

# Examples of Risk Tools for Pests in Peanut (*Arachis hypogaea*) Developed for Five Countries Using Microsoft Excel

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# Abstract

Suppressing pest populations below economically-damaging levels is an important element of sustainable peanut (*Arachis hypogaea* L.) production. Peanut farmers and their advisors often approach pest management with similar goals regardless of where they are located. Anticipating pest outbreaks using field history and monitoring pest populations are fundamental to protecting yield and financial investment. Microsoft Excel was used to develop individual risk indices for pests, a composite assessment of risk, and costs of risk mitigation practices for peanut in Argentina, Ghana, India, Malawi, and North Carolina (NC) in the United States (US). Depending on pests and resources available to manage pests, risk tools vary considerably, especially in the context of other crops that are grown in sequence with peanut, cultivars, and chemical inputs. In Argentina, India, and the US where more tools (e.g., mechanization and pesticides) are available, risk indices for a wide array of economically important pests were developed with the assumption that reducing risk to those pests likely will impact peanut yield in a positive manner. In Ghana and Malawi where fewer management tools are available, risks to yield and aflatoxin contamination are presented without risk indices for individual pests. The Microsoft Excel platform can be updated as new and additional information on effectiveness of management practices becomes apparent. Tools can be developed using this platform that are appropriate for their geography, environment, cropping systems, and pest complexes and management inputs that are available. In this article we present examples for the risk tool for each country.

Key words: agronomy, crop rotation, cultivar resistance, decision tool, IPM-Agriculture, pesticide

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	A PARAMAN A PARAMAN		
165 270	570	1345	
rop\Planting Date	20	Risk 100	Poir
Apr 15 to Apr 30, Jul 15 to Aug Jul 01 to Jul 14	30	100	
Jun 15 to Jun 30		40	2
May 01 to May 14, May 15 to M	/ay 31*, Jun 01 to Jun 14	20	
rop\Plants per 1m of Row		Risk	Poin
Broadcast (Variable Rate)		60 20	
4 plants (25 cm spacing) 5 plants (20 cm spacing)		20	
7 plants (15 cm spacing)		10	
10 plants (10 cm spacing, optin	num)	5	
rop\Seed Inoculant		Risk	Poi
No		25	
Yes*		5	
rop\Varlety Chinese (Span), Sarinut 1 (Vir-L	SP (2009)*	Risk 15	
	esari (Vir-LSR), Sarinut 2 (Span-LSR), Yenyawoso (Span-GRDR)	5	1
ield\Calciprill Application	control and source (spart and, contained type), and d	Risk	Poir
No		100	
Yes*		5	18
ield\Crop Rotation		Risk	Poir
Groundnut : Groundnut : Grou		80	
Soybean : Groundnut : Ground Groundnut : Maize : Groundnu	nut t, Groundnut : Sorghum : Groundnut, Soybean : Maize : Groundnut	60 50	
Groundnut : Maize : Groundnu Soybean : Soybean : Groundnu		50	
	aize : Sorghum : Groundnut, Sorghum : Maize : Groundnut	5	
ield\Fertilizer		Risk	Poi
None		80	
50 kg/ha (Yara Legume)		40	1
100 kg/ha (Yara Legume)*		15	17
	kg/ha (Yara Legume), 250 kg/ha (Yara Legume)	5	-
ield\Soil Fertility Low		Risk 20	POR
Moderate*		0	
High		-20	
ield\Soil pH		Risk	Poi
4.4 or lower, 7.0 or higher		50	
4.5 to 5.0		30	
5.1 to 5.5 5.6 to 6.9*		20	
ield\Tillage		Risk	Pol
Flat Beds (Conventional)		20	1
Plough and harrow (Improved)		10	1
larvest\Digging Timimg		Risk	Poi
21 Days Early, 21 Days Late		150	
14 Days Late		120 80	2
14 Days Early 7 Days Early, 7 Days Late		30	-
Optimum*		20	
larvest\Drying		Risk	Poir
Ground		160	
Cemented floor		50	1
Tarpulin*		10	_
est Management\Aphid Spray		Risk	Poi
No Yes*		10	
est Management\Bird Protectio	n	Risk	Pai
No		25	
Yes"		5	
est Management\Fungicides		Risk	Poi
None*		60	
1 Spray		40	6
2 Sprays		20	
3 Sprays est Management\Rodent Protect	tion	Risk	Pole
No		20	
Yes*		5	
est Management\Weed Control		Risk	Pol
	3 hand weedings during season	50	
	*, Post herbicides followed by 1 hand weeding	20	2
Pre herbicides followed by 1 ha torage\Groundnut Moisture	and weeding	5 Risk	Det
Greater than 15%		Risk 80	roll
10 to 15%*		20	2
Less than 10%		5	1
torage\Method		Risk	Poi
Traditional		160	2
Sealed*		20	
torage\Temperature		Risk	Poin
Higher than 32 °C		80	2
28 to 32 °C			2

Note: Reduction in pest risk value by a control practice will be less under low risk conditions.

Fig. 1. Risk summary for aflatoxin contamination in the northern Ghana peanut risk tool.

Peanut (*Arachis hypogaea* L.) is an important crop in many regions of the world and contributes to food security due to the resilience it adds in cropping systems and positive contributions to the human diet (Stalker et al. 2016, Valentine 2016). However, peanut is susceptible to a wide range of biotic and abiotic stresses that can limit yield

and quality and create issues associated with food safety (Nigam et al. 2018, Jordan et al. 2018). Low yield and poor quality can affect financial sustainability of peanut-based cropping systems. Employing cost-effective practices to minimize the impact of pests can increase peanut yield and financial sustainability. Research and

LOW	MODERATE	HIGH		
11111	250			
85 170		550	1220	
Crop\Planting Da	ite		Risk	Point
Jul 15 to Aug			100	
	30, Jul 01 to Jul 14		80	
May 01 to Ma	y 14, Jun 15 to Jun 30		30	10
May 15 to Ma	y 31*, Jun 01 to Jun 1	4	10	
Crop\Plants per				Point
Broadcast (Va			160	
4 plants (25 c			60	
5 plants (20 c			20	
7 plants (15 c			10 5	
Crop\Seed Inocu	cm spacing, optimum)			Point
No	idin		15	100
Yes*			5	
Crop\Variety				Point
Chinese (Span	1		70	
		n-LSR), Yenyawoso (Span-GRDR)	10	
	SR,GRDR), Sarinut 1 (\		5	
Field\Calciprill A			Risk	Points
No			50	5
Yes*			5	Э
Field\Crop Rotat	ion		Risk	Point
Groundnut : 0	Groundnut : Groundnu	t	50	
Soybean : Gro	undnut : Groundnut		40	
Soybean : Soy	bean : Groundnut		35	5
		oundnut : Sorghum : Groundnut, Soybean : Maize : Groundnut	15	
	: Groundnut*, Maize	: Sorghum : Groundnut, Sorghum : Maize : Groundnut	5	
Field\Fertilizer				Point
None			100	
50 kg/ha (Yara	CO. (Sec. 20, 1997)		50	
100 kg/ha (Ya			0	
150 kg/ha (Ya			-50	
200 kg/ha (Ya			-100	
250 kg/ha (Ya Field\Soil Fertilit				Point
Low	<b>y</b> )		100	
Moderate*			50	
High			5	
Field\Soil pH				Point
4.4 or lower,	7.0 or higher		100	
4.5 to 5.0			50	
5.1 to 5.5			25	
5.6 to 6.9*			5	
Field\Tillage			Risk	Point
Flat Beds (Cor	iventional)		20	10
Plough and ha	arrow (Improved)*		10	10
Harvest\Digging	Timimg		Risk	Point
21 Days Early			100	
21 Days Late			70	
14 Days Early,	14 Days Late		30	
7 Days Early, 1	7 Days Late		10	
Optimum*	100 10000		5	
Pest Managemei	nt\Aphid Spray			Point
No			80	
Yes*			5	
	ht\Bird Protection			Point
No Yes*			50	5
Pest Managemei	nt\Eungicidae		and the second se	Point
None*	a frankrings		100	
1 Spray			100	
2 Sprays			20	
3 Sprays			5	
	nt\Rodent Protection			Point
No			25	
Yes*			5	5
	nt\Weed Control			Point
Contraction of the second second	ng during season		100	
	ngs during season*		30	
			20	
3 hand weedi	ngs during season		20	
3 hand weedi	ngs during season as followed by 1 hand	weeding	10	

\* Selected options used in calculating pest risk.

