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Effect of Lifting Time and Drying Method on Yield, Quality and *Aspergillus Flavus* Incidence on Rainfed Groundnut

Abdelrahman K. Osman and Mohamed EIFatih K. Ali

Elobeid Research Station, Agricultural Research Corporation, Elobeid, Sudan.

ABSTRACT

Two experiments were conducted over a period of five years from 1985 to 1 989, at Elobeid Agricultural Research Station Farm to study the effect of lifting time and drying method on yield, grade, kernel moisture content and aflatoxin incidence of rainfed groundnut. A randomized complete block design with three replications was used. Seven lifting times were made at 10-day intervals, staffing at 80 days and continuing up to 140 days after planting. Four drying methods were tested, two traditional ones, in which the plants were stacked with pods placed in the centre of the heap or packed over each other, and the other two included inverted windrows with pods upward and a new suggested method in which plants were stacked with pods placed up exposed to direct sunlight and air current. Lifting time significantly (P=0.05) affected yield and its grade. Early lifting increased the percentage of immature pods and resulted in low yield of poor grade, while late lifting increased the underground losses and decreased intact yield. Significant (P=0.05) positive correlation was found between lifting time and pod infection with *A. flavus*. Higher *A. flavus* infection was observed at late lifting. The results of the drying method experiment indicated that the level of aflatoxin contamination varied from one season to another. In the new suggested method and the inverted windrow method, the drying rate is faster and the percentage of contaminated samples was lower than that of the two traditional drying methods. To obtain high intact yield of good grade and reduced aflatoxin contamination, it is recommended to lift the crop at 100-110 days from planting and dry it for 8 days by stacking the plants with pods placed upward, so as to expose the pods to direct sun-light and air current.

Introduction

Groundnut is a very important cash crop in the traditional rainfed sector of western Sudan. The crop is grown annually on about 0.8 million hectare with an estimated total production of 0.4 million ton. A significant proportion of the produce is exported. Aflatoxin contamination of groundnut products is becoming a leading factor in limiting the export of the crop. The problem of aflatoxin in this area was reported by Habish and Abdulla (1971), Hamouda (1991) and Omer *et al*. (1998). Incidence of contamination in lots ready for export, and rejection of Sudanese wholeship consignments by importing countries, due to the presence of excessive aflatoxin levels was reported by Kilman (1983) and Hamouda (991 1)Thus, there is an increasing concern about aflatoxin contamination because of the serious health hazards and economic losses it causes.

Importing countries have set limits on the levels of aflatoxin permissible in groundnut and groundnut products utilized for food and animal feed. These limits for products intended for human consumption ranged from 0-50 parts per billion (ppb) or microgram per kilogram (μg kg^{-1}). In animal feed permissible levels ranged from 20-200 ppb depending on the country, the feedstuffs and class of livestock concerned. Measures to prevent or reduce such contamination are essential for the marketing of the crop in the international trade. Certain crop management practices, such as lifting time and drying method have been found to influence the degree of fungal invasion and aflatoxin production. Several workers (Canen *et al,* 1976; Perry, 1978; Mixon and Branch, 1985; Knauft *et al*., 1986) have noticed that proper harvesting and drying of the crop improved the grade and reduced the levels of aflatoxin contamination. This study was conducted with the objective of determining the optimum lifting time and appropriate drying method for groundnut grown' in the traditional rainfed sector of western Sudan.

MATERIALS AND METHODS

Two field experiments were conducted under rainfed conditions for five years(1985-1989), with the groundnut cultivar Barberton (*Arachis hypogaea ssp. fastigiata var*. vulgaris) at Elobeid Agricultural Research Station Farm, North Kordofan, Sudan. Groundnut seeds were sown in sandy soil at a spacing of 60 cm between rows and 20 cm within row, with two seeds per hole. The crop was planted in each season after the onset of the first effective rain (more than 10 mm), and that usually falls between 7th and 21st of July.

