Effectiveness of a remote agricultural extension program in times of crisis: Experimental evidence from Myanmar

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Summary of the Paper

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Abstract:

Agricultural extension can have important impacts on vulnerable populations by increasing food production, which improves both rural incomes and urban food security. Yet, crises induced by violent conflict or disease outbreaks can severe the connections between extension agents and farmers. Understanding how agricultural extension systems can safely and effectively reach farmers in times of crisis could help stabilize agri-food systems in fragile states. In the context of COVID-19, a military coup, and an emergent threat of fall armyworm in Myanmar, this paper uses a randomized controlled trial to test the effectiveness of two cellphone-based extension interventions – a direct-to-farmer and a lead-farmer intervention – for fall armyworm control in maize. Despite low compliance, both interventions caused knowledge improvements. However, damage control estimates show that the lead-farmer group used pesticides most effectively. Similar cellphone-based lead-farmer programs could be an effective tool in fragile states and when faced with emergent threats to agriculture.

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1. Introduction

In times of crisis caused by disease or violence, the immediacy of threats and disruptions can divert attention and funding away from agricultural extension programs. Increased safety risks may prevent the delivery of information by extension agents to farmers. This may exacerbate crisis impacts as extension programs can have important livelihood and food security impacts on vulnerable populations through agricultural production. To prevent this loss of benefits, it is important to understand how agricultural extension systems can safely and effectively deliver information in times of crisis.

This paper tests the effectiveness of a remote agricultural extension program implemented during the dual crises of COVID-19 and a military coup in Myanmar. We use a randomized controlled trial to identify the causal impacts of the extension campaign on farmer knowledge, behaviors, and farm technical efficiency during the 2021 monsoon season. The extension program delivered information to maize farmers on the identification and management of fall armyworm, an insect pest that was first detected in Southeast Asia in 2019. Fall armyworm can cause large yield declines especially when effective control measures are not taken. Agricultural extension is especially urgent and significant in the context of emergent threats as farmers are unable to rely on individual or collective experience.

This paper makes three principal contributions to the literature. Frist, we provide a controlled test of extension programs during severe insecurity induced by a coup, something rarely done. In such contexts when traditional extension lines are severed, it is important to understand how to effectively reach farmers with critical and time sensitive information. Second, we add to the lead-farmer extension literature by testing the efficacy of a remote information transfer to farmers through lead farmers contacted by SMS. Third, we provide, to our knowledge, the first causal test of extension interventions on efficacy of pest control practices using a damage control specification. We apply a two-stage semi-parametric approach that allows us to identify differences in the impacts of pesticide use on technical efficiency across treatment group assignment.

2. Study setting and design

At the time of study, COVID-19 and the military coup presented immense obstacles to agricultural extension. In-person delivery of information was infeasible, and the military had blocked mobile internet. However, cellular networks for direct messaging or phone calls were largely uninterrupted allowing us to use two SMS-based extension interventions for our study – 1) direct SMS messages to farmers, and 2) a lead-farmer (LF) SMS program where SMS messages are sent to lead farmers who are then tasked with distributing that information to other farmers in their enumeration areas. The extension intervention consisted of delivering messages with three content themes – (i) fall armyworm identification and scouting, (ii) pest incidence action thresholds and control methods, (iii) and pesticide toxicity and safety. The content was delivered through four separate SMS messages. Each message contained information on pesticide action thresholds for a specific growth stage – early vegetative, early whorl, and late whorl – and we timed the messages following the modal maize production calendar such that the messages were sent at the relevant maize growth stage.

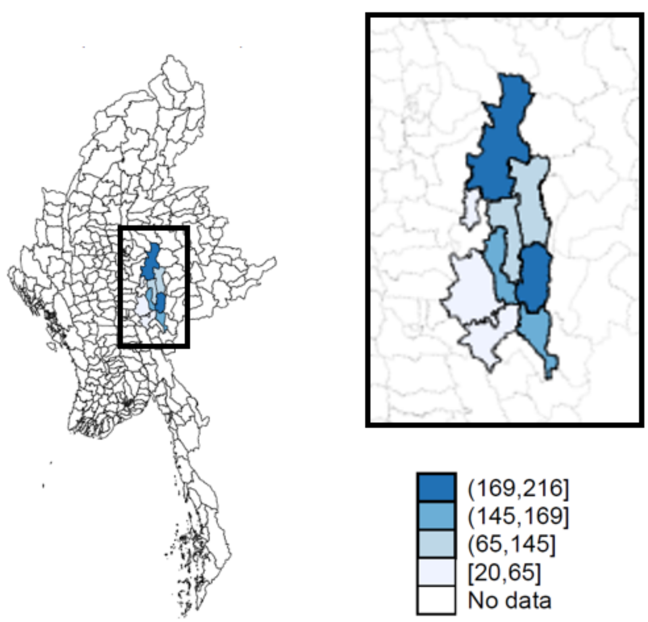
The messages were delivered to farmers in one of two ways, depending on randomized treatment group assignment. In the direct SMS treatment group, we sent messages directly to farmer cellphones using the confirmed and active contact numbers. In the LF treatment group, we sent messages to lead-farmers that were tasked with disseminating the information to a list of farmers in their villages. Lead farmers were compensated for their participation with a 15,000

