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*Corresponding author

David Jordan, Department of Crop and Soil Sciences, North Carolina State University, Raleigh, NC, USA

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Research Article

Adoption of Production Practices to Mitigate Aflatoxin Following Research Projects in Selected Villages in Ghana

A. A. Dankyi[1], M. B. Mochiah[1], M. Owusu-Akyaw[1], I. Adama[1], A. D. Agyekum[1], I. Yahaya[2], M. Abudulai[2], G. Y. Mahama[2], J. Nboyine[2], R. Akromah[3], D. L. Jordan[4]*, R. L. Brandenburg[5], J. Jelliffe[6], B. Bravo-Ureta[7], D. A. Hoisington[8] and J. Rhoads[8]

[1]*Council for Science and Industrial Research-Crops Research Institute, Fumesua, Kumasi, Ghana*

[2]*Council for Science and Industrial Research-Savanna Agricultural Research Institute, Nyanpkala, Tamale, Ghana*

[3]*Department of Crop and Soil Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana*

[4]*Department of Crop and Soil Sciences, North Carolina State University, Raleigh, NC, USA*

[5]*Department of Entomology and Plant Pathology, North Carolina State University, Raleigh, NC, USA*

[6]*USDA Economic Research Service, Kansas City, MO, USA*

[7]*Department of Agriculture and Resource Economics, Stores, CT, USA*

[8]*Feed the Future Peanut and Mycotoxin Innovation Lab, University of Georgia, Athens, GA, USA*

Abstract

Aflatoxin (a mycotoxin caused by *Aspergillus spp.*) in peanut (*Arachis hypogaea* L.) and other crops can have a major negative impact on human health. Previous research has been conducted to mitigate aflatoxin in the supply chain. However, documentation of adoption of proven interventions that decrease contamination by aflatoxin is limited in peanut. One objective of the research reported in this paper was to determine adoption of effective interventions for aflatoxin mitigation by farmers involved in a research project designed to quantify contamination in the field prior to harvest, immediately after drying, and following storage. A second objective was to compare adoption by spillover farmers (e.g., farmers not involved in the research project living in the same community as the research farmers) and a control group of farmers in other villages not exposed to the research project. The empirical study was conducted in Ghana from 2016 and 2017 to compare strategies to increase yield and reduce aflatoxin in peanut in five communities. Information on findings of the research were discussed among participating farmers and other local farmers through farmer field schools. Increases in yield and reductions in aflatoxin contamination were documented in this research and are reported elsewhere. Understanding concepts and implementing improved practices in the field, during drying, and in storage by farmers involved directly in research trials, farmers within research-targeted communities, and farmers in nearby communities without access to findings from the research were determined using a survey instrument near the end of the project in 2017 and 2018. Adoption of improved practices by farmers participating in the research and those of farmers influenced through discussions with participating farmers were often greater than a control group of farmers influenced by outcomes. For example, farmers in the research group and farmers gaining knowledge from the research findings dried peanuts on tarpaulins more than the control group of farmers. Farmers with greater exposure to the potentially negative impacts of aflatoxin on human health were less likely to consume peanut containing the mold causing aflatoxin and were more likely to discard contaminated peanut rather than selling them in the market.

Introduction

Peanut *(Arachis hypogaea* L.*)* is an important crop that impacts food security around the world [1,2]. Aflatoxin (caused by *Aspergillus flavus* and *A. parasiticum*) is a major food-safety issue in many countries, especially where raw food products are not sampled to determine the level of aflatoxin contamination [2-5]. Contamination occurs in the field during production and can increase in stored products and ultimately in foods consumed by humans and livestock if drying and storing conditions promote growth of *Aspergillus spp.* [3]. Human health is compromised through bioaccumulation of aflatoxin which can adversely affect growth and development of vulnerable individuals within populations, most notably infants, young children, the elderly, and individuals throughout the entire population with a compromised immune system [4,5].

