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Performance and Adoption Factors for Open Pollinated and Hybrid Maize Varieties

Evidence from Farmers' Fields in Northern Ghana

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ABSTRACT

Maize is the most widely grown starch in Ghana, and yet domestic supply does not meet demand, because maize productivity is low. Trials were performed in northern Ghana in 2015 to determine whether hybrid varieties would outperform the varieties planted by farmers and, therefore, increase maize productivity. Two foreign hybrids performed consistently better then Obaatanpa, the most widely used variety in the north. In 2016, Adikanfo, the best performing hybrid, and certified Obaatanpa were made available for purchase at subsidized rates in the communities where the 2015 trials had been conducted. A survey was then carried out to study whether the trials had any effect on technology uptake or behavioral change among farmers in the region and if the varieties performed as well on the farmers' fields as in the trials. This paper presents the descriptive results of the survey.

Keywords: Ghana; maize; hybrid

1. INTRODUCTION

Maize is an important food cereal in Ghana. It is the most widely grown starch. Yet, domestic supply does not meet demand, resulting in Ghana being a net importer of maize. While Ghana is nearly self-sufficient in white maize production, the type consumed by households, Ghana still imports yellow maize for poultry sector feed. Low maize yields may be causing this production gap. Different estimates put maize yields between 1.2 and 1.8 metric tons (mt) per hectare over the period 2010 to 2017 (FAOSTAT 2017; Ragasa, Chapoto, and Kolavalli 2014; DIRTS, 2014, 2015, 2016). Although there are many factors contributing to low yields, one important factor may be the lack of improved technologies for maize.

Even though several hybrids and open pollinated maize varieties (OPVs) have been developed and released in Ghana, the adoption of these new varieties remains low. The weighted average varietal age of maize is 23 years, even though Ghana's agricultural research system releases on average seven new varieties every 10 years (Ragasa, Chapoto, Kolavalli 2014). Using recycled OPV seed is the dominant seed practice among Ghana's maize farmers.

There are both demand and supply side constraints limiting the adoption of hybrid seed. On the demand side, there are both cost and production risks. Farmers face financial barriers to buying hybrid seed, including capital, liquidity, and credit constraints. Buying seed, rather than recycling, is a cost risk. In the event of a bad harvest, if the farmer is using recycled OPV seed they will not realize an overwhelmingly negative net income. Further, you cannot recycle hybrid seed, so planting hybrids is a cost risk every season. There are also production risks. In the absence of adequate information on how varieties will perform under conditions similar to their plots, adoption of improved inputs is seen as a risk. Further, this reluctance to buy improved seed is exacerbated by some seed vendors marketing mislabeled or inauthentic seed as improved varieties. Using recycled OPV seed ensures that the farmer will at least have similar yields to the previous year.

On the supply side, farmers have limited access to improved inputs. In some regions, there are few input dealers. Further, where there are input dealers, they may not sell improved seed. However, using data from an Innovations for Poverty Action (IPA) randomized evaluation in northern Ghana, we saw that, even when inputs were delivered to the communities, there was no significant increase in adoption (IPA, 2014, 2015, 2016). But, input dealers could be hesitant to supply products that do not have demonstrated demand on the part of farmers. Most likely though, the problem is upstream in the research system. Limited new improved maize varieties are developed and released to farmers because of weaknesses in the Ghanaian seed sector (Tripp and Ragasa 2015; Tripp and Mensah-Bonsu 2013).

To address several of these issues, in 2015 maize OPVs and hybrids were tested in controlled farmer trials to identify high-yielding varieties for Ghana's three most northern regions. To test the relative performance of the varieties, Innovations for Poverty Action (IPA), the Savanna Agricultural Research Institute (SARI), and the International Food Policy Research Institute (IFPRI) collaborated to set up demonstration plots in ten districts in the three northern regions of Ghana: four in Northern (Tolon, West Gonja, West Mamprusi, Yendi), three in Upper West (Nadowli Kaleo, Sissala East, Wa), and three in Upper East (Bawku, Bolgatanga, Kassena Nankana). At each site, five research-managed farm trials were conducted.

Five maize varieties were tested; two foreign hybrids – Pioneer 30 Y 87, locally called Adikanfo; and Pannar 53, referred to as Sika-aburo; one local hybrid, Mamaba; and two OPVs, Sanzal-sima and Obaatanpa. Adikanfo is yellow maize variety, while the other varieties tested are white. Obaatanpa

is the most widely used variety in northern Ghana and, therefore, it was used as a comparator variety – in the absence of better seed, farmers are likely to continue using Obaatanpa.

Table 1.1. Maize yields, 2015 farmer trials

Variety	Farms	Yield (mt/ha)	Yield (bags/ha)	Standard deviation (mt/ha)	Within-district correlation
Adikanfo (Pioneer)	57	5.0	99.9	23.2	0.20
Sika-aburo (PAN 53)	61	3.9	78.5	28.5	0.48
Obaatanpa	78	3.2	63.7	25.4	0.21
Sanzal-sima	60	3.1	62.7	26.9	0.50
Mamaba	58	3.0	59.6	29.8	0.73

Source: van Asselt et al. (2018)

Adikanfo produced the highest mean grain yield among the varieties in the study (Table 1.1). It had the highest plant stand, the highest biomass yield, and more cobs per acre than any other variety. Sika-aburo, the other foreign hybrid, was the second highest yielding variety. The two OPVs (Sanzal-sima, Obaatanpa) as well as the local hybrid, Mamaba, produced similar low grain yields. Adikanfo yields were 27 percent higher than Sika-aburo yields and 57 percent higher than Obaatanpa yields. Further, Adikanfo consistently produced higher yields across the sample. At every point in its yield distribution Adikanfo performed better than the other varieties, and in nine out of the ten districts in the study, Adikanfo was the best-performing variety. At the same time, however, its within-district variation was high compared to other varieties tested, which shows that good practices and tailored fertilizer application are essential for achieving high yields with the Adikanfo variety *(*van Asselt et al., 2018a*)*.

