Seed Aid Governance in South Sudan

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Abstract:

Seed aid—or free distribution of seeds to farmers—is a popular intervention to simultaneously reduce food insecurity and dependency on food aid in rural areas. However, seed aid distribution also has the potential to disrupt the development of local seed markets. In this study we analyze the targeting and impact of seed aid across the green belt or equatorial states of South Sudan. Using primary survey-data on 1,990 farm-households, we find that seed aid is widely rather than selectively distributed. Almost a third of farm-households receive seed aid despite the general availability of locally recycled seed varieties. Seed aid distribution does not seem to favor particularly poor, vulnerable and food insecure households, but those that are better connected to community based networks and organizations. Using a double robust methodology based on Inverse Probability Weighted Regression Adjustment (IPWRA), we also find that the adoption of seed aid by farm households does not result in increased agricultural production. And because seed aid is largely sourced from outside South Sudan it is also creating a disincentive for the development of local seed producers, traders and markets. Still, seed aid distribution is expected to be more effective and less disruptive above the green belt and especially in parts of the country characterized by lower agricultural potential, persisting conflicts and frequent natural disasters, where farmers would otherwise have insecure access to seeds. Seed aid distribution outside and beyond emergency situations is therefore justified only if humanitarian agencies start procuring an incremental amount of seeds from local producers and traders.

Keywords:

Seed Aid, Smallholder Farmers, Maize, Impact Evaluation, Inverse-Probability-Weighted Regression Adjustment (IPWRA), South Sudan.

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1. Introduction

Farmers require timely access to quality seeds to grow food, to earn a living and contribute to their own and others' food security. Farmers can acquire seeds by recycling and exchanging their agricultural produce, or through the formal seed sector. Because local seed recycling and exchanging practices offer limited opportunity for varietal improvement, access to high-yielding and uniform seed varieties that have been adapted and evaluated to perform optimally in certain agro-ecological conditions depends on the functioning of the formal seed sector (Louwaars and De Boef, 2012). In conflict and disaster afflicted rural areas, farmers can have insecure access to seeds due to reduced agricultural production and the disruption of local markets and extension services. In emergency situations, seed aid—free distribution of seed to farmers—is commonly adopted by governmental and non-governmental agencies as a solution to revive agriculture and simultaneously reduce food insecurity and dependency of food aid. Despite a general lack of empirical evidence about the effectiveness of seed aid, this solution is being deployed by an increasing number of countries and international organizations, and is even expanding to post-emergency contexts (Sperling et al., 2020).

The effects of seed aid distribution remain however understudied, poorly understood and controversial (Gautam, 2019; FAO et al., 2019; Maguet, 2014; Margolies and Hoddinott, 2012; Sperling and McGuire, 2010; Abdulai et al., 2005; Rohrbach et al., 2005; Tripp and Rohrbach, 2001; Schultz 1960). One concern is that the positive effect of seed aid on agricultural production may be undermined by allocative inefficiencies—which inevitably arise in a non-market based distribution system—resulting in the untimely provision of non-uniform, low-yielding and/or ill-adapted seed varieties to the wrong farmers (or to farmers who have sufficient access to similar or better quality seeds). Another concern is that seed aid may be distorting local seed markets. The protracted distribution of seed aid is expected to affect market-demand for seeds, creating a disincentive for local seed producers and traders to enter or re-enter the market. Any policy or program striving to develop or revive local seed markets may be rendered ineffective, as long as seed aid is abundant. Conversely, as long as local seed markets remain underdeveloped, seed aid agencies might feel justified to keep distributing free seeds.

In theory seed aid may be justified only in emergency contexts characterized by general seed insecurity. In other words, the inefficiencies and distortions associated with seed aid distribution can be reasonably expected to arise outside conflict and disaster afflicted communities. However, the restriction of seed aid distribution to emergency contexts may be difficult and risky in practice, resulting in wrongful discrimination and exclusion. Whereas good governance practices by humanitarian agencies could minimize the inefficiencies and distortions associated with seed aid distribution in post-emergency contexts. In particular, seed market failures, excessive seed transportation costs and time, as well as moral hazard and opportunistic behavior among seed suppliers are less likely to arise when humanitarian agencies procure seeds locally, as opposed to internationally. Accountable and transparent seed aid agencies—that also create business development opportunities for locally known and trusted seed producers and traders—can be expected to justify the distribution of seed aid not only for emergency but also for development purposes. Conversely, we can postulate that poor seed aid governance, associated with ill-targeted distribution of international seeds, is likely to hamper the development of local agricultural and seed markets.