Aspergillus spp. is considered ubiquitous in soil and can contaminate a host of crops when soil temperatures are high and moisture is limiting. Under these conditions, many microorganisms do not remain active while *Aspergillus spp.* is capable of growing and developing [6]. Additionally, when raw products or processed food products are stored under high temperatures and/or high moisture conditions *Aspergillus spp.* can increase dramatically [7-9]. This pathogen can produce the mycotoxin at levels high enough to threaten human health after storage even though the concentration was low going into either drying or storing steps in the supply chain. Peanut is a suitable host for a *Aspergillus spp.* and managing peanut in the field and during drying, storing, and processing steps in supply chains in manner that eliminates or minimizes contamination is important. Research has documented that various factors can increase the risk of *Aspergillus spp.* growth and development leading to aflatoxin production [3,10-13]. Likewise, practices that can reduce the likelihood of *Aspergillus spp* growth and production of the toxin are understood relatively well [3,13]. However, food contamination by aflatoxin and adverse effects on human health continue to be one of the most important food safety issues, especially among vulnerable populations [5]. The concept and application of aflatoxin mitigation in the supply chain can be complicated, and lack of knowledge of how to recognize risks posed to human health by this mycotoxin and how to identify the causal agent in many resource-poor areas of the world contribute to this problem. Also, the availability and affordability of practices and inputs that can reduce contamination are barriers to minimizing risk of food contamination [13].

Knowledge of the presence and negative impacts of aflatoxin on human health are poorly understood by many small farmers holder in resource-poor countries including Ghana. A major focus of the Feed the Future Peanut and Mycotoxin Innovation Lab (Feed the Future PMIL) in Ghana from 2013-2017 was aflatoxin mitigation [14,15]. One research project within this larger program was conducted in five communities in Ghana to compare peanut yield, estimated financial returns, and aflatoxin concentration in farmer stock peanut using combinations of traditional grower practices and practices specifically designed to minimize aflatoxin contamination [14,15]. Results from these experiments have demonstrated that increasing the number of times farmers weeded peanut fields, from one to two, applying local soaps to peanut foliage to suppress aphids (*Aphis craccivora* Kock), and application of calcium increased yield and estimated financial returns of peanut and reduced aflatoxin contamination at harvest. Drying on plastic tarps rather than on the ground decreased aflatoxin and storing peanut in hermetically-sealed bags rather than traditionally polysachs substantially decreased contamination of peanut that would be processed into food products or would be consumed directly. These results are supported by previous research demonstrating that production practices in the field that increase yield, rapidly drying peanut and minimizing the chance of rehydration and contamination from soil, and storing in a protected environment under moisture conditions below the threshold for growth of *Aspergillus spp.* can improve food safety by minimizing aflatoxin contamination [3]. A component of the research after four years of activity was to determine knowledge gained by farmers participating in the research and the spillover of that participation to other farmers in the community. The objective of this paper is to present results from a survey of farmers in these communities related to aflatoxin and its mitigation.

Materials and Methods

Three communities in the northern sector of Ghana including Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district were selected for the research outlined by Adudulai et al. [14]. Two additional communities included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district in the southern sector of Ghana [15]. The research was designed to compare field practices approached to drying, and variation storage that impact aflatoxin contamination compared to traditional practices used by these farmers [14,15]. In each project community, the 12 randomly selected farmers collaborating in the trials were interviewed using a questionnaire and are referred to as PMIL research farmers (PMILF) (n = 60). The PMILF were expected to pass on information learned from research activities with other farmers in their respective communities referred to as PMIL spillover farmers (PMILSOF). Twelve randomly selected PMILSOF were interviewed using the same questionnaire applied to the PMILF (n = 60) sample. One nearby community with 12 randomly selected farmers for each of the five research communities was selected as control farmers (PMILCF). These farmers most likely had not received information on aflatoxin and practices employed to reduce contamination (n = 60). Surveys were conducted in the southern region of Ghana in October 2016 and in both regions in November/December 2017. Data were analyzed by region due to differences in production practices and timing when the survey was administered [14, 15].

Results and Discussion

Farmer Demographics

Farmers in the PMILF group were about one decade older than farmers in the PMILSOF and PMILCF groups in both regions of Ghana (Table 1). The PMILSOF group in northern Ghana had an average of 1.9 more years of formal education than the PMILF group while the PMILCF had the least (0.2 years). In contrast to northern Ghana, PMILCF had the highest average years of formal education in the southern region (6.1), which is 2.7 and 1.2 more years than PMILF and PMILSOF, respectively.

Table 1: Means for descriptive information for farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF)[a].