Since the trials identified a hybrid variety that outperformed the other varieties tested, we wanted to see whether exposure to the trials would have any effect on technology uptake or behavioral change among farmers in the region. Therefore, in 2016, Adikanfo, the best performing hybrid, and certified Obaatanpa were made available for purchase at subsidized rates in the communities where the trials had been conducted in 2015. In addition to looking at adoption patterns, this intervention allowed us to test how the improved varieties performed on farmers' fields in comparison to in the managed trials.

2. FARMERS' FIELD TRIALS, 2016

In the 2016 Farmers' Field Trials, starter kits of Adikanfo and Obaatanpa were made available to farmers for the 2016 cropping season. We were unsure of whether the high costs of seed, at nearly GH₵ 40 per kg, would make Adikanfo inaccessible to smallholders. Therefore, to test whether exposure to the demonstration plots influenced uptake, we removed the price barrier and subsidized the seed kits.

In May 2016, with assistance from local Agricultural Extension Agents (AEAs), the team convened meetings in the same 10 communities that participated in the 2015 farmer trials, plus three new communities (Damankoyili in Sagnerigu; Fazehini and Balshee in Savelugu-Nantong) where farmers had not been exposed to the trials. Between 20 and 30 farmers participated in each meeting. The meeting began with a group discussion of the results of the 2015 trials. After the discussion, farmers were given the opportunity to buy starter kits of Adikanfo and/or Obaatanpa. The starter kits contained enough seed for planting one-tenth of an acre. Each starter kit included 1 kg of certified seed, 11 kg of NPK fertilizer, 5.5 kg of Sulfate of Ammonia fertilizer, 20 m of twine to measure a plot

of 400 sq. m., and an instruction guide. The costs of the starter packs were subsidized at three different levels (Table 2.1). The actual cost of an Adikanfo kit was valued at GH₵ 99 and an Obaatanpa kit at GH₵ 42. In most communities, the Adikanfo kit was priced at GH₵ 40 and the Obaatanpa kit was sold for GH₵ 35. The amount of the subsidy nearly covered the entire cost of seed.

Table 2.1. Prices and subsidy levels for Adikanfo and Obaatanpa starter kits

		Adikanfo			Obaatanpa		
Community	District	Price per kit, GH₵	Subsidy offered, %	Kits purchased, number	Price per kit, GH₵	Subsidy offered, %	Kits purchased, number
Bawku	Bawku Municipal	40	59	72	35	16	0
Navrongo	Kassena Nankana	40	59	320	35	16	0
Bolgatanga	Bolgatanga	60	39	34	35	16	1
Nadowli	Nadowli - Kalio	40	59	28	35	16	0
Tumu	Sissala East	40	59	2	35	16	0
Wa	Wa Municipal	60	39	0	35	16	8
Nyankpala	Tolon-Kumbungu	40	59	10	35	16	0
Walewale	West Mamprusi	40	59	39	35	16	0
Damongo	West Gonja	30	70	54	30	28	13
Yendi	Yendi Municipal	60	39	4	35	16	0
Damankoyili	Sagnerigu	40	59	15	35	16	0
Fazehini	Savelugu - Nantong	40	59	44	35	16	0
Balshee	Savelugu - Nantong	40	59	9	35	16	0

Source: Authors' calculations from 2016 farmers' fields data

The team took orders at the meeting, recorded the orders for the starter packs, and in mid-June began to distribute the starter packs to the farmers. However, not all the farmers who had ordered the starter packs were ready to purchase the packs. In some communities, for example, Wa Municipality and Sissala East, no one was ready to buy a kit when the distribution team arrived. Several methods were employed to address this issue. First, farmers were given the opportunity to pay later, on an agreed date with a witness guaranteeing payment for them. Second, the remaining kits, which were ordered and not purchased, were made available for purchase both for farmers who had already ordered kits and farmers who had not ordered kits.

In the end, of the 786 Adikanfo starter packs ordered, 631 were purchased and of the 77 Obaatanpa started kits ordered, 27 were purchased. As seen in Table 2.1, there was variation by community in the number of Adikanfo kits purchased. Farmers in Navrongo and Bawku together purchased nearly 400 kits. Further, although several farmers in Wa appeared interested in purchasing starter kits during the meeting, in the end no farmers in the community purchased a kit. Further, farmers in Tumu and Yendi purchased only 2 and 4 bags of Adikanfo, respectively. Farmers in the three new communities added to the study in 2016, Damankoyili, Fazehini, and Balshee, purchased more kits than farmers in several of the communities in which the 2015 trials were conducted.

In late March 2017, IPA carried out a survey to determine what were the characteristics of farmers who had purchased seed, how the varieties had performed on their fields, and whether they would continue planting the new variety in the future. The survey included modules on basic household characteristics, farm characteristics, maize production, maize production techniques, rainfall, and group membership. Among those surveyed were the forty farmers who participated in the trials and farmers who purchased starter kits. Further, each farmer who purchased a kit referred

a farmer who was exposed to the trial, but did not purchase. The referred farmers were also surveyed.

In the end, 276 maize farming households were surveyed. Of the 276 farmers, 127 farming households purchased starter kits from IPA, 136 farmers did not purchase starter kits, and 14 participants received seed for free from IPA as compensation for participating in the 2015 farmer managed trials. Of the farmers who purchased starter kits, 88 percent purchased Adikanfo only, while 12 percent purchased Obaatanpa or both Obaatanpa and Adikanfo.

3. FARMER UPTAKE

Before examining yields, we look at who chose to purchase starter kits and why. Although our survey is limited in terms of household characteristic questions, e.g., there were no household assets or consumption modules, there are several questions that can help us begin to understand who purchased improved seed and who did not. Table 3.1 presents basic characteristics of farmers based on whether they purchased starter kits.