MMK gift at the onset of the program and an additional 1,000 MMK payment per message delivered to farmers.

3. Data

This study focuses on 9 townships in southern Shan and northern Kayah states for their high densities of farmers growing maize, a crop most susceptible to fall armyworm (shown in Figure 1 with the final sample achieved in each township). The data come from three rounds of phone interviews conducted in June, September, and December 2021, respectively. The final sample for analysis consists of 1114 households. The sample is well-balanced over treatment group assignment for knowledge indices, maize practices, and other household characteristics (Table 1).

Figure 1. Study region map, final sample by township



Source: Author calculations

Table 2. Sample descriptives and balance tests of random group assignment

	All sample (n=1114)		Control group (n=362)		T1: SMS group (n=370)		T2: Lead Farmer group (n=382)		Test of equal means: C=T1=T2
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	p-value
Household characteristics									
# of household members									
Total	4.9	(1.7)	5.1	(1.8)	4.9	(1.8)	4.8	(1.7)	0.370
Male	2.4	(1.2)	2.5	(1.2)	2.4	(1.2)	2.3	(1.2)	0.248
Female	2.5	(1.2)	2.5	(1.2)	2.5	(1.2)	2.5	(1.2)	0.823
Self-reported occurrence of violence in area since coup (%)	17.3	(37.9)	16.9	(37.5)	15.9	(36.7)	19.1	(39.4)	0.938
Land area owned (acres)	9.4	(8.9)	9.8	(9.1)	9.2	(7.8)	9.2	(9.8)	0.869
Respondent information									
Female respondent (%)	16.9	(37.5)	16.6	(37.2)	19.2	(39.4)	14.9	(35.7)	0.585
Respondent age	39.2	(12.1)	39.8	(12.6)	38.8	(11.8)	38.9	(12.0)	0.672
Education (%)									
Completed high school or above	17.1	(37.7)	16.9	(37.5)	17.3	(37.9)	17.3	(37.9)	0.990
Never attended school	5.0	(21.9)	6.4	(24.4)	4.1	(19.7)	4.7	(21.2)	0.436
Monastery only	13.8	(34.5)	13.3	(34.0)	12.2	(32.7)	16.0	(36.7)	0.638
Able to read/type cell messages in Burmese (%)	91.4	(28.1)	92.0	(27.2)	93.5	(24.7)	88.7	(31.6)	0.114
Mobile Phone Ownership and Usage (HH level)									
# of Operating cellphones owned	2.2	(1.2)	2.3	(1.2)	2.2	(1.2)	2.2	(1.2)	0.619
# of Smartphones owned	1.8	(1.2)	1.9	(1.2)	1.7	(1.2)	1.7	(1.1)	0.262
Typical spending per month on mobile (HH level), Kyat	14,250	(13,625)	15,041	(14,035)	13,842	(12,279)	13,897	(14,449)	0.525
Knowledge (pre-intervention)									
Know about FAW (%)	90.5	(29.4)	93.1	(25.4)	87.0	(33.6)	91.4	(28.1)	0.121
Overall Knowledge Index [0,13]	2.36	(1.52)	2.40	(1.56)	2.32	(1.65)	2.35	(1.36)	0.938
Sub-Index: Scouting and Identification Knowledge [0,5]	0.92	(0.84)	0.89	(0.81)	0.91	(0.89)	0.95	(0.80)	0.825
Sub-Index: Action Threshold Knowledge [0,4]	0.83	(0.86)	0.88	(0.93)	0.79	(0.83)	0.81	(0.81)	0.795
Sub-Index: Pesticides Knowledge [0,4]	0.61	(0.73)	0.62	(0.69)	0.62	(0.76)	0.60	(0.72)	0.951
Maize history									
Experience (# years since HH first cultivated, including 2021)	12.3	(8.3)	12.0	(7.4)	12.8	(9.3)	12.1	(8.1)	0.732
Experienced FAW in last 3 years, all HHs (%)	60.3	(48.9)	60.5	(49.0)	61.1	(48.8)	59.4	(49.2)	0.889
2020 Monsoon Season									
Acreage cultivated, all crops	9.0	(8.7)	9.6	(10.0)	9.0	(7.7)	8.5	(8.2)	0.748
Acreage cultivated, maize only	6.5	(7.6)	7.5	(9.4)	6.2	(6.1)	5.9	(7.0)	0.416
Maize yield (kg/acre)	1,866	(823)	1,831	(795)	1,832	(824)	1,935	(847)	0.589
Planted purchased maize seed, %	99.1	(9.7)	99.4	(7.5)	99.2	(9.2)	98.6	(11.8)	0.642
Quantity of urea applied on maize plots (in 50 kg bags)	5.8	(8.1)	6.4	(9.0)	5.5	(7.1)	5.6	(8.2)	0.770
Quantity of compound fertilizer applied on maize plots (in 50 kg bags)	9.7	(13.8)	10.9	(15.1)	9.2	(12.6)	8.9	(13.5)	0.707