The remainder of this study contributes to substantiate and validate the latter hypothesis. In particular, it produces an empirical evaluation of the impact of seed aid distribution across the green belt of South Sudan, which is considered to be the most stable and secure part of the country, with the greatest potential for agricultural growth. Overall, South Sudan remains an infant country, a fragile state and a climate-vulnerable population, with internal conflicts flaring up on a regular basis. It is also an important receiver of international seed aid, with an estimated 40 percent of farm households having received free seeds at least once (FAO et al., 2019). At the same time, South Sudan has a long history of seed sector development interventions (FAO et al., 2019). This makes it a suitable and relevant country to study seed aid governance and its impact on farm households and seed markets.

To do so, we use primary and baseline data collected at the end of 2021 as part of the evaluation plan for the A3SEED project.[2] This project represents one of the main seed sector development efforts taking place in South Sudan, and it aims at strengthening quality seed

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[2] A3SEED is an acronym for Accelerating Agriculture and Agribusiness in South Sudan for Enhanced Economic Development. The A3SEED project is implemented by IFDC between 2021 and 2026.

production and commercialization by domestic seed producing and trading companies and their networks of local seed out-growers. The authors of this study are involved in A3SEED as independent project evaluators. Available data was provided by 1990 market-oriented (as opposed to subsistent) farmers, or farmers who regularly sell at least a part of their harvest. Surveyed farmers originated from five counties within the green belt of South Sudan, which encompasses the southern states of Eastern, Central and Western Equatoria. To explain the results of our data analysis and derive relevant policy implications, the authors also organized a 3-day multi-stakeholder workshop in Yambio (Western Equatoria state) that mobilized the participation of almost 100 local farmers, as well as of key representatives of the state ministry of agriculture and of the private seed sector. The workshop generated important insights about how local government officials, farm households and seed companies perceive seed aid distribution and interact with humanitarian agencies.

We find that seed aid was widely distributed within our sample, reaching almost a third of farmers in 2021. We also find that seed aid was distributed in a rather unselective manner. Seed aid distribution was not selectively targeted to the most vulnerable, food insecure and/or asset poor famers, but to community-based organizations, village leaders, and owners of mobile phones. Using inverse-probability-weighted regression adjustment (IPWRA), we find no evidence indicating that the distribution free seeds contributes to increase agricultural production and productivity, or land cultivation. Our findings thus suggest that seed aid distribution does not generate significant benefits for semi-commercial farmers operating in post-conflict and high potential rural areas. And because seed aid is largely sourced from outside South Sudan, it is likely to hinder the development of the local seed sector, as well as its potential to spur agricultural growth.

It is important to stress that our conclusions do not exclude that seed aid distribution may have a more positive and significant, or even life-saving impact in other and especially conflict or disaster afflicted areas within South Sudan. The impact of seed aid can be reasonably expected to improve above the green belt. By all means, seed aid distribution to seed-deprived farm households should continue, even within the green belt. However, a gradual transition from international to local seed procurement is recommended to minimize the adverse effects of seed aid on seed market development as well as on market-oriented farming. As such, this study add to the literature by shedding some and much needed light on seed aid governance in South Sudan.

2. Background

South Sudan came in existence as an independent country in 2011 following a popular referendum that legitimized its secession from Sudan. The years that followed were characterized by political instability and economic stagnation, leading up to internal, violent and country-wide conflicts in 2013 and 2016. Despite a revitalization of the peace agreement in September 2018 and the subsequent formation of a unity government in February 2020, South Sudan remains a country in turmoil and in the making. Due to extreme climate events (both droughts and floods), underdeveloped infrastructure, persistent insecurity and rampant corruption, 8.3 million people (or 75% of the population) were estimated by WFP to face food insecurity in 2022. Furthermore, 2.2 million people were estimated by IOM to be internally displaced at the end of 2021.