Descriptive information	PMILF	PMILSOF	PMILCF	PMILF vs. PMILSOF	PMILF vs. PMILCF	PMILSOF vs. PMILCF
Northern region[b]						
Age of farmer	48.4	37.1	40.4	S	S	NS
Years of formal education	1.4	3.3	0.2	S	S	S
Years as resident in village	38.8	31.8	32.2	S	NS	NS
Number of persons in the household	12.3	13.3	7.6	NS	S	S
Number of household persons assisting peanut production	4.2	4.1	2.8	NS	S	NS
Number of farmer's children	7.8	5.2	4.4	S	S	NS
Number of observations	36	36	36			
Southern region[c]						
Age of farmer	49.2	40.1	42.7	S	S	NS
Years of formal education	3.4	4.9	6.1	NS	S	NS
Years as resident in village	26.1	18.5	34.8	S	S	S
Number of persons in the household	7	6.6	7.6	NS	NS	NS
Number of household persons assisting peanut production	3.2	2.3	2	NS	S	NS
Number of farmer's children	4.1	3.2	4.3	NS	NS	S
Number of observations	26	21	65			

[a]S = significant based on a standardized t-test at $p < 0.05$.
[b]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[c]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Consumption of Peanut

In northern Ghana, there was a trend for greater consumption of peanut by PMILCF compared with other farmer groups across all four years (Table 2). Greater peanut consumption was reported by PMILSOF than PMILF. In southern Ghana, variation in consumption of peanut was noted across years and farmer groups. In general, consumption of peanut was more frequent by farmers in northern Ghana compared to farmers in southern Ghana (Table 2). This was not unexpected given the importance of peanut in the agricultural sector of northern Ghana compared with southern Ghana.

Table 2: Annual consumption of peanut in households for farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF).

Year	PMILF	PMILSOF	PMILCF
Northern region[a]			
2016	38.7	46.6	73.1
2015	31.8	44.1	79.7
2014	30.9	45.1	77.5
2013	36.9	42.9	69.5
Number of observations	36	36	36
Southern region[b]			
2015	18.9	45.3	17.1
2014	14.7	16.5	10.2
2013	10.8	13.2	8.7
Number of observations	26	21	65

[a]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[b]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Farm Size and Self-reported Yield

Farm size was greater in northern Ghana compared with southern Ghana regardless of PMIL grouping (Table 3 & Figure 1). Self-reported peanut yields in the northern region based on PMIL grouping did not statistically differ at the 95 percent confidence level where peanut yield for the PMILF and PMILCF is similar and less than yield for the PMILSOF. In southern Ghana, yield was similar when comparing PMILF and PMILSOF farmer groups (Table 3 & Figure 1). Yield was lower for the PMILCF group compared with the PMILF and PMILSOF groups at the 95 percent confidence level.

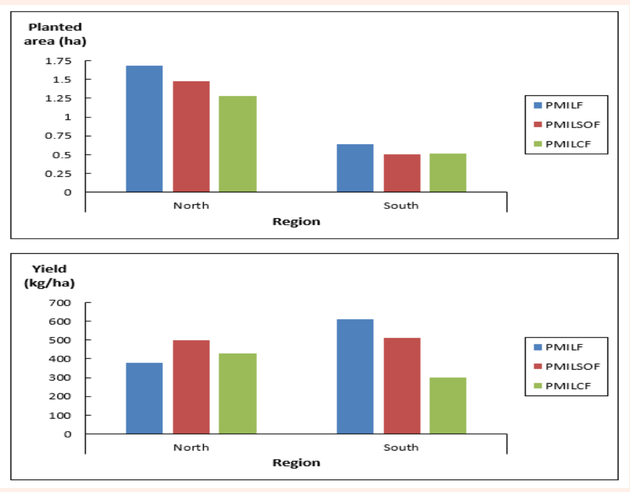

Figure 1: Planted area and yield by region and survey group.

Table 3: Land area planted and self-reported average yield for farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF).[a]

Category	PMILF	PMILSOF	PMILCF	PMILF vs. PMILSOF	PMILF vs. PMILCF	PMILSOF vs. PMILCF
Northern region[b]						
Hectares planted	1.68	1.48	1.28	NS	NS	NS
Shelled yield (kg/ha)	380	500	430	NS	NS	NS
Number of observations	36	36	36			
Southern region[c]						
Hectares planted	0.64	0.5	0.51	NS	NS	NS
Shelled yield (kg/ha)	610	510	300	NS	S	S
Number of observations	26	21	65			

[a]S = significant at 95% confidence interval. NS = not significant at 95% confidence interval.
[b]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[c]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Practices Related to Production and Pest Management