Note: Reduction in pest risk value by a control practice will be less under low risk conditions.

Fig. 2. Risk summary for yield in the northern Ghana peanut risk tool.

educational programs by the public institutions, the private sector, and nongovernmental organizations often provide solutions to pests that adversely affect the peanut crop. Many of these solutions are developed locally with an understanding of the financial impact of pests and use of interventions that are available and economically practical.

Even though effective strategies and tools are available to suppress pests in peanut, information about those strategies is often

Crop				Production		Index	Low	Med	High
Planting Date Plants per 1m of Row Seed Inoculant	May 15 10 plants (10 cm spacing, Yes	CROP\VARIETY	×	Aflatoxir Yield Red		270 250	0000	•	
Variety	Sarinut 1 (Vir-LSR, GRDR					ices to eliminate.			
Field		<ul> <li>Nkatisesari (Vir-LSR)</li> </ul>				djusting practices to r			
Calciprill Application	Yes	Sarinut 1 (Vir-LSR,GRDR)		Green Dots	- Risk is acce	ptable for selected pr	actices.		
Crop Rotation	Maize : Maize : Groundnut								
Fertilizer	100 kg/ha (Yara Legume)	<ul> <li>Yenyawoso (Span-GRDR)</li> </ul>			Est	imated Cost (¢/h	na): 3123		
Soil Fertility	Moderate								_
Soil pH	6.0								
Tillage	Plough and harrow (Impro	ved)						901	
Harvest				0	919	1,838 2,7	57 3,67	6	4,595
Digging Timimg	Optimum								
Drying	Tarpulin					<b>Create Production</b>	Log		
Pest Management									
Aphid Spray	Yes								
Bird Protection	Yes								
Fungicides	None								
Rodent Protection	Yes								
Weed Control	2 hand weedings during se	eason							
Storage									
Groundnut Moisture	10 to 15%								
Method	Sealed								
Temperature	Lower than 28 °C								

Fig. 3. Drop down menu for varieties in the northern Ghana peanut risk tool.

Crop				Production		Index	Low	Med	Hig
Planting Date	Apr 15	CRORINARIES	×	Aflatoxin		205			
Plants per 1m of Row	10 plants (10 cm spacing,	CROP\VARIETY	~	Yield Red	uction	90			
Seed Inoculant	Yes	Chinese (Span)							
Variety	Otuhia (Vir-LSR,GRDR)	C Konkoma (Span)		Red Dots - C	hange practice	es to eliminate.			
Field		C Obolo (Span-LSR)		Yellow Dots	- Consider adju	usting practices to r	educe risk.		
Calciprill Application	Yes	<ul> <li>Oboshie (Span-LSR)</li> </ul>		Green Dots -	- Risk is accept	able for selected pr	actices.		
Crop Rotation	Maize : Maize : Groundnut	Otuhia (Vir-LSR, GRDR)							
Fertilizer	150 kg/ha (Yara Legume)	C Yenyawoso (Span-GRD	R)		Estir	nated Cost (¢/h	na): 5350	)	
Soil Fertility	High					1.1			_
Soil pH	5.6						///////		
Tillage	Plough and harrow (Impro	ved)	11		1212220				
Harvest				0	1,318	2,636 3,9	54	5,272	6,590
Digging Timimg	Optimum							1	
Drying	Cemented floor					<b>Create Production</b>	Log		
Pest Management								-	
Aphid Spray	Yes								
Bird Protection	Yes								
Fungicides	2 Sprays								
Rodent Protection	Yes								
Weed Control	Pre herbicides followed by	1 hand weeding							
Storage									
Groundnut Moisture	Less than 10%								
Method	Sealed								
Temperature	Lower than 28 °C								

Fig. 4. Drop down menu for varieties in major season in the southern Ghana peanut risk tool.

presented for individual disciplines (e.g., entomology, plant pathology, nematology, and weed science). In some instances practitioners are required to search through resources to determine interaction across pest disciplines in order to develop a holistic approach to pest management. Several approaches have been developed to address this challenge. In the southeastern region of the US, the Peanut Rx guide allows growers and their advisors to determine the impact of production and pest management practices on tomato spotted wilt (tospovirus, Bunyaviridae) transmitted by thrips (*Frankliniella fusca* Pergande, *F. occidentalis* Hinds) and other pathogens in peanut (Anonymous 2022). In North Carolina in the United States, a Microsoft Excel platform was developed to assess overall risk from production and pest management practices for thirteen pests or groups of pests commonly found in peanut (Jordan et al. 2022). Outside of these educational resources, there are no electronic resources in other countries for peanut that allow the research and education community and practitioners to easily assess the composite risk based on strategies that are planned for a particular field and cropping cycle across several disciplines. An electronic tool that enables farmers and their advisors to assess overall risk with different practices in a more effective manner could potentially result in greater protection of yield and increased financial sustainability.

In NC, a Microsoft Excel platform was designed to allow farmers and their advisors (e.g., private crop consultants, extension agents, agribusiness, nongovernmental organizations, and Federal and State agencies) to identify risk from a set of practices based on field history (Jordan et al. 2022). The platform computes cost of each set of practices so that farmers can observe the financial impact of changes in practices designed to reduce risk. A data log function is also a part

Crop				Production		Index	Low	Me	d High	
Planting Date	Nov 15	The second s	140	Aflatoxin	()	310		•		
Plants per 1m of Row	10 plants (10 cm spacing,	CROP\VARIETY	×	Yield		275				
Seed Inoculant	No	Spanish								
Variety	Spanish	C Spanish (GRDR)		Red Dots - 0	hange practi	ces to eliminate.				
Field		⊂ Spanish (GRDR,LSR)		Yellow Dots	- Consider ad	justing practices to	educe risk	2		
Crop Rotation	Groundnut : Groundnut : 0	C Spanish (LSR)		Green Dots	- Risk is accept	ptable for selected p	actices.			
Fertilizer	None	C Virginia Type								
Gypsum at Bloom	Yes	C Virginia Type (GRDR)			Estim	ated Cost (MK/h	a): 479.3	760		
Soil Fertility	High	C Virginia Type (GRDR,LSR		-						
Soil pH	5.6	C Virginia Type (LSR)		7////						
Tillage	Hand dug and ridging							residus		
Harvest				0	141,922	283,844 425	766	567,688	709,610	
Digging Timimg	Optimum									
Drying	Cemented floor			Estimated Person Hours (hrs/ha): 3						
Method	Hand dug with hoe									
Pest Management				/////			///////	///////	////.	
Aphid Spray	Yes			0	54	107 10	1	214	268	
Bird Protection	Yes									
Fungicides	2 Sprays					121111112111211121	121102	1		
Rodent Protection	Yes					Create Production	Log			
Weed Control	2 hand weedings during se	eason								
Storage										
Groundnut Moisture	Less than 10%									
Method	Sealed									
Temperature	Lower than 28 °C									

Fig. 5. Drop down menu for varieties in the Malawi peanut risk tool.