Despite the abundance of land and favorable agro-ecological conditions, agriculture in South Sudan—the most important national economic sector after oil—remains largely underdeveloped. The most important staple crops produced within the country are sorghum (throughout the country) and maize (mainly in the Equatoria states). However, the country's agricultural potential is far from been realized. Only 4.3% of its arable land is regularly cultivated. In 2020, South Sudan produced about 75000MT of food against the country's demand of 140000MT. As a result, the country currently imports almost 50% of the food consumed by its population from neighboring countries. Land cultivation is constrained by the lack of mechanization. Instead, it relies on traditional farming practices and technology. Most farm households produce agriculture to meet their own food consumption needs. The commercialization of agricultural surplus is also limited by the road network, which is almost non-existent and affected by banditry, contributing to the fragmentation of the national food market into a myriad of thin and localized markets. (Miteng, 2021).

Like the rest of the agricultural sector, the seed sector remains largely underdeveloped in South Sudan. Farmers can use either: (a) improved seeds that were selected, produced and multiplied elsewhere, mostly by the national agricultural research organizations (NAROs) of Uganda, Kenya and Sudan, under different agro-ecological conditions and different farming practices; or (b) local and better-adapted but low-yielding seed varieties that have been recycled over and over by South Sudanese farmers. Seventy percent of imported seeds are distributed to South Sudanese farmers for free, as seed aid, by FAO and various governmental and non-governmental agencies. Seed aid in South Sudan has been present for more than three decades. In the past five years, over 40% of all farmers in South Sudan received some form of seed aid, and FAO has played a central role in the coordination of seed distribution in collaboration with multiple governmental and non-governmental agencies. (Miteng, 2021; FAO et al., 2019).

Although South Sudan has been a recipient of imported seed aid for decades, and the cost of seed aid distribution in South Sudan is roughly estimated at 10 million USD per year, the average yield for cereals in South Sudan (940 kg per hectare) is significantly lower than in Uganda (1931 kg/ha) or Kenya (1773 g/ha). This is particularly puzzling because South Sudan imports seeds from these countries. A widely supported explanation is that the seeds imported into South Sudan, mostly through the seed aid system, are not of similar quality than those used within exporting countries. This implies that the seed aid system may allow seed exporters to sell poor quality seeds without bearing the consequences. Since seed aid is internationally sourced and distributed through non-market based and thus inefficient channels, its delivery to farmers also tends to be untimely (or after the planting season). Finally, the agro-ecological conditions and farming practices that are required to exploit the potential of imported seeds may be significantly different from those available in South Sudan. (Miteng, 2021).

To reduce dependency on foreign seed aid, international NGOs have been implementing projects geared towards the development of a national private seed sector. Projects have, for example, contributed to the establishment of about 20 South Sudanese seed companies and the formation of a umbrella organization: “the Seed Trade Association of South Sudan” (STASS). Other ongoing projects focus on supporting these companies to increase local production of quality seeds, and the marketing of these seeds to farmers and to humanitarian agencies. According to FAO’s 2021 projections, the demand for seed aid in South Sudan is estimated at about 15000MT per year. The ensemble of South Sudanese seed companies are producing and marketing less than 20% of that demand. A sharp increase in the amount of seeds produced by national seed companies was observed in 2019 and 2020, as a result of FAO’s decision to procure up to 25% of its seed aid within South Sudan. However, this decision also induced foreign (and especially Ugandan) seed exporters to set up shop in Juba, in order to qualify as domestic seed suppliers. (Miteng, 2021).

3. Materials and Methods

The following sub-sections describe the quantitative data and qualitative insights that we gathered and analyzed for this study, and their respective sources, including: a farm household survey and a multi-stakeholder workshop.

3.1 Survey data

Data collection took place between September and December 2021 in five counties across Western, Central, and Eastern Equatorial states: Yambio (N=501), Nzara (N=500), Juba (N=65), Magwi (N=722), and Torit (N=194). This sample was intended to be representative of the population of farm households targeted by the A3SEED project across the green belt of South Sudan. In particular, the population targeted by the project is expected to comprise smallholding but progressive farmers, who are expected to be willing and able to buy seeds from the 10 national seed companies supported by the project. The total sample size is 1990 farm households. The sample size for each of the counties was set in proportion to the size of the target population. Villages were randomly selected in each county. Within each village, a random sample was drawn from lists of farm households provided by village leaders and local authorities.