A wide range of production and pest management practices for the three PMIL groups are provided in Tables 4-7. Of particular note is that all farmer groups in both regions sorted seed prior to planting (Table 4). Farmers in PMILF and the PMILSOF groups tested seed for germination in about equal percentages while farmers in the PMILCF tested germination at a lower rate (Table 4). The PMILCF incorporated fewer improved varieties into their production than the PMILF and PMILSOF. In the northern region, a similar percentage of farmers in all groups planted in rows (42 to 50%) while in southern Ghana 100%, 86%, and 52% of farmers planted in rows for the PMILF, PMILSOF, and PMILCF groups, respectively. Farmers in the PMILF group were more likely to apply a local soap for suppression than the PMILCG. In northern Ghana, farmers did not remove off-type plants and did not apply oyster shells as a calcium source. In contrast, in southern Ghana, growers in the PMILF and PMILSOF groups were more likely to remove diseased plants or apply oyster shells.

Table 4: Means for the percentage of farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF) for selected practices and decisions.

Practice or decision[a]	Recommendationa	PMILF	PMILSOF	PMILCF	Chi-Square Test[b]
Northern region[c]					
Selection of good land to plant	Fresh green and uniform vegetation	25	22	25	NS
Determining soil depth	Push cutlass into soil 30-50cm deep	42	39	31	S
Quality seed selection	Sorting of seeds	100	94	92	NS
Germination	Germination test	64	50	8	S

Variety	Improved	67	63	39	S
Planting arrangement	Rows	47	42	50	NS
Rossette disease suppression	"Alata" soap	17	3	0	S
Off-type groundnut plants	Rogue/Pull out off-type	75	64	47	NS
Fertility	Oyster shell application	28	14	11	NS
Number of observations		36	36	36	
Southern region[d]					
Selection of good land to plant	Fresh green and uniform vegetation	92	95	74	NS
Determining soil depth	Push cutlass into soil 30-50cm deep	89	76	42	S
Quality seed selection	Sorting of seeds	96	100	95	NS
Germination	Germination test	85	81	26	S
Variety	Improved	35	19	5	S
Planting arrangement	Rows	100	86	52	S
Rossette disease suppression	"Alata" soap	73	33	8	S
Off-type groundnut plants	Rogue/Pull out off-type	92	86	65	S
Fertility	Oyster shell application	69	19	2	S
Number of observations		26	21	65	

[a]Recommendation based on Ministry of Agriculture.
[b]S = significant at 95% confidence interval. NS = not significant at 95% confidence interval.
[c]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[d]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

In northern Ghana, the majority of farmers used saved seeds for planting (69-78%) (Table 5). A significant number of farmers (17-25%) purchased seed from local markets. Eight percent or less of all farmer groups received seed from Extension or Research personnel, neighbors, or seed dealers. In southern Ghana, the percentage of farmers obtaining seed from sources other than on-farm saving was more diverse than northern Ghana. For example, 50% of the PMILF group and 62% of PMILCF planted saved seed. In these respective groups, 23% and 37% of seed planted were from saved seed. However, within the PMILSF group, 48% of farmers purchased seed form the market versus 33% using saved seed for planting.

Table 5: Percentage of farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF) relative to seed source.

Source of seed	PMILF	PMILSOF	PMILCF
Northern region[a]			
Saved seeds	78	69	75
Market	19	25	17
Extension or Research	0	0	0
Neighbor	3	6	8
Seed dealer	0	0	0
Number of observations	36	36	36
Southern region[b]			
Saved seeds	50	33	62
Market	23	48	37
Extension or Research	27	5	0
Neighbor	0	9	1
Seed dealer	0	5	0
Number of observations	26	21	65

[a]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[b]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

The PMILF group was more aware of the presence of beneficial insects than the PMILSOF and PMILCF groups (Table 6). This group of farmers was more likely to use fungicides in both regions of Ghana. Use of insecticides did not differ among farmer groups in northern Ghana while in southern Ghana the highest percentage of farmers using insecticide was from the PMILSOF group. Farmers in the PMILF group were more likely to use botanicals for pest suppression than the other two groups in southern Ghana. Plant expressing disease symptoms were removed from the field in northern Ghana and southern Ghana at relatively high levels for PMILF and PMILSOF groups (Table 7). Removal of plants by PMILF and PMILSOF farmers was 77 to 75% in northern Ghana while only 42% of PMILCF removed plants. In both regions of Ghana, a higher percentage of PMILF applied chemicals or botanicals than the PMILSOF or PMILCF groups.

Table 6: Percentage of farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF) relative to pest management practices.