Crop		Production	Index	Low	Med	High
Planting Date	Jun 15	Aflatoxin	1085			
Plants per 1m of Row	4 plants (25 cm spacing)	Yield Reduction	905			
Seed Inoculant	No					
Variety	Chinese (Span)	Red Dots - Change pract	ices to eliminate.			
Field		Yellow Dots - Consider a	djusting practices to r	educe risk.		
Calciprill Application	No	Green Dots - Risk is acce	ptable for selected pr	actices.		
Crop Rotation	Groundnut : Groundnut : Groundnut					
Fertilizer	None	Es	timated Cost (¢/	ha): 818		
Soil Fertility	Low					_
Soil pH	5.5					
Tillage	Flat Beds (Conventional)				20.00	_
Harvest		0 919	1,838 2,7	57	3,676	4,595
Digging Timimg	14 Days Late				1	
Drying	Ground		<b>Create Production</b>	Log		
Pest Management				100.00		
Aphid Spray	No					
Bird Protection	No					
Fungicides	None					
Rodent Protection	No					
Weed Control	1 hand weeding during season					
Storage						
Groundnut Moisture	10 to 15%					
Method	Traditional					
Temperature	28 to 32 °C					

Fig. 6. Risk to aflatoxin contamination, yield, and cost of production for the limited input system in the northern Ghana peanut risk tool.

Crop		Production		Index	Low	Med	Hig
Planting Date	May 15	Aflatoxin		235			
Plants per 1m of Row	10 plants (10 cm spacing, optimum)	Yield Red	uction	110			
Seed Inoculant	Yes						
Variety	Sarinut 1 (Vir-LSR, GRDR)	Red Dots - C	hange practice	s to eliminate.			
Field		Yellow Dots	- Consider adju	sting practices to	educe risk.		
Calciprill Application	Yes	Green Dots	- Risk is accepta	able for selected pr	actices.		
Crop Rotation	Maize : Maize : Groundnut						
Fertilizer	150 kg/ha (Yara Legume)		Estim	nated Cost (¢/ł	a): 3608		
Soil Fertility	Moderate		111000725	100000			_
Soil pH	6.0	1////			///////		
Tillage	Plough and harrow (Improved)			10.000		1.1.1.1	
Harvest		0	919	1,838 2,7	57 3,	676	4,595
Digging Timimg	Optimum						
Drying	Tarpulin			<b>Create Production</b>	Log		
Pest Management					1000		
Aphid Spray	Yes						
Bird Protection	Yes						
Fungicides	2 Sprays						
Rodent Protection	Yes						
Weed Control	3 hand weedings during season						
Storage							
Groundnut Moisture	Less than 10%						
Method	Sealed						
Temperature	Lower than 28 °C						

Fig. 7. Risk to aflatoxin contamination, yield, and cost of production for the high input system in the northern Ghana peanut risk tool.

Crop		Production	Inde	ex Low	Med	Hig
Planting Date	May 15	Aflatoxin	5	0		
Plants per 1m of Row	7 plants (15 cm spacing)	Yield Reduction	48			
Seed Inoculant	No					
Variety	Chinese (Span)	Red Dots - Change p	ractices to eliminate.			
Field			er adjusting practices t	o reduce risk.		
Calciprill Application	No		cceptable for selected			
Crop Rotation	Maize : Maize : Groundnut					
Fertilizer	50 kg/ha (Yara Legume)		Estimated Cost (¢	/ha): 1418		
Soil Fertility	Moderate		contraced coor (4	1107. 1410		
Soil pH	6.0					
Tillage	Flat Beds (Conventional)				-	_
Harvest		0 919	1,838	1,757	3,676	4,595
Digging Timimg	Optimum				č.	
Drying	Tarpulin		Create Producti	on Log		
Pest Management		-		2002260		
Aphid Spray	Yes					
Bird Protection	No					
Fungicides	None					
Rodent Protection	Yes					
Weed Control	2 hand weedings during season					
Storage						
Groundnut Moisture	Less than 10%					
Method	Traditional					
Temperature	Lower than 28 °C					

Fig. 8. Risk to aflatoxin contamination, yield, and cost of production for the medium input system in the northern Ghana peanut risk tool.

Crop		Production			Index	Low	Med	High
Planting Date	Nov 15	Aflatoxin	16 - C		710 🔵			•
Plants per 1m of Row	7 plants (15 cm spacing)	Yield			450 🔵			•
Seed Inoculant	No							
Variety	Spanish	Red Dots - 0	Change pract	ices to eliminate	e.			
Field		Yellow Dots	- Consider a	djusting practic	es to redu	ce risk.		
Crop Rotation	Maize : Maize : Groundnut	Green Dots	- Risk is acce	ptable for selec	ted practi	ces.		
Fertilizer	None							
Gypsum at Bloom	No		Estim	ated Cost (N	AK/ha):	260.400	)	
Soil Fertility	Low						~	_
Soil pH	5.6	1////						
Tillage	Hand dug and ridging		111					
Harvest		0	141,922	283,844	425,766	567,6	588 7	09,610
Digging Timimg	Optimum							
Drying	Ground		Estimat	ed Person H	iours (hi	s/ha): 2	22	
Method	Hand dug with hoe				min			-
Pest Management					//////	///////	8	
Aphid Spray	No	0	54	107	161	21	4	268
Bird Protection	No							
Fungicides	None			Succession and a		~ 1		
Rodent Protection	No			Create Prod	uction Log	£		
Weed Control	2 hand weedings during season							
Storage								
Groundnut Moisture	10 to 15%							
Method	Traditional							
Temperature	Higher than 32 °C							

Fig. 9. Risk to aflatoxin contamination, yield, and cost of production for the limited input system in the Malawi peanut risk tool.

Crop		Production	Index	Low	Med	High
Planting Date	Nov 15	Aflatoxin	400			
Plants per 1m of Row	10 plants (10 cm spacing, optimum)	Yield	200			
Seed Inoculant	No					
Variety	Spanish (GRDR)	Red Dots - Change practi	ices to eliminate.			
Field		Yellow Dots - Consider a	djusting practices to r	educe risk.		
Crop Rotation	Maize : Maize : Groundnut	Green Dots - Risk is acce	ptable for selected pr	actices.		
Fertilizer	150 kg/ha (Yara Legume)					
Gypsum at Bloom	Yes	Estim	ated Cost (MK/h	a): 463.66	0	
Soil Fertility	Low				-	_
Soil pH	5.6					
Tillage	Hand dug and ridging		man	**	199521	
Harvest		0 141,922	283,844 425,7	766 567	,688	709,610
Digging Timimg	Optimum					
Drying	Tarpulin	Estimat	ed Person Hours	(hrs/ha):	283	
Method	Hand dug with hoe			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
Pest Management					///////	///.
Aphid Spray	No	0 54	107 16	1 2	14	268
Bird Protection	Yes					
Fungicides	None		121000000000000000000000000000000000000	1		
Rodent Protection	Yes		Create Production	Log		
Weed Control	2 hand weedings during season					
Storage						
Groundnut Moisture	Less than 10%					
Method	Traditional					
Temperature	28 to 32 °C					

Fig. 10. Risk to aflatoxin contamination, yield, and cost of production for the high input system in the Malawi peanut risk tool.

Crop		Production	Index	Low	Med	High
Planting Date	Nov 15	Aflatoxin	810	0000	0000	
Plants per 1m of Row	7 plants (15 cm spacing)	Yield	460			
Seed Inoculant	No					
Variety	Spanish	Red Dots - Change prac	tices to eliminate.			
Field		Yellow Dots - Consider	adjusting practices to r	educe risk.		
Crop Rotation	Maize : Maize : Groundnut	Green Dots - Risk is acc	eptable for selected pr	actices.		
Fertilizer	None					
Gypsum at Bloom	No	Esti	nated Cost (MK/h	a): 260.40	0	
Soil Fertility	Low		notes coor (inity it			_
Soil pH	5.6					
Tillage	Hand dug and ridging					_
Harvest		0 141,922	283,844 425,7	66 567	,688	709,610
Digging Timimg	14 Days Late					
Drying	Ground	Estima	ted Person Hours	(hrs/ha): 1	222	
Method	Hand dug with hoe			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	1	
Pest Management					1	
Aphid Spray	No	0 54	107 16	2	14	268
Bird Protection	No					
Fungicides	None					
Rodent Protection	No		Create Production	Log		
Weed Control	2 hand weedings during season					
Storage						
Groundnut Moisture	Greater than 15%					
Method	Traditional					
Temperature	Higher than 32 °C					

Fig. 11. Influence of timing of digging, drying method, and approaches to storage on aflatoxin contamination, yield, and cost of production in Malawi peanut risk tool with poor practices.