In the lifting time experiment, the experimental plot consisted of six rows, each five meters long. Only the middle four rows were harvested: The seven lifting time treatments were arranged in a randomized complete block design with three replications. Lifting was made at I0-day intervals, starting at 80 days and continuing up to 140 days after planting. Lifting was done by hand. Total, intact, and underground yields were measured. Grading parameters studied were shelling percentage and hundred kernel weight (HKW). For maturity determination, a sample of about 100 g was taken from each treatment at each replication and each pod in the sample was shelled and classified as:

l. Immature: if the kernels are not fully developed and the inside of hulls is fleshy, white, or light brown.

2. Mature: if the kernels are fully developed and the inside of hulls is dark, brown, or black.

A combined analysis of variance using MSTAT-C computer program was conducted for each parameter measured.

Fresh and dry samples of kernels and pods of groundnuts were taken from each lifting time at each replication and these were tested for *A. flavus* presence using a simple culturing method, in which kernels or pods were plated on moist filter paper in Petri dishes and incubated at room temperature for 5 to 8 days. Then the kernels or pods were checked for the presence of the contaminating fungus (*A. flavus*). If the fungus was present on the pods or kernels, then masses of yellow-green spore heads of *A. flavus* could be seen by the unaided eye.

To describe the effect of lifting time (independent variable) on the number of samples infected with *A. flavus* (dependent variable), a regression analysis was conducted. Number of samples infected is expressed as a function of lifting time.

In the dying method experiment, the crop was lifted by hand between 100 and 110 days after planting. Immediately following lifting, the groundnut plants were arranged according to the four drying methods tested. The drying methods used were two traditional drying methods (l and 2), which are used widely by farmers in the area, plus method three(inverted windrows), which is practiced on commercial large-scale production, where the crop is fully mechanized and method four which is a newly suggested method, in which we rely on the advantages and avoid the disadvantages of the traditional and inverted windrows methods. Specifications of the tested drying methods are presented below.

1. Traditional method (l)

Plants are closely packed and stacked into a circular shaped heap, with pods placed to the inside (centre of the circle). Pods are well protected from rats, birds and animals, but subject to poor ventilation without exposure to direct sunlight.

2. Traditional method (2)

Plants are stacked over each other with pods oriented to the outside (at one direction), Pods are not fully exposed to sunlight, rats may be a problem and drying is not uniform.

3.Inverted windrows method

Plants are inverted and placed in windrows (lines), so that pods are placed upwards, well exposed to sunlight and air currents, but not protected from rats, birds and animals. Windrowing was done manually، but it is commonly done using a tractor powered digger-shaker-inverter. This method is not suitable and is costly, especially if used in traditional small-scale production.

4. New suggested method

Plants are stacked into a circular shaped heap, with pods placed upwards (plants are put up-side-down). Pods are well ventilated, exposed to direct sunlight, but not well protected from rats and birds.

From harvest day (day 0), and at intervals of 4, 8, and 12 days, two samples were collected from each drying method for determination of kernel moisture content (KMC). The KMC (wet basis) was determined by heating the sample at 100 ^{o}C for two to three hours, cooled and then weighed. This process was continued until a constant weight was attained The KMC was obtained as weight loss of the dried samples, and is expressed as a percentage of the initial weight (Young *et al*., 1982).

At the end of the 12th day of drying, two 50-g samples of kernels, from each dying method were taken for chemical determination of aflatoxin Bl content, using Best Food Method (Horwitz, 1980). The aflatoxin analysis was carried out at Elobeid Quality Control Laboratory.

RESULTS AND DISCUSSION

Effect of lifting time

There were highly significant (P=0.0I) differences between among lifting dates for total, intact and underground pod yields (Table l) Lifting too early or too late resulted in a large total yield reduction. The best total yield of 553 kg ha^{-1} was obtained at the lifting time of 110 days from planting, whereas the least yield of 269 kg ha^{-1} was obtained at the last lifting time (140 days). Intact yield was highest between 90 and 110 days and lowest at the last three lifting times. Lifting up to 100 days did not show any underground losses, whereas these losses ranged from about 23 to 54% (from total yield) at the last three lifting times. At 110 days, these losses were only 9%. The increased underground losses at late lifting could be due to the weakening of the peg attachment to the early matured pods, and consequently increased shedding of pods from the plants during lifting. These results are in agreement with those obtained by Perry (1978), who found that early and delayed digging led to yield reduction in four groundnut genotypes, Young *et al.* (1982) also pointed out that total pod production continuously increased with growth period, but harvested yield reached a peak and then declined due to increased field losses at the longer growth period. The total loss was relatively constant at early lifting time and increased rapidly after that.