Knowledge or pest management practice	PMILF	PMILSOF	PMILCF	Chi-Square Test
Northern region[b]				
Awareness of beneficial insects	86	64	14	S
Use of fungicides	47	25	8	S
Use of insecticides	56	33	28	NS
Number of observations	36	36	36	
Southern region[c]				
Awareness of beneficial insects	69	33	20	S
Use of fungicides	58	19	11	S
Use of insecticides	39	52	22	S
Use of botanicals	46	5	8	S
Number of observations	26	21	65	

[a]S = significant at 95% confidence interval. NS = not significant at 95% confidence interval.
[b]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[c]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Table 7: Percentage of farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF) relative to presence of plants expressing disease.

Action	PMILF	PMILSOF	PMILCF
Northern region[a]			
Pull out diseased plant	75	67	42
Spray with chemicals/botanicals	17	8	3
Nothing	8	25	55
Number of observations	36	36	36
Southern region[b]			
Pull out diseased plant	65	67	66
Spray with chemicals/botanicals	31	14	5
Nothing	4	19	29
Number of observations	26	21	65

[a]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[b]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Aflatoxin Knowledge and Mitigation

PMILF in both regions of Ghana indicated that they were aware of the possibility of aflatoxin contamination in peanut at a higher rate than the PMILSOF group of the PMILCF group (Table 8). The percentage of PMILSOF was between the PMILF and PMILCF. In the northern region, PMILF were more likely to remove aflatoxin-contaminated grain prior to consumption or marketing. Farmers in the control group (PMILCF) and spillover farmers (PMILSOF) were more likely to remove grain contaminated with aflatoxin for consumption and marketing compared with this approach in northern Ghana. When considering response across farmer groups in both regions of the country, between 53 and 81% of farmers indicated that aggregators checked for aflatoxin prior to purchase. We use the term aflatoxin in this discussion; however, it is more likely that farmers were considering presence of visible mold (*Aspergillus flavus* or parasiticus) as the indicator as peanut evaluated by aggregators most likely did not involve testing for aflatoxin (Table 9).

Table 8: Percentage of farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF) indicating a positive response to issues associated with aflatoxin[a].

Issue or action	PMILF	PMILSOF	PMILCF	Chi-Square Test
Northern region[b]				
Heard about aflatoxin before?	100	72	31	S
Observation of aflatoxin-contaminated grain in farmers' peanut	92	75	50	S
Removal of aflatoxin-contaminated grain before eating?	94	61	47	S
Removal of aflatoxin-contaminated grain before selling?	86	53	47	S
Aggregator cross-check aflatoxin-free peanut?	69	53	56	NS
Number of observations	36	36	36	
Southern region[c]				
Heard about aflatoxin before?	96	52	22	S
Observation of aflatoxin-contaminated grain in farmers' peanut	-	-	-	
Removal of aflatoxin-contaminated grain before eating?	96	100	91	NS
Removal of aflatoxin-contaminated grain before selling?	91	88	88	NS
Aggregator cross-check aflatoxin-free peanut?	81	59	67	S
Number of observations	26	21	65	

[a]S = significant at 95% confidence interval. NS = not significant at 95% confidence interval.
[b]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[c]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Table 9: Self-reported estimates of aflatoxin-contaminated peanut by farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF)[a].

Issue or action	PMILF	PMILSOF	PMILCF	PMILF vs. PMILSOF	PMILF vs. PMILCF	PMILSOF vs. PMILCF
Northern region[b]						
Estimated percentage	6.3	3	4.8	S	NS	S
Number of observations	36	36	36			
Southern region[c]						
Estimated percentage	3.3	2.5	6.7	NS	S	S
Number of observations	26	21	65			

[a]S = significant at 95% confidence interval. NS = not significant at 95% confidence interval.
[b]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.

[c]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Farmers in the PMILF group in northern Ghana estimated that grain was contaminated at a rate of 6.3% (Table 10). The percentage differed when comparing PMILF to PMILSOF or PMILSOF with PMILCF but not when comparing PMILF with PMILCF. In contrast, farmers in the control group (PMILCF) estimated higher levels of contamination than either PMILF or PMILSOF. Farmers in northern Ghana were less likely to throw away moldy grain (presumably aflatoxin-contaminated) compared with southern Ghana (Table 10). However, in both regions 56% to 70% of farmers in the PMILF group threw away grain they deemed contaminated. The percentage of farmers throwing away contaminated grain in northern Ghana was 56%, 25%, and 22% for PMILF, PMILSOF, and PMILCF, respectively. Conversely, the percentage for discarding grain in this manner was 70%, 82%, and 91% for these respective groups in southern Ghana.