Farm households were interviewed on their two most important crops for income generation purposes, according to their own perception. Maize was identified as the most important crop by 1329 farmers (or 67% of farm households). The other crops that were commonly identified as “most important” were sorghum (N=234), groundnut (N=918), cowpea (N=48), beans (N=152), millet (N=9), and rice (N=90). To comply with county-specific cultures and languages, all enumerators were locally recruited and conducted interviews only in their counties of origin. All enumerators received a three-day training on the questionnaire and data collection approach, right before the beginning of field work.

Table 1. Household characteristics

	Full sample Mean (Std.Dev.)	Maize farmers Mean (Std.Dev.)
Household received seed aid in 2021 (yes/no)	26% (44%)	27% (44%)
Vunerability:		
Displaced household (yes/no).[3]	4% (20%)	5% (21%)
Number of months of adequate household food provisioning (min=0; max=12)	10.8 (1.2)	10.9 (1.1)
Number of shocks experienced by the household	2.22 (1.8)	2.28 (2.2)
Asset:		
Tenure security (yes/no)	71% (46%)	73% (44%)
House ownership (yes/no)	94% (23%)	96% (19%)
Motorbike ownership (yes/no)	29% (45%)	32% (47%)
Radio ownership (yes/no)	50% (50%)	55% (50%)
Land holdings (hectares)	2.30 (3.1)	2.48 (3.1)
Household head is educated beyond primary school (yes/no)	33% (47%)	34% (47%)
Social network:		
CBO membership (yes/no)	59% (49%)	61% (48%)
Households regularly visits religious house (yes/no)	83% (38%)	84% (38%)
Village leader (yes/no)	24% (43%)	22% (43%)
Mobile phone ownership (yes/no)	36% (46%)	37% (46%)
General characteristics and fixed effects:		
Children in school (yes/no)	81% (39%)	80% (39%)
Household size	8.7 (4.7)	9.0 (4.8)
Dependency ratio.[4]	74.4 (77)	72.1 (71.1)
Household head is young (age<35; yes/no)	38% (48%)	39% (49%)
Household head is female (yes/no)	29% (45%)	25% (45%)
County of residence = Juba	3% (18%)	2% (17%)
County of residence = Yambio	25% (43%)	23% (43%)
County of residence = Nzara	25% (43%)	30% (45%)
County of residence = Torit	10% (29%)	3% (18%)
County of residence = Magwi	36% (48%)	42% (49%)
Maize-specific indicators:		
Input use: fertilizer (yes/no)	/	1% (9%)
Input use: pest-management.[5] (yes/no)	/	9% (12%)
Land under maize cultivation (ha)	/	1,59 (1.6)
Maize production (kg)	/	1380 (2215)
Maize productivity (kg/ha)	/	1177 (1708)
Share of maize harvest sold (%)	/	42% (27%)
Number of observations	*1990*	*1461*

[3] Includes households that were displaced or returned to their communities within the last three years.
[4] The dependency ratio is calculated by dividing the number of dependent household members (those under the age of 15 and above the age of 65) by the total number of household members.
[5] This includes the use of insecticides, herbicides and fungicides.

Table 1 presents the basic characteristics of the farm households in our sample. It describes data available for the entire sample and for a sub-sample of maize-producing farm-households, given that maize was the most widely produced crop. The average farm household appears to be large, including about nine members, and to have a high dependency ratio. On average, households had 0.7 dependent members (elderly or youth) for each household member in the labor force. Throughout 2021, farm households experienced slightly more than one month of food insecurity, or inadequate food provisioning, on average. Input use appears to be very limited among maize producing farm households, which on average cultivate one to two hectares of land to produce 1,380 kg of maize, with an average productivity of 1177 kg of maize per hectare. It is important to note that FAOSTAT (2020) reports average maize yields of almost 2000 kg/ha in Kenya and almost 3000 kg/ha in Uganda. The average share of maize production that is sold is estimated at 42 percent. This means that most (58 percent) of the maize produced by a farm household is used to satisfy its own food consumption needs.