Table 3.1. Farmer characteristics of starter kit purchasers and non-purchasers

	Did not purchase	Purchased	t-test
Male, percent	83	90	
Age, years	44.5	45.0	
Some education, %	48	58	*
Years of education	3.5	4.2	
No secondary occupation, %	21	14	
Total acres	5.1	7.6	**
Total maize acres	2.3	3.7	**
Number of visits per month to major town in region	5.9	11.8	**
Have an Agricultural Extension Agent that visits the community, %	74	86	**
Member of Farmer Based Organization (FBO), %	46	62	***
Planted maize from an out-grower or contract scheme previously,%	18	35	***
Planted maize from an NGO for free previously, %	22	32	*
Previous experience with Adikanfo, %	64	83	***
Number of farms visited with Adikanfo	0.3	2.8	***
Number of observations	151	125	

Source: Authors' calculations from 2016 farmers' fields data.

Note: 90% percent CI * 95percent CI ** 99percent CI ***

The 14 participants who received seed for free as well as the 28 participants who did not farm maize have been excluded from the sample.

A two-sample t-test was conducted to compare the characteristics of farmers who purchased a starter kit with those who did not. We see significant differences between these two groups in terms of having some education, size of area cultivated, maize area planted, visits to major towns, membership in FBOs, previous participation in NGO projects or out grower schemes, and previous experience with Adikanfo. There was no significant differences in the age, gender, or marital status of the household head between non-purchasing and purchasing households.

A larger percentage of farmers who purchased seed had some education, although there was no significant difference in the number of years of education between the two samples. More than half the sample had no education, whereas those who had attended school usually completed secondary. There was a significant difference in mean number of acres, both maize and total acres, between non-purchasers and purchasers. Those who purchased Adikanfo had 2.5 more acres on

average than non-purchasers. There was a significant difference in the mean number of times per month a famer visits the largest city in their region between non-purchasers (5.5) and purchasers (11.8).

Previous exposure to new maize varieties and participation in a Farmer Based Organization (FBO) or NGO project also appear to be important determinants of purchasing the new variety. Fifty-three percent of farmers surveyed were part of an FBO, 26 percent had taken part in an out-grower or contract scheme, and 26 percent had received maize seed from an NGO in the past. There were significant differences in the mean percentage of farmers who participated in an FBO, out-grower scheme, contract scheme, and NGO maize project between non-purchasers and purchasers. Those who purchased had a higher participation rate in the groups.

Additionally, 40 percent of farmers had visited the 2015 variety trial plots in which Adikanfo was among the varieties tested, other farmers only participated in the meetings held for discussing the results from the 2015 trials, while others had no previous exposure to the variety. Eighty-three percent of farmers who purchased starter packs had prior experience with Adikanfo (saw or heard good things about other farmers planting Adikanfo), compared with only 64 percent of farmers who did not purchase. Further, farmers who purchased the packs, visited on average 2.8 Adikanfo plots, while most farmers who did not purchase had not visited any plots in which the Adikanfo maize variety was grown.

Table 3.2. Farmer reasons for purchasing starter kits, percent of farmers surveyed

	Northern Ghana	Northern region	Upper East region	Upper West region
Agricultural Extension Agent recommended it	36	29	53	24
It performed well in 2015 trial plots	32	28	32	42
Heard Adikanfo yields were higher	21	29	9	21
It performed well somewhere else	6	9	2	6
Others bought it	1	0	4	0
Wanted to test it	1	2	0	0
Other reasons	3	3	0	6

Source: Authors' calculations from 2016 farmers' fields data

Farmers who planted Adikanfo were also asked to select the reasons for their choice. Table 3.2 shows that 36 percent of Adikanfo purchasers planted Adikanfo because it was recommended in a meeting with the AEAs. A further, 32 percent of farmers planted Adikanfo because they saw that it performed well in the 2015 trial plots. An additional, 21 percent of farmers planted it because they heard the yield was better than the varieties they normally plant. Another 6 percent planted Adikanfo because they saw it perform well somewhere else. This suggests that farmers decisions are influenced by what they see, and that the 2016 farmers' fields trials and sensitization meetings had an impact on creating farmer demand for improved varieties, although our results do not prove causality. Descriptive statistics from our experiment suggest that exposure to demonstration plots leads to farmer adoption of improved technologies.

Survey respondents were also asked to list the reasons why they did not purchase seed starter kits. Table 3.3 presents the responses for all northern Ghana. Not having enough money was the largest hindrance to purchasing seed. This may have been an even bigger barrier if the kits were not subsidized. Sixty percent of farmers who did not purchase starter kits did not have enough money to purchase them at the time of sale. Although the farmers did not have enough money to purchase the seed, only a small percentage of farmers thought that the seed was too expensive. Fifteen percent of farmers did not purchase seed because they already had seed for the given growing

season. Most of these farmers also lacked the resources to purchase seed, and therefore used the recycled seed they already owned.

Table 3.3. Farmer reasons for not purchasing Adikanfo starter kits, percent of farmers

Did not have the money	59
Seed prices were too high	2
Did not receive information about sales in time	11
Had seed already	13
Unavailable during sales	9
Had not heard of the variety before	7
No interest	1
Did not think seed would do well	2
Refuse to answer	1

Source: Authors' calculations from 2016 farmers' fields data.
Note: There were 52 surveyed farmers who did not purchase Adikanfo who did not respond to this question. Participants could select more than one response.

Around 20 percent of the sample did not purchase starter kits in part because either they did not receive information about sales on time or they were unavailable during sales. Half of these farmers listed this as their sole reason for not buying the kits.