Test of equal means across group assignment is an F-test of equality across groups with village clustered standard errors. All variables are pre-intervention.

4. **Outcomes and empirical strategy**

We assess the effect of direct SMS and LF SMS programs on four types of outcomes—knowledge, scouting behavior, maize yield changes, and damage control. To test the causal impacts of the remote extension interventions we use the intention-to-treat (ITT) regression model. Since many farmers assigned to treatment did not actually receive information, we also use the instrumental variables approach to estimating the local average treatment effect (LATE).

The damage control estimation method estimates the reduced losses from pest pressure. It explicitly models these impacts by separating the productive inputs – i.e., direct yield influences – and damage control inputs. There is no consensus on the best damage control estimation method and there are tradeoffs to each approach. We elect to use a two-stage estimation procedure following the damage control examples of Kousmanen et al. (2006) and Iqbal and Sial (2018) that can test damage control input impacts for multiple groups (in our case, treatment assignments).

5. Results

We highlight four main results and implications that will generate further discussion. First, the SMS extension method – as expected – had greater compliance (30%) than the LF method (22%) (Table 2). Both methods were only moderately successful in reaching farmers despite 90% of the messages successfully delivered. Unopened or ignored messages were likely to be reasons for low compliance. At a time of low trust following a coup by a military, unsolicited messages may not have been welcomed by some farmers. The low compliance in the lead farmer extension intervention was likely driven by lead-farmers not delivering the messages to all the farmers on the list and self-selecting peers with whom to share information.

Table 2. Treatment Group Compliance

Group	Sample Assignment	Sample that Took-up Treatment	Compliance Rate (%)
Control	362	--	--
SMS	370	111	30.0
Lead Farmer	382	83	21.7
Total Observations	1114	194	

Source: Fall armyworm phone survey

Second, despite low compliance, we observe significant knowledge changes in both extension treatments relative to the control group, but the changes were not significantly different between the two treatments (Table 3). Third, in terms of behavior changes, despite similar knowledge index changes across treatments, the LF group was significantly more likely to scout than control group and the SMS group (Table 4). One possible explanation is that the knowledge change on toxicity action threshold – which shows strong improvements for the lead-farmer group – also led to an increase in scouting through a heightened concern or awareness to the risks and need to take action. Yields for LF group were also higher than both SMS and control groups, but insignificantly different (Table 4). These results are robust to only using plots that were fully harvested at time of interview.

Fourth, our results of the damage control analysis suggest that pesticide use significantly improved technical efficiency (i.e., reduced technical inefficiency) for the LF group but had insignificant effects for the SMS group (Table 5). We estimate that a 1,000 MMK increase in pesticide use by the LF group leads to a 1.1% improvement in maize technical efficiency. An alternative model specification also shows similar results and effect sizes, confirming robustness of this result.