Figure 1. Percentage of households receiving seed aid, by crop and county

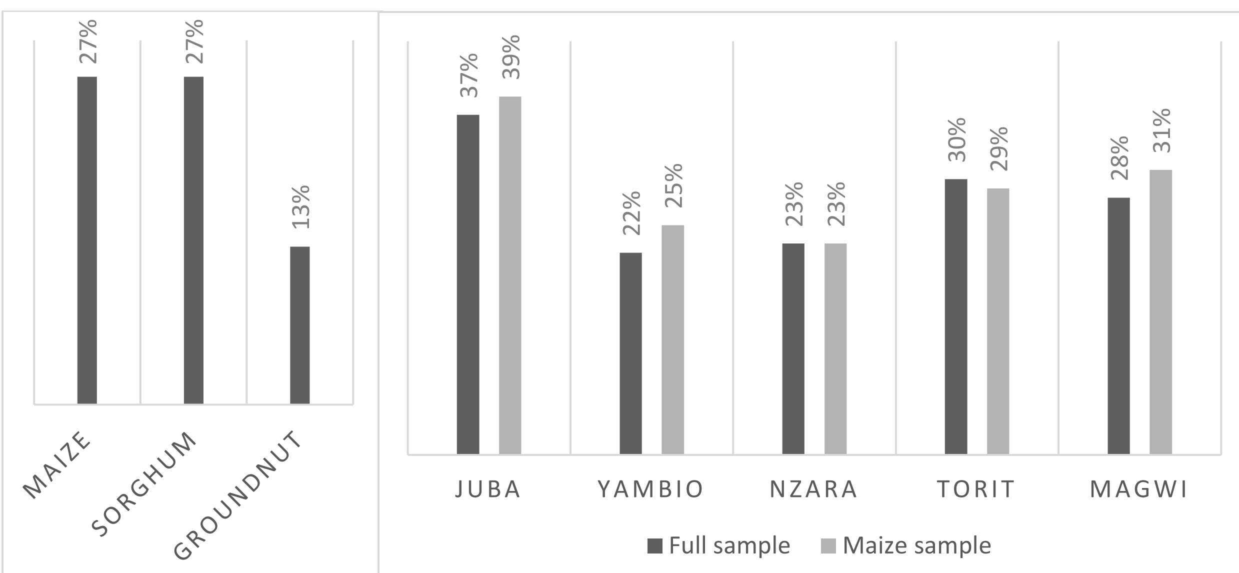

Table 1 also indicates that 26 percent of the farmers have received seed aid for at least one of their crops during the past agricultural season (2021). Figure 1 shows the variation in seed aid distribution by crop and county. Seed aid is mostly provided for staple crops, such as maize and sorghum. For both these crops, 27 percent of the households received relief seed. A smaller share (13 percent) of the households received free groundnut seeds. The distribution of seed aid was more concentrated in Juba, Magwi and Torit. The quantity of seed aid received by the average farm household was 11.5 kg for maize, which is roughly sufficient to cultivate one *feddan* (or acre) of maize. Sorghum farmers received 10.5 kg of free seeds on average, which allows to cultivate a bit more than one hectare. The dominant variety of freely distributed maize seeds was the Longe5, which is an open-pollinated (as opposed to hybrid) variety developed by the National Agricultural Research Organizations of Uganda.

3.2 Workshop insights

The multi-stakeholder workshop was held between the 28th and 30th of June 2022, in the town of Yambio (Western Equatoria state). The workshop brought together representatives of the state ministry of agriculture, of the private seed sector and of local farming communities, in order to identify key challenges and opportunities to agricultural and seed market development.

The workshop gathered about 120 participants over three days, including 82 market-oriented farmers from both Yambio and Nzara counties; representatives of two seed producing companies (Green Horizon and Pro-SEED) operating in both Yambio and Nzara counties, as well as their local seed outgrowers and dealers; representatives of IFDC, KIT, STASS, GIZ, WorldVision, CordAid; and the state Minister of agriculture and his staff. All participants were selected and invited with the intention to gather a representative group of seed sector stakeholders operating in the Western Equatoria state. Out of the 82 farmers that attended the event, 33 (or 40%) were women and 49 (or 60%) were men; 27 (or 33%) of the farmers were between the age of 19 and 35, thus qualifying as youth, including 12 young women and 15 young men.