Table l. Pod yield, grade characteristics, maturity, pod and kernel infection by *A. flavus* of groundnut at different lifting times, averaged over five years.

Lifting time (DAP)[a]	Pod yield (kg ha^{-1})			Shelling%	HKW(g)	Maturity%	Contaminated samples (0/0)[b]	
	Total	Intact	Under-ground				Pods	Kernels
80	419	419	0	60.9	27.5	32.3	31	38
90	488	488	0	60.9	24.9	51.5	38	31
100	447	447	0	60.0	.30I	54.0	56	13
110	553	504	49	66.9	33.7	58.7	63	25
120	440	333	107	68.1	33.1	57.5	63	31
130	457	248	209	71.7	33.3	75.4	69	25
140	269	198	71	65.0	32.7	69.0	69	38
Mean	439	377	62	60.9	30.8	56.9	-	-
SE(±)	40**	40**	14**	2.0**	1.0**	3.3**	-	-

[a] DAP days after planting **denote significance level at P = 0.0I.
[b] 16 pods and 16 kernels were examined at each lifting time.

Highly significant (P=0.0I) differences were obtained for shelling percentage, HKW and maturity (Table l). The highest shelling percentage was realized at the last lifting time, while the three earliest lifting times showed the lowest shelling percentages. HKW was also low in the first three lifting times, and high in the subsequent four lifting times. The best maturity was achieved at the last two lifting times, and lifting even 10 days earlier resulted in substantial decrease in maturity. Similarly, Mixon and Branch (1985) reported a decrease in market grade characteristics‹ such as extra-large kernels, sound mature kernels, kernel weight and shelling percentage, when groundnut was dug earlier than 110 days after planting. Knauft *et al*. (1986) also found that delayed digging increased sound mature kernels and shelling percentage.

A. flavus presence at different lifting times is shown in Table l. About 42% of the examined samples (224), showed contamination with A. *flavus*. The pod contamination was higher than that of the kernel. Results of the regression analysis are shown in Table 2. Highly significant (P= 0.01) positive correlations between number of total or pod contaminated samples and lifting time were observed, with correlation coefficients of 0.86 and 0.90, respectively. The highly significant regression indicated that there is a highly significant trend for *A. favus* incidence to increase as the lifting time is advanced. Several workers have pointed out that over-maturity and delayed harvest are among the factors most frequently associated with pod invasion by *A. flavus* and aflatoxin contamination in groundnut (McDonald and Harkness, 1967; Dickens *et al*., 1973; Mixon and Branch, 1985). It is suggested that late digging is associated with elevated temperature and soil moisture stress, which provide a favorable environment for the development of *A. flavus* and subsequent pod or seed infection by the fungus (Hill *et al*., 1983).

Table 2. Computation of regression equation between lifting time and number of samples invaded by *A. flavus*, averaged over five years.

Independent variable	Dependent variable	Significance of the model	Regression intercept	Regression slope	Adjusted R square
Lifting time	Infected pods	**	-2.54	0.104	0.834
	Infected kernels	ns	4.18	0.029	0.196
	Infected total	**	1.64	0.107	0.880

**denotes level significance level at = 0.01

ns denotes no significance.