Table 3. Intention-to-treat (ITT) and local average treatment effect (LATE) estimates of treatment on knowledge indices

	Knowledge indices							
Dep Var	Overall [0,13]		Scout & ID [0,5]		Action Threshold [0,4]		Toxicity [0,4]	
Estimator	ITT	LATE	ITT	LATE	ITT	LATE	ITT	LATE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SMS assignment	0.416**		0.157		0.098		0.161**	
	(0.166)		(0.107)		(0.066)		(0.066)	
	[0.011]		[0.104]		[0.159]		[0.036]	
Lead Farmer assignment	0.383**		0.124		0.199***		0.06	
	(0.184)		(0.083)		(0.067)		(0.068)	
	[0.018]		[0.136]		[0.004]		[0.380]	
SMS treated		1.388**		0.524		0.328		0.536**
		(0.545)		(0.348)		(0.224)		(0.217)
Lead Farmer treated		1.761**		0.57		0.916***		0.275
		(0.865)		(0.375)		(0.335)		(0.314)
Control group mean	2.74	2.74	1.23	1.23	0.95	0.95	0.56	0.56
Underidentification test	-	24.68***	-	24.68***	-	24.68***	-	24.68***
Coefficient equality test: SMS = LF	0.87	0.68	0.77	0.91	0.194	0.086	0.213	0.427
N	1114	1114	1114	1114	1114	1114	1114	1114
R-Squared	0.015		0.011		0.010		0.014	

Note: Cluster robust SEs at the village level in parentheses. Randomization inference test p-values in brackets. For LATE analysis, "SMS Treated" and "LF Treated" variables are instrumented by "SMS Assignment" and "LF Assignment". * p<.1, ** p<.05, *** p<.01. Underidentification test is the Kleibergen-Paap rk LM statistic. Estimators in columns 1, 3, 5, and 7 are ordinary least squares. Estimators in columns 2, 4, 6, and 8 are instrumental variables.

To put our estimates into context we take an admittedly imperfect step to compare the relative cost efficacies of each extension program (Table 6). We use a naïve approach to estimate the benefits of each program by assuming an increase in pesticide expenditures equivalent to US$1 for all farmers and apply the average partial effect estimate for each group from Table 5, column 1.

The fixed costs of the design and management are the same for both methods, and the variable costs end up being quite similar as well: $816 for the SMS method and $796 for the lead-farmer method, mostly in lead-farmer incentives for distributing information. Lower compliance in the lead-farmer program means that the costs per farmer reached are higher than in the SMS method. However, the higher maize yield improvements in pesticide efficacy for the lead-farmer method imply a much larger benefit from the extension program from an assumed average increase in pesticide use of $1. The larger benefits drive much higher estimated returns for the lead-farmer extension method. The net value per targeted farmer was $23 for the lead-farmer method and $6 for the SMS method.

Table 4. Intention-to-treat (ITT) and local average treatment effect (LATE) estimates of treatment on scouting for fall armyworm and maize yield

Dep Var	Scouted for FAW [0,1]		Yield (kg/ac)	
Estimator	ITT	LATE	ITT	LATE
	(1)	(2)	(3)	(4)
SMS assignment	0.014		-72.05	
	(0.041)		(96.920)	
	[0.704]		[0.183]	
Lead Farmer assignment	0.064		81.358	
	(0.042)		(126.127)	
	[0.082]		[0.182]	
SMS treated		0.047		-240.168
		(0.136)		(323.096)
Lead Farmer treated		0.294		374.445
		(0.195)		(595.564)
Control group mean	0.73	0.73	1,390	1,390
Underidentification test		24.68***		24.68***
Coefficient equality test: SMS = LF	0.15	0.099	0.24	0.29
N	1114	1114	1114	1114
R-Squared	0.004		0.008	

Note: Cluster robust SEs at the village level in parentheses. Randomization inference test p-values in brackets. For LATE analysis, "SMS Treated" and "LF Treated" variables are instrumented by "SMS Assignment" and "LF Assignment". * p<.1, ** p<.05, *** p<.01. Underidentification test is the Kleibergen-Paap rk LM statistic. Estimators in columns 1 and 3 are ordinary least squares. Estimators in columns 2 and 4 are instrumental variables.

6. Conclusion

In this paper, we explore the effects of two remote farmer extension programs to reduce the economic costs of an emergent pest during a crisis when traditional extension methods were infeasible due to political instability and COVID-19. Our results show that both extension programs improved farmer knowledge, but in different ways. The SMS-group learned more in pesticide toxicity while the lead-farmer group learned more in pesticide action thresholds. Both effect sizes are 96% of the control group knowledge scores. These results are broadly in-line with previous findings on pesticide extension and knowledge (Goeb and Lupi, 2021; Goeb et al., 2022). Importantly, the knowledge changes did not lead to noticeable improvement in practices for the SMS group, but the lead-farmer group was 6% more likely to scout than the control group. More importantly, the lead-farmer group used pesticides more effectively than the SMS group and the control group.