Only 9 percent of the farmers did not plant Adikanfo because they had not heard of the variety and 2 percent because they felt that the seed would not do well. This suggests that, on the demand side, the largest deterrent to expanding the use of improved seed varieties is lack of cash, followed by exposure. This is further supported by the differences in characteristics of non-purchasing and purchasing households presented above.

4. MAIZE YIELDS AND PRODUCTION

Yields calculated using quantity and area reported by farmers, shows that in 2016 Adikanfo performed better than the other maize varieties planted. Table 4.1 splits maize varieties into six principal categories – Adikanfo, Obaatanpa, Sika-aburo, Mamaba, other OPVs, and other unspecified maize varieties. Although, Sika-aburo and Mamaba only have 7 and 10 observations, respectively, we still present the results to get a sense of their yields. Adikanfo and Obaatanpa have been further divided into two categories – seed sourced from IPA and seed that has been either recycled or purchased from other input dealers.

Table 4.1. Maize yields, 2016 farmers' fields

	Farms	Yield (mt/ha)	Yield (bags/ha)	Standard deviation (mt/ha)	Maximum (mt/ha)
Adikanfo, all sources	145	2.5	49.6	1.8	7.7
Adikanfo, IPA	132	2.6	50.9	1.9	7.7
Adikanfo, other source	13	1.9	37.1	1.0	3.7
Obaatanpa, all sources	118	1.1	21.7	0.5	3.0
Obaatanpa, IPA	17	1.3	26.5	0.8	3.0
Obaatanpa, other source	101	1.0	20.8	0.5	3.0
Sika-aburo	7	0.8	16.9	0.5	2.0
Mamaba	10	1.6	32.9	1.1	4.4
Other OPVs	120	1.4	27.1	0.7	4.0
Other undetermined	41	1.4	28.1	0.7	4.4

Source: Authors' calculations from 2016 farmers' fields data

Farmers who planted Adikanfo had the highest yields. Of the 145 farmers who planted Adikanfo, 132 planted certified seed from the starter kits, while 13 obtained their Adikanfo from either a different experimental project or a friend or relative. Overall, Adikanfo yielded 2.5 mt of maize per hectare. Adikanfo yields increased slightly to 2.6 mt/ha when non-IPA sourced Adikanfo was excluded from the sample. Most Obaatanpa, unlike Adikanfo, was obtained by farmers through their own means. Only 17 farmers planted certified Obaatanpa from the starter kits. The rest of the seed were either recycled (85 percent), obtained from a friend or relative (10 percent), or supplied through an out-grower scheme (5 percent). Obaatanpa only yielded 1.1 mt/ha. Again, yields from IPA sourced seed were greater than yields from seed from other sources, but we can only compare 17 farms.

Sika-aburo, a foreign hybrid, performed worse than Obaatanpa: yields were 0.8 mt/ha, with a maximum yield recorded of 2.0 mt/ha, much lower than Obaatanpa's maximum yield. However, three of the seven farmers growing Sika-aburo indicated that they had recycled the variety from the previous year. As a hybrid, Sika-aburo cannot be expected to yield well when recycled. Mamaba, a local hybrid, yielded 1.6 mt per hectare. Farmers indicated that they had purchased it certified. Other OPVs and other unspecified varieties yielded 1.4 mt/has, slightly more than Obaatanpa. This seed was almost entirely recycled.

Table 4.2. Maize yields, 2015 trials and 2016 farmers' fields

	Farms	Yield (mt/ha)	Yield (bags/ha)	Standard deviation (mt/ha)
Adikanfo - 2015 trial	57	5.0	99.9	0.5
Adikanfo - 2016 farmers' fields	132	2.5	50.9	0.8
Obaatanpa - 2015 trial	78	3.2	63.7	0.5
Obaatanpa - 2016 farmers' fields	118	1.1	21.7	0.2
Mamaba - 2015 trial	58	3.0	59.6	0.6
Mamaba - 2016 farmers' fields	10	1.6	32.9	0.4
Sika-aburo - 2015 trial	61	3.9	78.5	0.6
Sika-aburo - 2016 farmers' fields	7	0.8	16.9	0.2

Source: Authors' calculations from 2016 farmers' fields data and van Asselt, et al., 2017

Figure 4.1. Maize yields by variety, 2015 maize trials and 2016 farmers' fields

Source: Authors' calculations from 2016 farmers' fields data

All the varieties performed poorer on farmers' fields in 2016 than in the field trials conducted with supervision in 2015.It is important to note that when we compare Obaatanpa, Mamaba, and Sika-aburo across years, we are comparing certified varieties in 2015 with varieties obtained by farmers in 2016. When we compare Adikanfo, on the other hand, we are comparing certified hybrid seed with certified hybrid seed. Although in 2016, like in 2015, Adikanfo outperformed the other varieties, the yields in 2016 were much lower than the yields from the 2015 trials (Table 4.2 and Figure 4.1). Adikanfo yields in 2016 were 51 percent of the Adikanfo 2015 trial yields, while Mamaba yields were 55 percent of 2015 yields, and Obaatanpa yields were only 41 percent of 2015 yields. Sika-aburo yields were barely 22 percent of 2015 trial yields. This could be because half of the hybrids were recycled. Further, while in 2016, some Adikanfo and Mamaba farmers had yields at the right tail of the 2015 yield distribution, no Obaatanpa or Sika-aburo farmers came close to reaching 2015 maximums.