Table 10: Approach to use of known aflatoxin-contaminated peanut by farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF) indicating a positive response to issues associated with aflatoxin.

Northern region[a]			
Throw away	56	25	22
Use for soup/stew	0	11	28
Burn	14	17	0
Animal feed	3	0	0
Sell	0	3	0
Bury	25	8	0
Nothing/no action	2	36	50
Number of observations	36	36	36
Southern region[b]			
Throw away	70	82	91
Use for soup/stew	13	0	5
Burn	9	0	0
Animal feed	0	6	2
Sell	0	6	0
Bury	4	6	0
Nothing	4	0	2
Number of observations	23	17	55

[a]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[b]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Farmers in both regions in the PMILF and PMILSOF dried peanut on tarpaulin at a higher percentage than the PMILCF group (Table 11). PMILF and PMILSOF dried peanut on tarpaulin at about the same rate. Conversely, farmers in the PMILCF group were more like to dry peanut on bare or cemented surfaces. Less than 5% of farmers in any of the groups or regions dried peanut on platforms or by other methods. In northern Ghana, none of the farmers reported storing peanut in hermetically-sealed bags regardless of group (Table 12). In contrast, 46%, 5%, and 2% of farmers in the PMILF, PMILSOF, and PMILCF groups, respectively, stored peanut in these bags. Polysacs were more popular in northern Ghana than in the southern region of the country while fertilizer bags were popular in southern Ghana.

Table 11: Percentage of farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF) relative to surface used for drying peanut.

Surface	PMILF	PMILSOF	PMILCF
Northern region[a]			
Tarpaulin or poly sheet	33	28	14
Bare/cemented floor	64	67	83
Platforms	3	3	0
Others	0	2	3
Number of observations	36	36	36
Southern region[b]			
Tarpaulin or poly sheet	84	85	42
Bare floor	12	10	52
Platforms	0	5	5
Others	4	0	1
Number of observations	26	21	65

[a]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[b]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Table 12: Percentage of farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF) relative to containers used for storing peanut.

Northern region[a]			
Hermetically-sealed bags	0	0	0
Polysacs	42	33	31
"Fertilizer" bags	33	56	33
Open pans	0	0	0
Jute sacs	6	0	22
Mud Silo	19	6	11
Others	0	5	3
Number of observations	36	36	36
Southern region[b]			
Hermetically-sealed bags	46	5	2
Polysacs	4	9	14
"Fertilizer" bags	42	86	79
Open pans	0	0	1
Jute sacs	8	0	3
Others	0	0	1
Number of observations	26	21	65

[a]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[b]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Marketing Peanut and Household Expenditures

All three groups of farmers in northern Ghana indicated that low prices for peanut were a major concern (Table 13). In northern Ghana, few differences in the percent of farmer groups were observed with respect to price. In contrast, in southern northern Ghana, approximately 95% of PMILF and PMILSOF were concerned about price of peanut. The percentage of these two groups of farmers exceeded that of PMILCF (66%). In northern Ghana, PMILF and PMILCF were more concerned about traders dictating price of peanut than PMILSOF. Size of bags used by traders, inability to find traders, transportation, and purchasing on credit were listed as issues faced by farmers. However, price was the major concern for most farmers.

Table 13: Percentage of views on issues and approaches to marketing by farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF).

Issues and Approaches to Marketing	PMILF	PMILSOF	PMILCF
Northern region[a]			
Low price	89	94	97
Traders dictating prices	100	75	94
Traders use large bags	69	67	67
Cannot find traders	61	39	53
Transportation	36	22	47
Traders buy on credit	0	4	64
Number of observations	36	36	36
Southern region[b]			
Low price	96	95	66
Traders dictating prices	89	86	51
Traders use large bags	85	81	49
Cannot find traders	62	62	32
Transportation	62	71	23
Traders buy on credit	31	19	23
Low price	96	95	66
Number of observations	26	21	65

[a]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[b]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Uses of Income for Households

Income from peanut sales was used for a wide-range of household purchases (Table 14). Food and beverages, recreation and education, and agriculture-related inputs were the highest categories of household expenditures across regions of Ghana and farmer groupings. No clear trends across uses of income were noted when comparing farmer groups within a use category.