Crop		Production	Index	Low	Med	High
Planting Date	Nov 15	Aflatoxin	385			
Plants per 1m of Row	v 7 plants (15 cm spacing)	Yield	450			
Seed Inoculant	No					
Variety	Spanish	Red Dots - Change prac	tices to eliminate.			
Field		Yellow Dots - Consider	adjusting practices to r	educe risk.		
Crop Rotation	Maize : Maize : Groundnut	Green Dots - Risk is acc	eptable for selected pr	actices.		
Fertilizer	None					
Gypsum at Bloom	No	Estir	nated Cost (MK/h	a): 328,93	80	
Soil Fertility	Low			1	-	_
Soil pH	5.6					
Tillage	Hand dug and ridging					
Harvest		0 141,922	283,844 425,	/66 56	7,688	709,610
Digging Timimg	Optimum					
Drying	Cemented floor	Estima	ted Person Hours	(hrs/ha):	226	
Method	Hand dug with hoe			11111111	111	
Pest Management						
Aphid Spray	No	0 54	107 16	1 7	214	268
Bird Protection	No					
Fungicides	None			AN 1910-	ſ	
Rodent Protection	No		Create Production	Log		
Weed Control	2 hand weedings during season					
Storage						
Groundnut Moisture	Less than 10%					
Method	Sealed					
Temperature	Lower than 28 °C					

Fig. 12. Influence of timing of digging, drying method, and approaches storage on aflatoxin contamination, yield, and cost of production in Malawi peanut risk tool with improved practices.

of the platform that enables the user to electronically record production and pest management practices for the field and other important factors including yield, market grade characteristics, and rainfall. A detailed description of the NC peanut risk tool and examples of pests and pest management interactions are provided elsewhere (Jordan et al. 2022). When the NC peanut risk tool was under development, the decision to use Microsoft Excel as the platform was made so that tools for other states in the US or other countries could use the platform to create their own risk management tool. A portion of the funding for the development of the NC peanut risk tool was from the USAID Feed the Future Innovation Lab for Peanut with a specific goal of creating a tool that was transferable to partnering countries and ultimately a risk management tool that is available for the general public. In this paper, we provide examples of Microsoft Excel based peanut risk tools developed for Argentina, Ghana, India, and Malawi using the peanut risk tool initially developed for NC. The current iteration of each of these tools, a blank template, and an instructional video for creation of a risk tool can be found at: https://cropmanagement.cals.ncsu.edu/risk-tools/peanut.html.

# Peanut Risk Tools in Ghana and Malawi

The peanut risk tools for Ghana and Malawi were developed simultaneously with information from both countries exchanged among scientists and practitioners. Risk to yield and contamination by aflatoxin (produced by *Aspergillus flavus* and *A. parasiticus*)

Crop				Disease (Foliar)	Index	Low	Med	High	
Cultivar	GG 20			Alternaria Leaf Spot	118				
Planting Date	Jun 25		_	Early Leaf spot - Rainfed	118				
Plants per 1m Row	6 or fewer	CROP\CULTIVAR ×	(c)	Early Leaf Spot - Summer	118				
Row Pattern	Single (75 - 1	G BG 3		Late Leaf Spot - Rainfed	118				
Field		C CSMG 84-1		Late Leaf Spot - Summer	118				
Intercrop	None	C GG 2		PBND	136				
Irrigation	Irrigated	@ GG 20		Rust	123				
Soil pH	7.0	C GG 7		Disease (Stem)	Index	Low	Med	High	
Tillage	Conventional	C ICG FDRS 10		Aflaroot	106				
Field Crop Rotation		C ICGS 44		Collar Rot	106		0000		
1 Crop Season Ago	Groundnut	C ICGS 76		Stem Rot	126				
2 Crop Seasons Ago	Groundnut	C ICGV 86590		Insect	Index	Low	Med	High	
3 Crop Seasons Ago	Groundnut	C M 335		Defoliaters	136				
4 Crop Seasons Ago	Groundnut	C M 522		Sucking Pests	136		0000		
<b>Field Nematode Population</b>		C R 8808		Nematode	Index	Low	Med	High	
Root Knot	High	C R 9201		Root Knot	80				
Root Lesion	High	Somnath		Root-Lesion	80				
Stunt	High	C TG 37 A		Stunt-Kalahasty Malady	80				
Field Pest History		C TPG-41		Soil	Index	Low	Med	High	
Aflaroot	Problem even	1 / 1 / 1 / 2 / 2 / 2 / 2 / 2 / 2 / 2 /	trol program	Pests	131				
Alternaria Leaf Spot	Problem even		n						
Collar Rot	Problem even	with good fungicide/bioc	ontrol program	Red Dots - Change practices to	eliminate.				
Defoliators	Problem even	with good pesticide prog	ram	Yellow Dots - Consider adjustin	g practices to r	educe risk.			
Early Leaf Spot Rainfed	Problem even	with good fungicide prog	Iram	Green Dots - Risk is acceptable for selected practices.					
Early Leaf Spot Summer	Problem even	with good fungicide prog	Iram						
Late Leaf Spot Rainfed	Problem even	with good fungicide prog	Iram		reate Productio	n log	1		
Late Leaf Spot Summer	Problem even	with good fungicide prog	Iram		reate Froduction	in Log	-		
PBND	Problem even	with good fungicide prog	Iram						
Rust	Problem even	with good fungicide prog	Iram						
Soil Pests	Problem even	with good pesticide prog	ram						
Stem Rot	Problem even	with good fungicide/bioc	ontrol program						
Sucking Pests	Problem even	with good pesticide prog	Iram						
Natural Pest Enemy Popula	ition								
Defoliators	Low/Below Av	verage							
Sucking Pests	Low/Below Av	verage							
Pest Control									
Nematicide	None								

Fig. 13. Drop down menu for varieties in India peanut risk tool.

were compared using information for five categories of practices. Examples of the components of the northern Ghana peanut risk tool are presented in Figs. 1 and 2. The risk tools differed between the countries primarily in areas of cultivar selection, planting patterns and plant population, and planting dates. Also, peanut production in Ghana is impacted by a bimodal rainfall pattern in southern Ghana and a unimodal rainfall pattern in northern Ghana. Malawi has a single production season similar to northern Ghana. Risk tools in Ghana and Malawi include estimates of production and pest management costs. The Malawi risk tool also includes estimates of the time required to complete tasks (e.g., labor costs in person hours). Cultivar selection is a major driver of yield and is an important element of risk tools in Ghana and Malawi. Drop down menus for cultivar selection for both risk tools in Ghana (unimodal and bimodal rainfall seasons) and the risk tool in Malawi are presented in Figs. 3-5.

Risk to yield and aflatoxin contamination for three levels of input for northern Ghana are contrasted in Figs. 6–8. When inputs are limited, risk to both yield and aflatoxin are high as noted with three dots in the red category for both parameters (Fig. 6). This approach to peanut production in many areas of Ghana is not uncommon where availability of interventions are limited and financial constraints exist (e.g., financial credit and access to loans) (Abudulai et al. 2020, Appaw et al. 2020). Estimated cost of production for this low input system was \$131/ha (818 Ghana cedes/ha). When resources are available and interventions are included across all categories, risk to yield and contamination by aflatoxin was essentially eliminated but at a cost that is over four times the cost of the low input system (\$577/ha or 3,608 Ghana cedes/ha) (Fig. 7). Few peanut farmers in Ghana have access to all interventions and/or financing to purchase available resources prior to the cropping cycle. A reasonable alternative to both the low and high input systems is presented in Fig. 8. Risk in this scenario remains relatively high (e.g., yellow dots for yield and aflatoxin) but with lower costs at \$226/ha (1,418 Ghana cedes/ha). Although cost is greater than the low input system, risk to yield and aflatoxin is lowered considerably compared with the low input system.