Table 4.3. Difference in yields, fertilize use, and seeding rate between 2015 trials and 2016 farmers' field, by district

	Adikanfo 2015 yield, bags/ha	Adikanfo 2016 yield, bags/ha	Fertilizer 2015, 50 kg bags/ha	Fertilizer 2016, 50 kg bags/ha	Seeding rate 2015, kg/ha	Seeding rate 2016, kg/ha	Untimely rainfall 2016, percent reported
Northern							
Tolon	102	63	15	6.5	20	4.2	85
West Gonja	90	49	15	7.2	20	4.0	67
West Mamprusi	94	62	15	6.2	20	2.3	79
Yendi Municipal	94	82	15	9.9	20	3.1	65
Upper West							
Nadowli-kaleo	94	34	15	5.4	20	2.2	53
Sissala East	122	52	15	8.2	20	3.2	79
Wa Municipal	121	30	15	11.5	20	3.5	22
Upper East							
Bawku Municipal	98	76	15	7.7	20	3.9	31
Bolga Municipal	102	34	15	5.5	20	2.6	94
Kassena-nankana	77	30	15	5.5	20	3.0	47

Source: Authors' calculations from 2016 farmers' fields data.

Note: One bag is equal to 50 kg. Untimely rainfall refers to the percent of farmers in each district reporting poor or untimely rainfall.

Table 4.3 compares 2015 and 2016 yield data at district level for Adikanfo. Adikanfo yields are lower in 2016 on farmer's fields compared with the 2015 trials. If we assume that aggregate conditions were similar in both years, it seems this can be attributed to two key factors – lower fertilizer use and a low seeding rate. In 2016, Adikanfo farmers used on average 6.5 bags of fertilizer per hectare compared to 15 bags per hectare in 2015. Further, while the seeding rate in 2015 was 20 kg of seed per hectare, the seeding rate in 2016 was 3.3 kg of seed per hectare. When the starter packs were distributed, farmers were instructed to plant the seed on one tenth of an acre. Instead, it is clear that in many instances the seed was distributed across more than an acre. Finally, although we do not have data for comparison from 2015, farmers reported untimely or poor rainfalls in 2016, which could have negatively affected their harvests. It is possible that the lower yields in 2016 were simply a product of worse rainfall or poorer aggregate conditions affecting all maize grown that year in northern Ghana.

Evidence so far presented seems to suggest that in 2016, while some farmers adopted improved seed, they did not adopt other recommended practices. Adikanfo farmers used slightly more NPK and one bag more of Sulphate of Ammonia (SA) per hectare than farmers who did not purchase

starter packs. All farmers did on average 1.9 rounds of weeding, which is one round less of weeding then in the 2015 trials. Around 24 percent of farmers used pesticides. There was no statistically significant mean difference in use of pesticides between farmers who purchased starter packs and farmers who did not.

Table 4.4. Farmer practices, by maize variety

	Adikanfo, Starter pack	Obaatanpa, Not certified	Other hybrids, All origins	Other OPVs, Not certified	Average
Yield, mt/ha	2.5	1.1	1.5	1.4	1.6
Total area, ha	3.1	2.9	2.1	2.8	2.7
NPK, bags, 50 kg bags/ha	3.9	3.1	3.3	3.1	3.3
Sulphate of Ammonia, 50 kg bags/ha	2.8	1.8	1.8	1.9	2.1
Weeding rounds, number	1.94	1.97	1.97	1.82	1.93
Fertilizer was used on plot, %	98	93	93	88	93
Pesticides were used on plot, %	25	25	23	21	24
Row planting, %	92	60	77	61	72
Farmer did thinning, %	23	29	40	27	30
Farmer did refilling/replanting, %	20	37	33	28	30
Plot was affected by grazing, %	20	25	23	19	22
Plot was affected by pest or disease, %	40	46	37	46	42
Plot effected by flooding, %	24	25	17	20	22
Poor or untimely rainfall resulted in lower yields than usual, %	65	70	43	65	61
Rainfall was poor in area, %	46	49	33	48	44
Number of observations	132	118	30	161	441

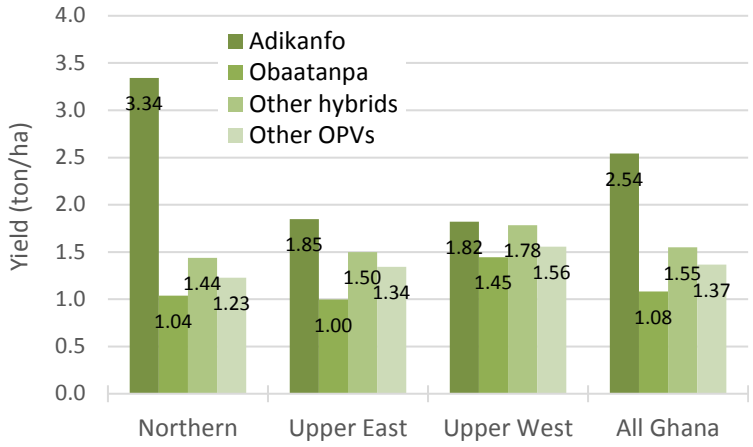
Source: Authors' calculations from 2016 farmers' fields data

One important difference in technique was the use of row-planting. Ninety-one percent of farmers who purchased starter kits planted their maize in rows, whereas only 63 percent of farmers who did not purchased starter kits used rows for planting (Table 4.4). Further, while only 23 percent of starter kit Adikanfo farmers had to replant their crops after planting many seeds in one hole (thinning), 29 percent of Obaatanpa farmers and 40 percent of other hybrid farmers had to thin. On the other hand, while 37 percent of Obaatanpa farmers put new seed in holes where the seedlings did not sprout (refilling), only 20 percent of Adikanfo farmers refilled. This may be another factor resulting in lower average yields in 2016.

Other factors may include poor rainfall, as shown above, floods, grazing, and pests. Nearly half of the sample of farmers reported that rainfall was very poor or untimely in their community, and for more than 60 percent of farmers said this resulted in lower yields than usual. Further, 22 percent of Adikanfo plots and 25 percent of Obaatanpa plots were flooded. Overall, 24 percent of plots were affected by grazing and 38 percent were affected by pests or diseases. There was no statistical mean difference between the percentage of plots affected by these issues between varieties. Finally, despite these pre-harvest loss issues, Adikanfo still outperformed all other varieties.