Effect of drying method

Seasonal levels of aflatoxin contamination are shown in Table 3. The percentage of contaminated samples ranged from zero in season four and five to 75% in seasons one and two. It is evident from this data that the degree of contamination varied from one season to another. Similarly، McDonald and Harkness (1964; 1965) have reported that the toxicity of the groundnut crop varied from year to year at specific sites, and that contamination of kernels was influenced by both weather and type of handling after harvest. Total rainfall and its distribution during the seasons of the study are presented in Table 4. It is clear that the first and second seasons of the study were extremely dry. The high degree of contamination observed in these dry seasons could be associated with drought, whereas the low level or absence of fungal invasion and aflatoxin contamination in the latter three seasons might be due to lack of moisture stress during these seasons, especially near harvest. Several workers (Dickens *et al*., 1973; Wilson and Stansell, 1983) have reported that drought stress has been the main factor most frequently associated with aflatoxin in groundnut.

Table 3. Seasonal levels of aflatoxin contamination.

Season	No. of samples contaminated	Contamination (ppb)	
		Range	Average
1st	6 (75%)	I .2-6000	884
2nd	6 (75%)	3.1-767	105
3rd	2 (25%)	0.5-2.2	0.3
4th	0(0)	0	0
5th	0(0)	0	0

Note: 8 samples tested in each season

Table 4. Total rainfall (mm) and its distribution during the study period.

Season	May	June	July	Aug.	Sept.	Oct.	Total
1st	-	35	68	17	35	-	155
2nd	-	15	64	44	54	-	177
3rd	-	23	100	103	135	-	361
4th	-	12	10	166	-	52	240
5th	6	41	55	138	22	-	262

The results of the effects of drying methods on KMC at 0, 4, 8 and 12 days after lifting are shown in Table 5. Before drying, there were no significant (P=0.05) differences in KMC among the drying methods. However, after four days of drying, the KMC of the samples from the traditional (2), inverted windrows and new suggested method were significantly (P=0.05) lower than that of the traditional (l) drying method. After 8 and 12 days of drying, the there were highly significant (P= 0.0I) differences in KMC among drying methods. After 8 days of drying, the inverted windrows and the new suggested method had significantly (P=0.0I) lower KMC than the two traditional drying methods, For the four drying methods, eight days were enough to bring the KMC to below the 10% level, which is needed for safe storage and prevention of any aflatoxin production.

Table 5. Effect of drying method on kernel moisture content‹(%) aflatoxin content and percentage contamination by *A. flavus* of ground-nut, averaged over five years.

Drying method	Days after lifting				Range of aflatoxin Content (ppb)	Contaminated Samples (%)
	0	4	8	12		
Traditional (l)	32.4	16.0	6.5	4.0	0.5-500	60
Traditional (2)	32.5	11.2	5.7	3.5	2.0-6000	40
Inverted windrows	33.5	10.9	4.5	2.2	51. 1-200	20
New suggested	33.0	12.5	4.4	3.2	I .2-767	20
SE±	0.89^{ns}	0.67*	0.22**	0.12**		

* **denote significance level at P = and P = 0.01, respectively.

^{ns}denote no significance.

The number, contamination percentage and the aflatoxin content of the samples taken from each drying method are shown in Table 5. The percentage of the contaminated samples in the traditional drying methods were higher than those of the inverted windrows and the new suggested methods. However, there was a very wide variability in the level of aflatoxin contamination within each drying method. This could be attributed to the low number of samples analyzed and/or the sampling procedure. Generally, groundnuts dried using the traditional methods were more liable to *A. flavus* invasion and aflatoxin contamination. This could be correlated with the drying rate. The major disadvantage of the first traditional method is that the drying rate is slower, which may give more opportunity for the fungus to invade the crop and cause aflatoxin contamination. In inverted windrows and the new suggested drying methods, pods are exposed to direct sunlight and air current which cause their rapid drying and bring the KMC to the required safe moisture (less than 10%) level within a shorter period. The importance of rapid drying in reducing *A. flavus* invasion and aflatoxin contamination was mentioned by several workers, including McDonald and Harkness (1964، 1965 Carren *et al* (1976).

The results of this study clearly indicated that lifting groundnut between 100 and 1 10 days from planting and dry it for 8 days by stacking the plants with pods placed upwards exposed to direct sun-light and air current is recommended to obtain high intact yield of good grade and reduced aflatoxin contamination.

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