The Malawi peanut risk tool allows practitioners to observe not only changes in cost of production as risk is addressed but also gives an estimate of the labor involved as practices are modified. For example, cost of production when inputs are limited is \$322/ha (260,400 Malawian kwacha/ha) with 222 person hours required in the limited input system (Fig. 9). In contrast, risk was lowered with increased inputs (e.g., fertilizer, gypsum, fungicide, and additional hand weeding) but required an increase to 283 person h/ha and a cost of \$574/ha (463,660 Malawian kwacha/ha) (Fig. 10). The Malawi risk tool also demonstrates the value of adopting improved practices associated with digging peanut, drying, and storage to mitigate aflatoxin contamination (Figs. 11 and 12). Two red dots were present when peanut was dug 14 d after optimum pod maturity, dried on the ground to moisture exceeding 15%, and stored in a traditional setting at temperatures exceeding 32°C (Fig. 11). Risk was reduced to only one yellow dot when peanut was dug at optimum maturity, dried on cement flooring to less than 10% moisture, and stored in sealed bags at 28°C or lower (Fig. 12). Although not captured in this version of the Malawi risk tool, previous research (Appaw et al. 2020) reported that drying on tarps and storing in hermeticallysealed bags prevented increases in aflatoxin contamination during storage compared with traditional practices (e.g., drying on soil and storing in non-sealed bags) and also resulted in more higher quality

LOW		ERATE		ligh			
				111111111111111111111111111111111111111	.23		
43	60	85			133		
Crop\Cultivar					F	tisk F	Points
GG 20*						30	
BG 3, CSMG 84-1	L, GG 2, GG 7, ICGS 4	4, ICGS 76, M 335, M	522, Somnath			20	30
ICG FDRS 10, ICG	GV 86590, R 8808, R	9201, TG 37 A, TPG-4	1			10	
Crop\Planting Date					R	tisk F	Points
Jun 20 to Dec 31	*					10	10
Jan 01 to Jun 19						5	10
Field\Intercrop					R	lisk F	Points
Cluster Bean, Co	tton, Maize, Pearl N	illet, Pulses, Sorghum	ı			15	5
None*						5	2
Field\Irrigation					F	tisk F	Points
Irrigated (Recom	mended), Irrigated*					15	15
Non-Irrigated						5	15
Field\Tillage					F	tisk F	Points
Conventional*, [	Deep (Improved)					15	15
Strip into killed o	cover crop or previou	us crop residue				5	13
Field Crop Rotation	1 Crop Season Ago				R	lisk F	Points
Groundnut*						15	15
Chickpea, Cottor	n, Cumin, Fodder, Ga	irlic, Melons, Onion, F	Pearl Millet, Vegetab	les, Wheat		3	13
Field Crop Rotation	\2 Crop Seasons Ag	D			R	lisk F	Points
Groundnut*						10	10
Chickpea, Cottor	n, Cumin, Fodder, Ga	irlic, Melons, Onion, F	Pearl Millet, Vegetab	les, Wheat		2	10
Field Crop Rotation	\3 Crop Seasons Ag	D			F	tisk F	Points
Groundnut*						5	5
Chickpea, Cottor	n, Cumin, Fodder, Ga	irlic, Melons, Onion, F	Pearl Millet, Vegetab	les, Wheat		2	2
Field Crop Rotation	\4 Crop Seasons Ag	0			R	lisk F	Points
Groundnut*						3	3
Chickpea, Cottor	n, Cumin, Fodder, Ga	irlic, Melons, Onion, F	Pearl Millet, Vegetab	les, Wheat		1	3
Field Pest History\F	Rust				F	tisk F	Points
Problem even wi	ith good fungicide p	rogram*				15	
Present but not a	a problem with good	fungicide program				10	15
None (Groundnu	ıt never grown)					5	
2							

# Groundnut - Rust Risk Summary

Note: Reduction in pest risk value by a control practice will be less under low risk conditions.

Fig. 14. Risk summary for rust in the India peanut risk tool.

\* Selected options used in calculating pest risk.

kernels for the market. Less time and labor would be needed by the farmer because quality of peanut is at a higher level due to improved harvest, drying, and storage.

### Argentina, India, and the United States

In contrast to Ghana and Malawi, farmers in Argentina, India, and NC (USA) have greater resources and inputs at their disposal to manage pests. While discussed in detail elsewhere, the NC risk tool includes individual risk indices for 13 pests or groups of pests and a wide range of pesticides available to suppress pest populations (Jordan et al. 2022). At the current time, risk tools for Argentina and India do not have cost of inputs. Improved cultivars are widely available for adoption as they are released because of a reliable certified seed delivery system. With the exception of tomato spotted wilt, a significant number of pesticides is available to suppress all pests that are economically important for peanut. However, cultural practices also contribute to suppression of pests.

The India peanut risk tool includes 16 pests or groups of pests under five categories (Fig. 13). A drop down menu for cultivars is presented in Fig. 13. Practices that affect rust (*Puccinia arachidis* Speg.) in peanut are presented in Fig. 14. When peanut was grown continuously and intercropped with corn (*Zea mays* L.) with limited inputs, risk was high (e.g., numerous red dots) for all pests (Fig. 15). In contrast, establishing a more effective rotation sequence with two cycles of cotton (*Gossypium hirsutum* L.), not intercropping, and planting a cultivar with resistance to this pathogen decreased risk substantially (Fig. 16). The current India peanut risk tool does not include the cost associated with production and pest management practices.

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Crop	
Cultivar	BG 3
Planting Date	Jun 25
Plants per 1m Row	6 or fewer
Row Pattern	Single (75 - 100 cm)
Field	
Intercrop	Maize
Irrigation	Non-Irrigated
Soil pH	6.3
Tillage	Conventional
Field Crop Rotation	
1 Crop Season Ago	Groundnut
2 Crop Seasons Ago	Groundnut
3 Crop Seasons Ago	Groundnut
4 Crop Seasons Ago	Groundnut
Field Nematode Population	
Root Knot	High
Root Lesion	High
Stunt	High
Field Pest History	
Aflaroot	Problem even with good fungicide/biocontrol program
Alternaria Leaf Spot	Problem even with good fungicide program
Collar Rot	Problem even with good fungicide/biocontrol program
Defoliators	Problem even with good pesticide program
Early Leaf Spot Rainfed	Problem even with good fungicide program
Early Leaf Spot Summer	Problem even with good fungicide program
Late Leaf Spot Rainfed	Problem even with good fungicide program
Late Leaf Spot Summer	Problem even with good fungicide program
PBND	Problem even with good fungicide program
Rust	Problem even with good fungicide program
Soil Pests	Problem even with good pesticide program
Stem Rot	Problem even with good fungicide/biocontrol program
Sucking Pests	Problem even with good pesticide program
Natural Pest Enemy Popula	ition
Defoliators	Low/Below Average
Sucking Pests	Low/Below Average
Pest Control	
Nematicide	None

Disease (Foliar)	Index	Low	Med	High
Alternaria Leaf Spot	98		0000	
Early Leaf spot - Rainfed	98			
Early Leaf Spot - Summer	98			
Late Leaf Spot - Rainfed	98	0000		
Late Leaf Spot - Summer	98			
PBND	136			
Rust	113			
Disease (Stem)	Index	Low	Med	High
Aflaroot	101	0000		
Collar Rot	101			
Stem Rot	121			
Insect	Index	Low	Med	High
Defoliaters	121	0000		•
Sucking Pests	121			•
Nematode	Index	Low	Med	High
Root Knot	80			
Root-Lesion	80			
Stunt-Kalahasty Malady	80			
Soil	Index	Low	Med	High
Pests	116			

Red Dots - Change practices to eliminate. Yellow Dots - Consider adjusting practices to reduce risk. Green Dots - Risk is acceptable for selected practices.