In addition to variation in yields between varieties and across years, there was also significant inter-variety regional variation in Adikanfo yields in 2016. This was not the case in 2015, when Adikanfo yields were consistently high across regions. In 2016, Adikanfo yields were much higher in the Northern region compared with yields in the Upper East and Upper West regions (Figure 4.2). Adikanfo yields in all regions were statistically different from the mean. Yields were 3.3 mt/ha in the North, compared with 1.9 mt/ha in the Upper East and 1.8 mt/ha in the Upper West.

Figure 4.2. Maize yields by variety, by region



Source: Authors' calculations from 2016 farmers' fields data

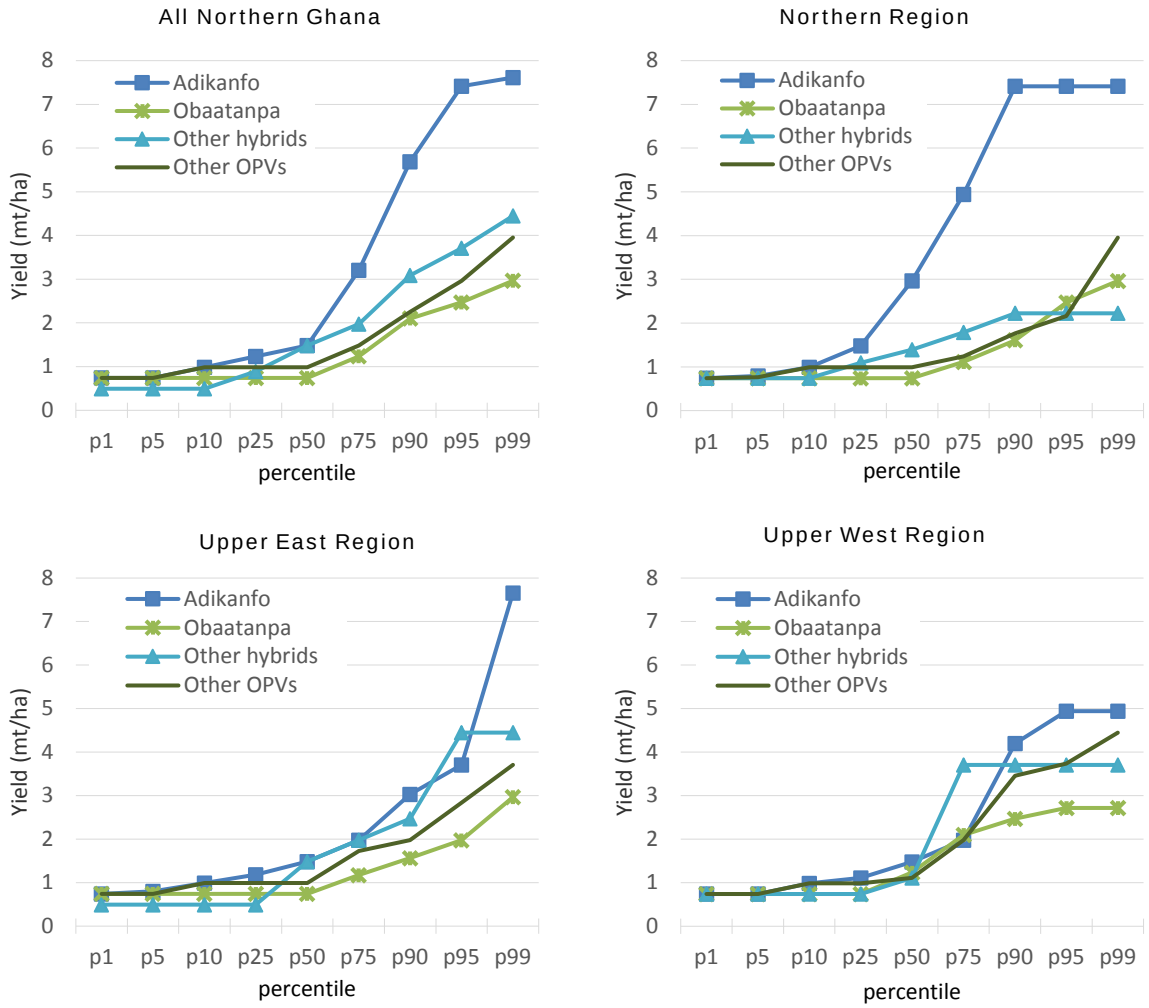
Obaatanpa yields were nearly consistent across regions, with statistically different higher yields only observed in the Upper West region. There was no regional variation in the performance of other hybrids. Finally, other OPVs performed slightly worse in the Northern region compared to the Upper East and Upper West regions. While these yield numbers suggest that Adikanfo is better adapted to the environment in the Northern region, a larger sample size and inferential analysis would be needed to check this finding.

As shown in Figure 4.3, unlike the previous year, Adikanfo did not exhibit first-order stochastic dominance over all other varieties. Its median performance was equivalent to the performance of the other hybrids. It did, however, perform better than Obaatanpa and other OPVs at every point in the distribution greater than the 10th percentile. In the Northern region, Adikanfo outperformed all varieties past the 10th percentile. In the Upper East and Upper West regions, Adikanfo struggled to outperform the other hybrids, even at the higher end of the distribution, though it still outperformed Obaatanpa.

From our data, it is hard to single out the causes of regional variation in Adikanfo yields. Seeding rates were on average the same across regions, 3.3 kg/ha. Farming practices, however, were slightly better in the North than in the two other regions. Three more bags of fertilizer per hectare were used on average in the Northern region and 100 percent of farmers used fertilizer on their plots. Across all Adikanfo plots, when fertilizer use increased by one bag from a starting point of anything less than 6 bags per hectare, yields increased significantly.