Table 14: Household expenditures associated with peanut-derived income by farmers involved in research addressing aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF) in northern and southern Ghana.

Expenditure item	PMILF	PMILSOF	PMILCF
Northern region[a]			
Food and beverage	11.8	12.28	12.08
Alcohol and tobacco	1.3	0.28	0.56
Clothing and footwear	11.1	9.7	9.3
Housing and utilities	7.9	7.75	5.56
Education and Recreation	21.4	15.97	11.9
Transport and communication	5.06	5.89	7.5
Health	15.3	11.8	9.58
Household goods	9	12	7.92
Agricultural-related expenses	15	19.89	21.39
Miscellaneous	1.3	1.9	0.69
Number of observations	36	36	36
Southern region[b]			
Food and beverage	23.5	24	24.2
Alcohol and tobacco	1.5	1.2	0
Clothing and footwear	7.7	7.9	7.5
Housing and utilities	5.6	11.2	6.4
Education and recreation	24.4	14.8	20.5
Transport and communication	4.3	4.8	4
Health	6.5	6.2	7.9
Household goods	5.5	8.1	6.9
Agricultural-related expenses	18	19.1	18.5
Miscellaneous	3	2.7	4.1
Number of observations	26	21	65

[a]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[b]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Sources of Information and Interactions with Extension

With respect to planting peanut in rows, PMILF, PMILSOF, and farmer experience were the top three sources of information (Table 15). The top two sources for sorting peanut was from relatives or the farmer's own experience. Forty-six percent of farmers listed PMILF as their source of information relative to germination testing. Primary site selection (e.g., proper vegetation) sources were PMILF, PMILCF, and experience. Experience was the primary source of information when considering soil selection for peanut.

In southern Ghana, PMILF was the source listed most often for information on improved varieties, planting in rows, testing seed for germination, selection of sites for peanut planting based on soil (Table 15). Information from relatives was the primary source for sorting peanut while PMILF and relatives were important sources of information for site selection based on vegetation.

Table 15: Sources of information for farmers in Ghana relative to peanut production.

Source of learning	Technology or recommendations (%)					
	Improved varieties	Row planting	Sorting	Germination testing	Proper vegetation	Good soil
Northern region[a]						
PMILF	20	34	18	46	27	20
PMILSOF	4	14	9	14	4	13
PMILCF	50	4	8	2	27	8
Relative	7	8	27	11	4	10
Experience	8	28	28	23	27	35
Media	0	0	3	0	4	5
Extension agent	4	8	5	2	4	5
Others/ NGO's	7	2	2	0	4	3
Farmer Field School	0	2	1	2	0	3
Number of observations	46	50	103	44	26	40
Southern region[b]						
PMILF	73	33	21	38	26	32
PMILSOF	27	22	15	23	15	20
PMILCF	0	5	11	7	7	3
Relative	0	19	28	11	26	15
Experience	0	8	15	7	13	17
Media	0	0	0	0	1	0
Extension agent	0	13	10	14	12	13
Number of observations						

[a]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[b]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

As expected, contact with Extension personnel within the past three years was higher for the PMILF group compared with the PMILSOF or PMILCF groups in both regions of Ghana (Table 16). The PMILF group was active in the research project and interacted often with research and extension personnel. However, prior to start of the research project with PMILF, interaction of farmers and extension was similar is relatively low across farmer groups in both regions.

Table 16: Interaction of Extension professionals with farmers conducting research to minimize aflatoxin contamination (PMILF), spillover farmers (PMILSOF), and a control group of farmers (PMILCF)[a].

Extension activities	PMILF	PMILSOF	PMILCF	PMILF vs. PMILSOF	PMILF vs. PMILCF	PMILSOF vs. PMILCF
Northern region[b]						
Extension to farmer contact in last 3 years	6.9	2.78	1.78	S	S	S
Farmer to extension contact in last 3 years	0.78	0.56	0.25	NS	S	NS
Number of observations	36	36	36			
Southern region[c]						
Extension to farmer contact in last 3 years	6.1	3.3	2.7	S	S	NS
Farmer to extension contact in last 3 years	1.5	0.9	0.4	NS	S	NS
Number of observations	26	21	65			

[a]S = significant at 95% confidence interval. NS = not significant at 95% confidence interval.
[b]Included Zankali in the Karaga district, Nako in the Wa West district, and Kpalbe in the Salaga district.
[c]Included Dagomba in the Drobonso district and Ejura Nkwanta in the Ejura-Sekyedumasi district.