**Create Production Log** 

Fig. 15. Risk from pests in the India peanut risk tool with limited inputs and practices.

Crop		Disease (Foliar)
Cultivar	ICG FDRS 10	Alternaria Leaf Spot
Planting Date	May 15	Early Leaf spot - Rainfed
Plants per 1m Row	13 or more	Early Leaf Spot - Summer
Row Pattern	Twin (15 - 25 cm)	Late Leaf Spot - Rainfed
Field		Late Leaf Spot - Summer
Intercrop	None	PBND
Irrigation	Irrigated (Recommended)	Rust
Soil pH	7.0	Disease (Stem)
Tillage	Conventional	Aflaroot
Field Crop Rotation		Collar Rot
1 Crop Season Ago	Cotton	Stem Rot
2 Crop Seasons Ago	Cotton	Insect
3 Crop Seasons Ago	Groundnut	Defoliaters
4 Crop Seasons Ago	Groundnut	Sucking Pests
Field Nematode Population		Nematode
Root Knot	High	Root Knot
Root Lesion	High	Root-Lesion
Stunt	High	Stunt-Kalahasty Malady
Field Pest History		Soil
Aflaroot	Present but not a problem with good fungicide/biocontrol program	Pests
Alternaria Leaf Spot	Present but not a problem with good fungicide program	
Collar Rot	Present but not a problem with good fungicide/biocontrol program	Red Dots - Change practices to elimina
Defoliators	Present but not a problem with good pesticide program	Yellow Dots - Consider adjusting practi
Early Leaf Spot Rainfed	Present but not a problem with good fungicide program	Green Dots - Risk is acceptable for sele
Early Leaf Spot Summer	Present but not a problem with good fungicide program	
Late Leaf Spot Rainfed	Present but not a problem with good fungicide program	Create P
Late Leaf Spot Summer	Present but not a problem with good fungicide program	Create P
PBND	Present but not a problem with good fungicide program	
Rust	Present but not a problem with good fungicide program	
Soil Pests	Present but not a problem with good pesticide program	
Stem Rot	Present but not a problem with good fungicide/biocontrol program	
Sucking Pests	Present but not a problem with good pesticide program	
Natural Pest Enemy Popula	tion	
Defoliators	Low/Below Average	
Sucking Pests	Low/Below Average	
Pest Control		
Nematicide	Metam Sodium	

Disease (Foliar)	Index	Low	Med	High
Alternaria Leaf Spot	73			
Early Leaf spot - Rainfed	68			
Early Leaf Spot - Summer	73			
Late Leaf Spot - Rainfed	68			
Late Leaf Spot - Summer	73		000	
PBND	68			
Rust	73			
Disease (Stem)	Index	Low	Med	High
Aflaroot	68		•	
Collar Rot	68		0	
Stem Rot	83			
Insect	Index	Low	Med	High
Defoliaters	98			
Sucking Pests	98			
Nematode	Index	Low	Med	High
Root Knot	35			
Root-Lesion	35			
Stunt-Kalahasty Malady	35			
Soil	Index	Low	Med	High
Pests	88		0000	

nate. ctices to reduce risk. elected practices.

Production Log

Fig. 16. Risk from pests in the India peanut risk tool with improved inputs and practices.

Crop Practices				
Cultivar	Granoleico		×	
Plant Pattern	> 10 plts/m (7	CROP PRACTICES\CULTIVAR	*	
Field		C ASEM 400		
Soil Smut Inoculum	1500 or greate	C EC-191 RC		
Tillage System	Reduced Tilla	C EC-214		
Weeds and Herbicide Resistance	Palmer A. (AL	○ EC-98		
Field Crop History		Granoleico		
Crop 1 Season Ago	Soybean	○ MA-02		
Crop 2 Seasons Ago	Soybean	○ MA-757		
Crop 3 Seasons Ago	Soybean	C MA-88		
Leaf Spot Management	a contentation			
Chlorothalonil Applications	3 Sprays			
Fungicide Resistance	Groups 3+7+1	1+M		
Spray Schedule	Calendar			
Pest History				
Leaf Spot	Problem with g	good fungicide program		
Sclerotoina Blight	Present			
Smut	Problem with g	good fungicide program		
Treatments				
Iridium Applictions	None			
Miticides	Abamectin			
Weed Mgmt	PRE + EPOS	T + MPOST		
Weather Pattern				
Period 1 Sept and Oct	Moist			
renou reoprana our	Moist			
Period 2 Nov and Dec	MOIST			
	Moist			

Arthropod	Index	Low	Med	High
Spider Mites	73		0	
Disease (Foliar)	Index	Low	Med	High
Leaf Spot	286	0000		•
Disease (Soil Borne)	Index	Low	Med	High
Sclerotinia Blight	243			
Smut	300			
Plant	Index	Low	Med	High
Weeds	75			

Red Dots - Change practices to eliminate

Yellow Dots - Consider adjusting practices to reduce risk. Green Dots - Risk is acceptable for selected practices.

**Create Production Log** 

Fig. 17. Drop down menu for varieties in the Argentina peanut risk tool.

Crop Practices		Arthropod	Index	Low	Med	High
Cultivar	Granoleico	Spider Mites	73		0	
Plant Pattern	> 10 plts/m (70 cm single row)	Disease (Foliar)	Index	Low	Med	High
Field		Leaf Spot	306		0000	
Soll Smut Inoculum	1500 or greater spores/g soll	Disease (Soil Borne)	Index	Low	Med	High
Tillage System	Reduced Tillage	Sclerotinia Blight	229	0000		
Weeds and Herbicide Resista	nce Palmer A. (ALS resistant)	Smut	300	0000	0000	
Field Crop History		Plant	Index	Low	Med	High
Crop 1 Season Ago	Corn	Weeds	75	0000	00	
Crop 2 Seasons Ago	Peanut					
Crop 3 Seasons Ago	Corn	Red Dots - Change practices t	o eliminate.			
Leaf Spot Management		Yellow Dots - Consider adjust	ing practices to re	educe risk.		
Chlorothalonil Applications	3 Sprays	Green Dots - Risk is acceptabl	e for selected pra	actices.		
Fungicide Resistance	Groups 3+7+11+M					
Spray Schedule	Calendar		Create Productio	nlog		
Pest History			create Froductic	in Log		
Leaf Spot	Problem with good fungicide program					
Sclerotoina Blight	Present					
Smut	Problem with good fungicide program					
Treatments						
Iridium Applictions	None					
Miticides	Abamectin					
Weed Mgmt	PRE + EPOST + MPOST					
Weather Pattern						
Period 1 Sept and Oct	Moist					
Period 2 Nov and Dec	Moist					
Period 3 Jan and Feb	Moist					
Period 4 Mar and Apr	Moist					

Fig. 18. High risk of smut disease in the Argentina peanut risk tool with short rotations and planting a cultivar without resistance to this disease.

The Argentina peanut risk tool includes indices for two-spotted spider mites (*Tetranychus urticae* Koch), peanut smut disease (caused by *Thecaphora frezii* Carranza and Lindquist), early leaf spot disease [caused by *Mycosphaerella arachidicola* W.A. Jenkins (*syn. Passalora arachidicola* W.A. Jenkins], late leaf spot disease [caused by *Nothopassalora personata* (Berk. & M.A. Curtis) U. Braun, C. Nakash., Videira & Crous], Sclerotinia blight (*Sclerotinia minor* Jagger), and weeds (Fig. 17). Eight cultivars are listed in the drop down menu for Argentina (Fig. 17). Similar to the India peanut risk tool, the current tool for Argentina does not include a cost comparison for management inputs. Risk to smut disease was high when the cultivar Granoleico was planted and the rotation prior to peanut was corn, peanut, and soybean [*Glycine max* (L.) Merr.] (Fig. 18). Adding one more year of corn prior to peanut and planting the cultivar EC-191 RC eliminated risk of smut disease (Fig. 19).