Further, in the Northern region 32 percent of Adikanfo farmers used pesticides, compared with only 20 percent and 17 percent in the Upper East and West, respectively. Row planting was done by more farmers in the North and thinning by fewer farmers. At the same time, however, pre-harvest loss due to rainfall, grazing, pest, and disease affected farmers in all regions. Grazing and flooding affected the largest percentage of farmers in the Upper East, with 36 percent and 41 percent affected, respectively. While pests and poor rainfall were larger issues in the Northern region, affecting 64 percent and 70 percent of farmers. Differences in these outside factors leading to pre-harvest losses, therefore, cannot explain regional differences in yields.

Figure 4.3. Maize yield distribution, mt/ha, by variety



Source: Authors' calculations from 2016 farmers' fields data

Differences in average total farm-size may also explain regional differences in yields. In the Northern region, farmers had 4.0 hectares in total, compared with 1.9 ha and 2.8 ha in the Upper East and West, respectively. For Adikanfo, larger plot size, both in terms of total farm size and area planted to maize, seems to be associated with higher yields – farmers with plots less than 1 hectare in size had Adikanfo yields of 1.5 mt/ha, while those with plot sizes of more than 3 hectares had yields of 2.5 mt/ha. This pattern is seen even when farmers are divided into three groups based on the size of their maize plots. In this case, yields ranged from 2.0 mt/ha for farmers with less than one hectare of maize to 3.0 mt/ha for farmers with more than 3 hectares. No such pattern existed among Obaatanpa farmers. This suggests that larger farmers who purchased starter kits were more likely to adopt best practices.

5. ADIKANFO FUTURE ADOPTION

After the 2016 farming season, farmers in all three regions felt that Adikanfo outperformed the other maize varieties they planted. Adikanfo was perceived to be more productive than both OPVs and other maize hybrids. Table 5.1 shows that 91 percent of farmers felt that the Adikanfo variety was much better than the other maize varieties they used on their other plots, or the varieties they used in previous seasons. Six percent of farmers felt that the variety was only a little bit better than

other varieties, and only three percent said that the variety was either the same or worse. Nine percent of Adikanfo farmer in Upper East and 12 percent of Adikanfo farmers in Upper West felt that the variety had only performed a little bit better than other varieties compared with no Adikanfo farmers in the Northern region.

Table 5.1. Farmers' impressions of Adikanfo performance, percent of farmers

	All northern Ghana	Northern	Upper East	Upper West
Better than other varieties	91	95	89	85
A little better than other varieties	6	0	9	12
About the same than other varieties	1	2	0	3
A little worse than other varieties	1	3	0	0
Much worse than other varieties	1	0	2	0

Source: Authors' calculations from 2016 farmers' fields data

Farmers were asked to reflect on why they thought Adikanfo had performed better than the other maize varieties. Table 5.2 gives the principal reasons cited by farmers. Most farmers, especially in the Northern region, felt that Adikanfo yields were high because the Adikanfo variety was better than the other maize varieties. Moreover, 50 percent of farmers cited this as the only reason that Adikanfo performed better. Among other reasons cited, farmers stated that Adikanfo yields were higher because of coaching on its use from AEAs, row planting, and increased fertilizer application. At the same time, however, farmers rarely cited the overall use of better farming practices as an explanation for improved yields with Adikanfo. Finally, few farmers believed that the variety performed better simply because it was new. This shows that not only is there significant room for improvement in increasing yields by planting improved varieties, farmers can still benefit from coaching on planting techniques.

Table 5.2. Farmer reasons Adikanfo performed better than other varieties, percent of farmers

	All northern Ghana	Northern	Upper East	Upper West
The variety is better	66	72	57	67
Agricultural Extension Agent coaching	28	14	55	15
Farmer applied fertilizer	19	15	26	15
Row planting	12	6	26	6
Better practices	1	0	2	0
The variety is new	66	72	57	67

Source: Authors' calculations from 2016 farmers' fields data

While farmers felt that Adikanfo outperformed the other maize varieties they planted, this does not mean that farmers will demand or purchase Adikanfo moving forward. Limited access to cash or credit, higher price of seed, or a lack of interest in using inputs could limit farmers' demand to continue using the improved variety. Adikanfo farmers therefore were asked if they would buy the variety at GH₵ 32 or GH₵ 16 per kg and what percentage of land they would plant to Adikanfo.

In the Northern region, where Adikanfo performed best, 97 percent of farmers said they would plant Adikanfo if it cost GH₵ 32 (Table 5.3). There was no change in the number of farmers who would plant Adikanfo if the cost decreased to GH₵ 16, since nearly all the farmers would plant at the higher price. The change in price, however, did result in Northern farmers increasing the amount of maize land they would plant, from 48 percent of their land to 62 percent. In the Upper East region, the percentage of farmers who would plant Adikanfo was smaller than in the Northern region, 83 percent, and there was no change in the number of farmers who would plant Adikanfo if the

price decreased to GH₵ 16. In the Upper West, 81 percent of farmers said they would plant Adikanfo at GH₵ 32. This increased by seven percentage points with a price decrease to GH₵ 16. Farmers in the Upper West said that they would plant the greatest area of land to Adikanfo, 64 percent at GH₵ 32 and 74 percent at GH₵ 16. The cost of seed influenced the proportion of area farmers would plant with the variety and not whether they would plant the variety.