Table 5. Average partial effects of pesticide expenditures by treatment assignment

	ln(Technical inefficiency scores)			
	Two-stage DEA		Bias corrected DEA	
	(1)	(2)	(3)	(4)
Pesticide expenditure by group ('000 MMK/ac)				
Control assignment	-0.005**		-0.002	
	(0.002)		(0.003)	
SMS assignment	-0.003		0.000	
	(0.003)		(0.003)	
Lead Farmer assignment	-0.011***		-0.008**	
	(0.004)		(0.004)	
Inverse hyperbolic sine of pesticide expenditure by group ('000 MMK/ac)				
Control assignment		-0.031		-0.01
		(0.020)		(0.021)
SMS assignment		-0.015		0.002
		(0.017)		(0.015)
Lead Farmer assignment		-0.071**		-0.053*
		(0.028)		(0.028)
Covariates	Yes	Yes	Yes	Yes
Coefficient equality tests p-value				
SMS = LF	0.139	0.099	0.085	0.079
Control = LF	0.265	0.254	0.234	0.218
Control = SMS	0.594	0.549	0.545	0.630
Number of Observations	1112	1112	1112	1112

Notes: Cluster robust SEs at the village-level in parentheses. Significance: * p<.1, ** p<.05, *** p<.01. Covariates are weed pressure variables: indicators for high and low weed pressure, and the number of complete weedings conducted on the plot. Coefficient equality tests are chi-squared tests. Columns 1 and 2 are estimated by Tobit regression and columns 3 and 4 are estimated by truncated regression (second stage).

Table 6. Costs and benefits comparisons of SMS and lead-farmer extension methods

	Extension method	
	SMS	Lead-farmer
Costs		
Fixed costs		
Message design & development	$ 3,000	$ 3,000
Management	$ 2,000	$ 2,000
Variable costs		
SMS delivery costs	$ 816	$ 20
Lead-farmer communications		$ 25
Lead-farmer payment		$ 771
Costs per farmer targeted		
Total	$ 15.72	$ 15.22
Variable	$ 2.21	$ 2.14
Costs per farmer reached		
Total	$ 52.40	$ 70.07
Variable	$ 7.35	$ 9.83
Estimated benefits from 1USD increase in pesticide use		
Maize		
Total	$ 10,106	$ 34,499
Per targeted farmer	$ 27	$ 90
Net value		
Total	$ 2,368	$ 8,964
Per targeted farmer	$ 6	$ 23
Benefit-cost ratio		
Total	0.4	1.5
Variable costs	2.9	11.0

Notes: Costs exclude researcher time. Estimated benefits calculated as $\widehat{APE_j} * 1.62 * Y_i * A_i$ where $\widehat{APE_j}$ is the average partial effect estimate for treatment group j (column 1 in Table 6); 1.62 is USD to MMK exchange rate divided by 1000; Y_i is the maize yield for farmer i; and A_i is the area of the maize plot. Net value is the value of additional maize output using the sample average maize price minus the assumed pesticide cost increase.

Altogether, our results show the importance of information on pesticide action thresholds in management of FAW, particularly when delivered by a peer-farmer within the community. Perhaps more important for policy, our results demonstrate that lead-farmer information dissemination mechanisms can be effective – and more effective than direct SMS campaigns – in a time of high distrust and crisis. Though more research is needed to understand the modes of communications they used and how to incentivize them to relay the messages to more farmers.

Both interventions can be easily scaled to reach more farmers at low marginal costs, making them attractive investments at a larger scale than our experiment. However, implementing the direct SMS method requires a large database of farmer phone numbers to contact which is not cost-free to obtain. Governments could, at lower cost, allow farmers to self-select into a registry to receive such messages, of course with the tradeoff that only the registered farmers would benefit. Yet, this research shows that disseminating information through lead farmers, even without the ability to train lead farmers in person, could have a greater impact without the need for large farmer registries. Instead, governments or NGOs could work with extension staff to identify appropriate lead farmers and incentivize them to share information within their villages.

We had low compliance in our information interventions and there is much room for design improvements to reach a larger share of the intended recipients and to increase impact. Future research should explore such design issues including making messages more targeted and direct, other innovative information delivery mechanisms through a known number, or different incentive schemes for lead farmer information sharing including higher payments for in-person information delivery.

Lastly, extension information may be a relatively fast and low-cost way to improve farmer welfare in the face of a new production threat and in fragile states, but future research should compare the impacts and cost effectiveness of other farm interventions. Cash transfers may be a particularly important intervention to test in contexts of insecurity or in the presence of new threats requiring cash expenditures for new inputs and in conflict areas where cellphone applications could be used for the safe transfer of money.

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