Similar to the NC peanut risk tool (Jordan et al. 2022), the Argentina peanut risk tool includes a drop down menu for resistance to fungicides with respect to leaf spot disease and herbicides (Figs. 20 and 21). Three scenarios associated with risk to two-spotted spider mites are presented in Figs. 22–24. Applying chlorothalonil (a broad spectrum and nonsystemic fungicide) three times during the season created greater risk for two-spotted spider mites compared with only one application of this fungicide (Fig. 22). Chlorothalonil and other fungicides can decrease presence of beneficial fungal pathogen *Entomophthora fresenii* Nowakowski, that adversely affects two-spotted spider mites in peanut, especially when moisture is limited (Carner and Canerday 1968, Campbell 1978). Chlorothalonil can also increase risk of Sclerotinia blight (Figs. 22 and 23) but is an effective fungicide for resistance management because it is a multi-site fungicides (Culbreath et al. 2002). Abamectin moderated risk to two-spotted mites (Fig. 24).

Crop Practices		Arthropod	Index	Low	Med	High	
Cultivar	ASEM 400	Spider Mites	73	0000	•	-11	
Plant Pattern	> 10 plts/m (70 cm single row)	Disease (Foliar)	Index	Low	Med	High	
Field		Leaf Spot	289	0000			
Soil Smut Inoculum	1500 or greater spores/g soil	Disease (Soil Borne)	Index	Low	Med	High	
Tillage System	Reduced Tillage	Sclerotinia Blight	216				
Weeds and Herbicide Resista	nce Palmer A. (ALS resistant)	Smut	195				
Field Crop History		Plant	Index	Low	Med	High	
Crop 1 Season Ago	Com	Weeds	75	0000		10	
Crop 2 Seasons Ago	Corn						
Crop 3 Seasons Ago	Corn	Red Dots - Change practices t	o eliminate.				
Leaf Spot Management		Yellow Dots - Consider adjusti	ng practices to n	educe risk.			
Chlorothalonil Applications	3 Sprays	Green Dots - Risk is acceptable for selected practices.					
Fungicide Resistance	Groups 3+7+11+M						
Spray Schedule	Calendar		Create Productio	nlog	F		
Pest History			create Froudelik	in Log	1		
Leaf Spot	Problem with good fungicide program						
Sclerotoina Blight	Present						
Smut	Problem with good fungicide program						
Treatments							
Iridium Applictions	2 Sprays						
Miticides	Abamectin						
Weed Mgmt	PRE + EPOST + MPOST						
Weather Pattern							
Period 1 Sept and Oct	Moist						
Period 2 Nov and Dec	Moist						
Period 3 Jan and Feb	Moist						
Period 4 Mar and Apr	Moist						

Fig. 19. Risk of smut disease in the Argentina peanut risk tool when the number of years between peanut plantings is increased, a smut tolerant variety is planted, and iridium is applied.

Crop Practices				Arthropod	Index	Low	Med	High
Cultivar	MA-02	LEAF SPOT MANAGEMENT\FUNGICIDE RESISTANCE	8	Spider Mites	73	0000	0	
Plant Pattern	> 10 plts/m (7	LEAF SPOT MANAGEMENT (FUNGICIDE RESISTANCE	×	Disease (Foliar)	Index	Low	Med	High
Field		Group M (Multi-site)		Leaf Spot	246	0000	00	
Soil Smut Inoculum	1500 or greate	⊂ Groups 3+7		Disease (Soil Borne)	Index	Low	Med	High
Tillage System	Reduced Tilla	← Groups 3+11		Sclerotinia Blight	216	0000	0000	
Weeds and Herbicide Resistance	Palmer A. (AL	○ Groups 7+11		Smut	245			•
Field Crop History		Groups 3+7+11		Plant	Index	Low	Med	High
Crop 1 Season Ago	Corn			Weeds	85			
Crop 2 Seasons Ago	Corn							
Crop 3 Seasons Ago	Corn			Red Dots - Change practices t	o eliminate.			
Leaf Spot Management				Yellow Dots - Consider adjust		educe risk.		
Chlorothalonil Applications	3 Sprays			Green Dots - Risk is acceptabl	e for selected pra	actices.		
Fungicide Resistance	Groups 3+7+1	1						
Spray Schedule	Calendar				Create Productio	n log		
Pest History				1	create Froductic	in Log		
Leaf Spot	Problem with g	good fungicide program						
Sclerotoina Blight	Present							
Smut	Problem with g	good fungicide program						
Treatments								
Iridium Applictions	None							
Miticides	Abamectin							
Weed Mgmt	PRE + EPOS	T + MPOST						
Weather Pattern								
Period 1 Sept and Oct	Moist							
Period 2 Nov and Dec	Moist							
Period 3 Jan and Feb	Moist							
Period 4 Mar and Apr	Moist							

Fig. 20. Drop down menu for fungicide resistance in the Argentina peanut risk tool.

### **Future Goals for Peanut Risk Tools**

The risk tools described for peanut in this article serve as a starting point and are designed for modification as well as expansion to other peanut production areas. In the process of developing these tools several limitations have been identified due to dynamic nature of risk components. First, it is possible that modifications to create tools or portions of tools do not reflect the current knowledge of peanut production systems. Of course, the current versions are not complete in the sense that empirical data sets are a foundation for all of the point designations within and across pest disciplines and individual pests. A considerable amount of the information used in these tools reflects information provided by practitioners that are not verified by experimental data. However, it is important that risk tools created represent the current knowledge base for peanut production and pest management. When tools are modified there also needs to be a reference file that is considered 'official' so that the risk tool is consistent in format and content. With that said, modifications that represent other production areas are a recommended and are a key reason why the initial risk tool was created in Microsoft Excel, especially given the ubiquitous nature of this platform.

A second limitation to the current platform is that it is designed primarily as a planning tool with limited options once the cropping cycle begins. Integrating the tool with other outreach platforms or

Crop Practices			
Cultivar	MA-02	FIELD\WEEDS AND HERBICIDE RESISTANCE	×
Plant Pattern	> 10 plts/m (7	FIELD/WEEDS AND HERBICIDE RESISTANCE	~
Field		C Annual Grass	
Soil Smut Inoculum	1500 or greate	C Annual Grass (ACC and ALS resistant)	
Tillage System	Reduced Tilla	<ul> <li>Annual Grass (ACC resistant)</li> </ul>	
Weeds and Herbicide Resistar	nce Palmer A. (AL	<ul> <li>Annual Grass (ALS resistant)</li> </ul>	
Field Crop History	1	Conyza	
Crop 1 Season Ago	Corn	<ul> <li>Conyza (Glyphosate resistant)</li> </ul>	
Crop 2 Seasons Ago	Corn	○ Others	
Crop 3 Seasons Ago	Corn	C Palmer A.	
Leaf Spot Management		Palmer A. (ALS resistant)	
Chlorothalonil Applications	3 Sprays	C Pigweed	
Fungicide Resistance	Groups 3+7+1	Pigweed (ALS resistant)	
Spray Schedule	Calendar	C Sedges	
Pest History		C Volunteer Corn	
Leaf Spot	Problem with	C Volunteer Soybean	
Sclerotoina Blight	Present		
Smut	Problem with		
Treatments			
Iridium Applictions	None		
Miticides	Abamectin		
Weed Mgmt	PRE + EPOS	T + MPOST	
Weather Pattern			
Period 1 Sept and Oct	Moist		
Period 2 Nov and Dec	Moist		
Period 3 Jan and Feb	Moist		
Period 4 Mar and Apr	Moist		

Arthropod	Index	Low	Med	High
Spider Mites	73	0000	•	
Disease (Foliar)	Index	Low	Med	High
Leaf Spot	286			•
Disease (Soil Borne)	Index	Low	Med	High
Sclerotinia Blight	216			
Smut	245	0000		•
Plant	Index	Low	Med	High
Weeds	85			i.
	actices to eliminate. r adjusting practices to re cceptable for selected pra			
			1	

Fig. 21. Drop down menu for weeds based on herbicides resistance in the Argentina peanut risk tool.