Table 5.3. Purchasing Adikanfo in the future

	All northern Ghana	Northern	Upper East	Upper West
Farmers purchase Adikanfo for 32 GH₵, percent	89	97	83	81
Farmers purchase Adikanfo for 16 GH₵, percent	92	97	89	88
Farmers plant Adikanfo if free, percent	98	100	94	100
Maize land planted if Adikanfo is 32 GH₵, percent	48	45	41	64
Maize land planted if Adikanfo is 16 GH₵, percent	62	65	50	74
Maize land planted if Adikanfo is free GH₵, percent	74	78	66	78

Source: Authors' calculations from 2016 farmers' fields data

When asked whether the farmers would plant Adikanfo if it was free, 100 percent of farmers in the Northern region and the Upper West region responded that they would plant Adikanfo. In the Upper East region, only 94 percent of farmers were interested. With free seed, the percentage of maize land farmers said they would plant to Adikanfo increased across all regions, to 78 percent, 66 percent, and 78 percent, respectively. Farmers would continue planting other maize varieties on their field, however, with the bulk of their maize crop as Adikanfo.

6. CONCLUSION

A foreign hybrid, Adikanfo, performed well across districts in northern Ghana. In the 2015 farm-managed trials, Adikanfo performed better than the other hybrids and all OPVs in all study regions. In 2016, the foreign hybrid was offered to farmers to test on their fields under their typical farming management. On farmers' fields Adikanfo also outperformed the other maize varieties.

Starter packs of Adikanfo and Obaatanpa were made available to farmers in the 2016 farming season at subsidized prices in communities exposed to the 2015 trials and three new communities. Farmers who had disposable income at the time of starter pack distribution were more likely to purchase Adikanfo starter kits. Farmers felt that price was not a deterrent for purchasing the starter kits, only having enough cash.

Farmers decisions are influenced by what they see. Exposure to the 2015 trials was very important for adoption. Although most farmers had already heard about the improved variety, they only purchased starter kits when they saw or heard from a reliable source that it had performed well. Also, farmers who participated in an FBO or a previous NGO or out-grower project were more likely to purchase Adikanfo.

Results from the 2016 farmers' field experiment confirmed findings from 2015 trials: Adikanfo performed better than the other hybrids and OPVs in all study regions, with particularly good performance in the Northern region. Adikanfo yields remained consistently higher than other maize yields, despite difficulties with rain and pests.

Although Adikanfo performed better than the other maize varieties in 2016, its yields in 2016 were significantly lower than yields in 2015. Adikanfo yields were 5.0 mt per hectare in 2015 compared with only 2.5 mt per hectare in 2016. Spreading starter pack seed over larger than recommended areas may have contributed to lower yields. Further, differences in practices, such as

fertilize use, weeding and refilling, may also explain lower yields. Additionally, the weather conditions may have played a key role, though we do not have adequate data to formally test this hypothesis. Finally, pest management continues to be a problem – in 2016, 42 percent of farmers felt that they had lower yields because of pests.

Differences in Adikanfo yields across years suggests that improvements in farming practices are still needed. Farmers who purchased Adikanfo starter kits had slightly better farming practices than those who did not use these improved seed – this is particularly true for Adikanfo farmers in Northern region. Although instructions were supplied, practices did not mirror those in 2015. Future research should examine how to ensure that farmers' adoption of improved seed varieties is combined with the adoption of appropriate farming practices to maximize the seed's yield potential.

Although yields in 2016 were lower compared to 2015, farmers in all three regions felt that Adikanfo outperformed the other maize varieties they planted, and at the end of the project, farmers expressed interest in continuing to plant the variety. In Northern region, where Adikanfo performed the best, 97 percent of farmers said they would plant Adikanfo if it cost GH₵ 32. In the Upper East and Upper West regions, 83 percent and 81 percent of Adikanfo farmers, respectively, said they would plant Adikanfo at GH₵ 32. Lowering the cost of Adikanfo from GH₵ 32 to GH₵ 16 barely changed uptake behavior. Nearly all farmers said they would plant Adikanfo if it was free. This suggests that among households convinced that Adikanfo is a good technology, the cost of the technology itself in the range we measured may not be a constraint to scaling up, although a significant group were constrained by not having cash in hand.

Demonstration trials give farmers the opportunity to experiment and learn about a new technology and make decisions about adoption. Farmers who have disposable income may adopt new technologies on a small scale, as suggested by many of our respondents. Further, although Adikanfo was subsidized for this study, farmers appear to be willing to pay the full cost of the seed. And since exposure to demonstration trials of high-yielding varieties is important for adoption, gradually, as more farmers witness the high productivity of the variety, adoption may become more widespread. These trials suggest that farmers in northern Ghana are ready to adopt new high yielding maize technologies.

REFERENCES

FAOSTAT (Food and Agriculture Organization of the United Nations, Statistics Division). 2014. Food Crops. http://faostat3.fao.org/home/E. Accessed August 1, 2017.

Innovations for Poverty Action. 2015, 2016 unpublished. Testing Agricultural Technologies - Project Database: 2015 Trials and 2016 Farmers' Survey.

Innovations for Poverty Action. 2014, 2015, 2016. Disseminating Innovative Resources and Technologies to Smallholder Farmers - Project Database: Mid-line Survey and Baseline Surveys.

Ragasa, C., A. Chapoto, and S. Kolavalli. 2014. *Maize Productivity in Ghana*. Ghana Strategy Support Program Policy Note 5. Accra: International Food Policy Research Institute.

Tripp, R., and A. Mensah-Bonsu. 2013. *Ghana's Commercial Seed Sector: New Incentives or Continued Complacency?* Ghana Strategy Support Program Working Paper 34. Accra: International Food Policy Research Institute.

Tripp, R., and C. Ragasa. 2015. *Hybrid Maize Seed Supply in Ghana*. Ghana Strategy Support Program Working Paper 40. Accra: International Food Policy Research Institute.

van Asselt, J., F. DI Battista, S. Kolavalli, and C. Udry. 2018. *Agronomic Performance of Open Pollinated and Hybrid Maize Varieties: Results from On-Farm Trials in Northern Ghana*. Ghana Strategy Support Program Working Paper 44. Accra: International Food Policy Research Institute.

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