Summary

Observations from this survey contribute to our understanding of peanut production systems in Ghana in two ways. First, these data provide a baseline for production practices and perceptions around them by peanut farmers in Ghana. Secondly, this survey provides information on success of farmer-led research on adoption of innovations by farmers outside the research cohort, especially with respect to aflatoxin mitigation in peanut

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References

1. Fletcher SM, Shi Z (2016) An overview of world peanut markets. In Stalker HT, Wilson RF (Eds.), Peanuts: Genetics, processing, and utilization. Amsterdam: Elsevier, USA, pp. 267-288.
2. Williams J, Phillips TD, Jolly PE, Stiles JK, CM Jolly, et al. (2003) Human aflatoxicosis in developing countries: a review of toxicology, exposure, potential health consequences, and interventions. Am J Clin Nutri 80(5): 1106-1122.
3. Jordan D, Brandenburg R, Payne G, Hoisington D, Magnan N, et al. (2018) Preventing mycotoxin contamination in groundnut cultivation. In: Sivasankar S, Berguinson D, Gaur P, Kumar S, Beebe S, et al. (eds.), Achieving Sustainable Cultivation of Grain Legumes; Improving Cultivation of Particular Grain Legumes. Burleigh Dodds Series in Agricultural Science, Burleigh Dodds Science Publishing, Cambridge, UK. 2: 181-214.
4. Kew MC (2012) Hepatocellular carcinoma in developing countries: Prevention, diagnosis and treatment. World J Hepatol 4(3): 99-104.
5. Turner PC, Moore SE, Hall AJ, Prentice AM, Wild CP (2003) Modification of immune function through exposure to dietary aflatoxin in Gambian children. Environ Health Perspect 111(2): 217-220.
6. Paterson RRH, Lima N (2011) Further mycotoxin effects from climate change. Food Research International 44(9): 2557-2566.
7. Hell K, Cardwell KF, Setamou M, Poehling H (2000) The influence of storage practices on aflatoxin contamination in maize in four agroecological zones of Benin, West Africa. J Stored Prod Res 36(4): 365-382.
8. Mutegi CK, Wagacha JM, Christie ME, Kimani J, Karanja L (2013) Effect of storage conditions on quality and aflatoxin contamination of peanuts *(Arachis hypogaea L.)*. International Journal of Agri Science 3(10): 746-758.
9. Villers P (2014) Aflatoxins and safe storage. Frontiers in Microbiology. 5.
10. Jordan DL, Buol GS, Brandenburg RL, Shew BB, Wilkerson GG, et al. (2022a). A risk tool and production log created using Microsoft Excel to manage pests in peanut *(Arachis hypogaea)*. J Integr Pest Manag 13(1): 9.
11. Jordan DL, Buol GS, Brandenburg RL, Reisig D, Nboyine J, et al. (2022b) Examples of risk tools for pests in peanut *(Arachis hypogaea)* developed for five countries using Microsoft Excel. Journal of Integrated Pest Management 13(1): 101-115.
12. Nigam SN, Jordan DL, Janila P (2018) Improving cultivation of groundnuts. In: Sivasankar S, Berguinson D, Gaur P, Kumar S, Beebe S, et al. (eds.), Achieving Sustainable Cultivation of Grain Legumes; Improving Cultivation of Particular Grain Legumes. Burleigh Dodds Series in Agricultural Science, Burleigh Dodds Science Publishing, Cambridge, UK 2: 155-180.
13. Njoroge SMC (2018) A Critical Review of Aflatoxin contamination of peanuts in Malawi and Zambia: The past, present, and future. Plant Disease 102(12): 2394-2406.
14. Abudulai M, Mahama G, Dzomeku I, Seidu A, Sugri I, et al. (2020) Evaluation of agricultural practices to increase yield and financial return and minimize aflatoxin contamination in peanut in northern Ghana. Peanut Sci 47(3): 156-162.
15. Appaw W, Ellis WO, Akromah R, Mochiah MB, Dankyi A, et al. (2020) Minimizing aflatoxin contamination in the field, during drying, and in storage in Ghana. Peanut Sci 47(2): 72-80.
16. Valentine H (2016) The role of peanuts in global food security. In: Stalker HT, Wilson RF (Eds.), Peanuts: Genetics, processing, and utilization. Amsterdam: Elsevier, USA, pp. 447-461.