلوجرام/ ملمتر).