Crop Practices		Arthropod	Index	Low	Med	High	
Cultivar	MA-02	Spider Mites	103	0000	0000	•	
Plant Pattern	> 10 plts/m (70 cm single row)	Disease (Foliar)	Index	Low	Med	High	
Field		Leaf Spot	246				
Soll Smut Inoculum	1500 or greater spores/g soil	Disease (Soil Borne)	Index	Low	Med	High	
Tillage System	Reduced Tillage	Sclerotinia Blight	224				
Weeds and Herbicide Resistant	nce Palmer A. (ALS resistant)	Smut	255			•	
Field Crop History		Plant	Index	Low	Med	High	
Crop 1 Season Ago	Corn	Weeds	85				
Crop 2 Seasons Ago	Soybean						
Crop 3 Seasons Ago	Corn	Red Dots - Change practices t	o eliminate.				
Leaf Spot Management		Yellow Dots - Consider adjusti		educe risk.			
Chlorothalonil Applications	3 Sprays	Green Dots - Risk is acceptable for selected practices.					
Fungicide Resistance	Groups 3+7+11						
Spray Schedule	Calendar	Create Production Log					
Pest History			create Productic	on Log			
Leaf Spot	Problem with good fungicide program						
Sclerotoina Blight	Present						
Smut	Problem with good fungicide program						
Treatments							
Iridium Applictions	None						
Miticides	None						
Weed Mgmt	PRE + EPOST + MPOST						
Weather Pattern							
Period 1 Sept and Oct	Moist						
Period 2 Nov and Dec	Moist						
Period 3 Jan and Feb	Moist						
Period 4 Mar and Apr	Moist						

Fig. 22. Risk of two-spotted spider mite infestation when three applications of chlorothalonil are made to peanut in the Argentina peanut risk tool.

applications on smartphones would create a time sensitive approach that would be an important advance. If used appropriately, the current risk tool platform decreases the likelihood that practitioners will begin the cropping cycle with elevated risk. The risk tool also serves as a historical record of a field or group of fields by using the production log feature. In this sense the risk tool is future looking. However, greater flexibility in the risk tool for decision-making during the cropping cycle is needed.

A third limitation to these risk tools is the economic component. While this element serves the user by allowing observations of changes in risk linked to production and pest management costs, moving this component of the risk tool toward a true financial comparison using empirical and observation data based on net returns rather than a simple cost of pest management would be an improvement. Efforts are currently underway in both Ghana and NC to address this limitation by collecting survey data from farmers using categories listed in the risk tool along with weather data, reported yield for that particular cropping cycle, and yield estimates over a longer period of time.

As with all models and tools, validation is needed with these risk tools. As these risk tools are put into practice, adjustments in distribution of points within categories in context of points in other categories need refinement. None-the-less, these risk tools provide a source of greater information exchange on the complicated nature of pest management in peanut for five countries across four continents.

Crop Practices		Arthropod	Index	Low	Med	High		
Cultivar	MA-02	Spider Mites	83		000	100 (100 (100 (100 (100 (100 (100 (100		
Plant Pattern	> 10 plts/m (70 cm single row)	Disease (Foliar)	Index	Low	Med	High		
Field		Leaf Spot	246			1		
Soil Smut Inoculum	1500 or greater spores/g soil	Disease (Soil Borne)	Index	Low	Med	High		
Tillage System	Reduced Tillage	Sclerotinia Blight	214					
Weeds and Herbicide Resista	nce Palmer A. (ALS resistant)	Smut	255					
Field Crop History		Plant	Index	Low	Med	High		
Crop 1 Season Ago	Corn	Weeds 85 000				00000		
Crop 2 Seasons Ago	Soybean							
Crop 3 Seasons Ago	Corn	Red Dots - Change practices to eliminate.						
Leaf Spot Management		Yellow Dots - Consider adjusti	ng practices to re	educe risk.				
Chlorothalonil Applications	1 Spray	Green Dots - Risk is acceptable for selected practices.						
Fungicide Resistance	Groups 3+7+11	Create Production Log						
Spray Schedule	Calendar							
Pest History			create Productio	in Log				
Leaf Spot	Problem with good fungicide program							
Sclerotoina Blight	Present							
Smut	Problem with good fungicide program							
Treatments								
Iridium Applictions	None							
Miticides	None							
Weed Mgmt	PRE + EPOST + MPOST							
Weather Pattern								
Period 1 Sept and Oct	Moist							
Period 2 Nov and Dec	Moist							
Period 3 Jan and Feb	Moist							

Fig. 23. Risk of two-spotted spider mite infestation when one application of chlorothalonil is made to peanut in the Argentina peanut risk tool.

Crop Practices		Arthropod	Index	Low	Med	High		
Cultivar	MA-02	Spider Mites	73	0000				
Plant Pattern	> 10 plts/m (70 cm single row)	Disease (Foliar)	Index	Low	Med	High		
Field		Leaf Spot	246					
Soil Smut Inoculum	1500 or greater spores/g soil	Disease (Soil Borne)	Index	Low	Med	High		
Tillage System	Reduced Tillage	Sclerotinia Blight	224					
Weeds and Herbicide Resistance	Palmer A. (ALS resistant)	Smut	255			•		
Field Crop History		Plant	Index	Low	Med	High		
Crop 1 Season Ago	Corn	Weeds	85					
Crop 2 Seasons Ago	Soybean							
Crop 3 Seasons Ago	Corn	Red Dots - Change practices to eliminate.						
Leaf Spot Management		Yellow Dots - Consider adjusti	ing practices to re	educe risk.				
Chlorothalonil Applications	3 Sprays	Green Dots - Risk is acceptable for selected practices.						
Fungicide Resistance	Groups 3+7+11							
Spray Schedule	Calendar							
Pest History			create Froductic	in Log				
Leaf Spot	Problem with good fungicide program							
Sclerotoina Blight	Present							
Smut	Problem with good fungicide program							
Treatments								
Iridium Applictions	None							
Miticides	Abamectin							
Weed Mgmt	PRE + EPOST + MPOST							
Weather Pattern								
Period 1 Sept and Oct	Moist							
Period 2 Nov and Dec	Moist							
Period 3 Jan and Feb	Moist							
Period 4 Mar and Apr	Moist							

Fig. 24. Risk of two-spotted spider mite infestation when three applications of chlorothalonil are made and abamectin is applied in the Argentina peanut risk tool.

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Conceptualization, D.L.J. and G.S.B; methodology, D.L.J. and G.S.B.; investigation, D.L.J., G.S.B., B.B.S., R.B., J.N., M.A., R.O., M.B.M., S.A., R.A., W.M., J.C., S.M., J.A.B., J.H.M., K.S.J., P.J., T.P.P., H.G., P.H., N.M., and G.M.; resources, D.L.J.; data curation, D.L.J. and G.S.B.; original draft preparation, D.L.J.; review and editing, D.L.J., G.S.B., R.B., J.N., M.A., R.O., M.B.M., S.A., R.A., W.M., J.C., S.M., J.A.P., J.H.M., K.S.J., P.J., T.P.P., H.G., P.H., N.M., G.M., D.H., and J.R.; project administration, D.L.J.; funding acquisition, D.L.J. All authors have read and agreed to the published version of the manuscript.

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