The farmers who attended our workshop seemed to agree that seed aid distribution has generally failed to boost germination rates and agricultural yields. These shortcomings were generally attributed to the foreign origin of these seeds, which appear ill-adapted to the agro-ecological conditions (climate patterns and plant-diseases) and farming practices of South Sudan, and need to be transported over long distances thus increasing the probability of seed damage. Farmers also indicated that seed aid packs were often distributed too late for sowing.

Overall, the farmers who participated in the workshop expressed their desire to buy higher-yielding seed varieties, if these were made available on the market. However, the seed companies that attended the workshop concluded that most farmers are likely to continue spending their limited cash on other goods or services instead, given that (free) seed aid remains largely available and easily accessible. The protracted and mass distribution of seed aid was described by seed companies as a major disincentive for farmers to purchase seeds. The representatives of seed companies explained that, for this reason, their main marketing strategy remains geared to selling their seeds to FAO and other humanitarian agencies, rather than directly to farmers. By selling seeds to FAO, South Sudanese seed companies also expected to minimize the transaction and transportation costs associated with direct sales to a myriad smallholders scattered over a large and poorly connected rural territory.

4. Results

This section presents and discusses a two-step analysis of available data, which is geared to better understand how seed aid is targeted in practice—or which typology of farm households are most likely to receive seed aid—and to assess the effect of seed aid on maize production.

4.1 Targeting of seed aid

We run a Probit regression to identify key factors explaining whether a farm household received seed aid in 2021, or not. Our model includes four categories of explanatory variables, which are assumed to be exogenous and to explain the likelihood for a farm household to receive seed aid.

The first category of explanatory variables is specified to capture vulnerability or whether farm households were: a) displaced or returned to their original location during 2021; b) exposed to livelihood disrupting shocks of any kind during 2021; or c) affected by food insecurity before the start of the 2021 main planting season. We expect seed aid to be targeted to particularly vulnerable households and therefore we expect these variables to have positive and significant coefficients. The second category includes proxy variables for a farm household's social network: a) whether the head of a farm household is a village leader, a member of at least one community-based organization (CBO), a regular visitor of a religious house, and/or the owner of a mobile phone. We also expect these variables to have positive coefficients, as social networks or connections have the potential to increase the farm-households' access to seed aid. The third category focuses on household assets, measured on the basis of land holdings and rights, attained education level, house ownership and ownership of other assets (motorbike and radio). We expect negative coefficients for these variables, since we expect asset poor households to be a more likely target for seed aid. Finally, the model specifies also a few variables capturing general farm household characteristics and fixed effects (or location specific effects).

Table 2.Probit regression results: probability of receiving seed aid.

VARIABLES	Coefficient (Robust Standard Error)
Vulnerability:	
Displaced household	0.347 (0.152) **
Number of shocks experienced by the household	-0.014 (0.018)
Months of adequate food provision before planting season	-0.032 (0.044)
Social networks:	
CBO membership	0.339 (0.079) ***
Households regularly visits religious house	0.266 (0.096) ***
Village leader	0.181(0.074) **
Mobile phone ownership	0.0577 (0.028) **
Assets:	
House ownership	0.192 (0.139)
Motorbike ownership	-0.086 (0.077)
Radio ownership	-0.016 (0.070)
Land owned (ha)	0.004 (0.004)
Household has land rights	-0.069 (0.080)
Household characteristics and fixed effects:	
Household size	0.009 (0.007)
Children are attending school	0.024 (0.085)
Dependency ratio	0.001 (0.000)
Household head age < 35	-0.018 (0.067)
Female-headed household	-0.087 (0.075)
Household head is educated beyond primary school	-0.071 (0.072)
County = 2, Yambio	-0.591 (0.192) ***
County = 3, Nzara	-0.511(0.183)***
County = 4, Torit	-0.132 (0.196)
County = 5, Magwi	-0.448(0.181) **
Constant	*-0.715 (0.381)**
Observations	*1,957*

*Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

Table 2 presents the results. In line with Figure 1, location is an important determinant for receiving seed aid. Farm households in the relatively central counties of Juba and Torit are more likely to have received seed aid than farm households in the more remote counties of Magwi, Nzara, and Yambio. In addition, displaced or returning households were more likely to receive seed aid. However, other vulnerability indicators, such as food security and exposure to shocks, and being asset poor are not significant in explaining access to seed aid. More important and significant is the combined predictive power of proxy variables for a household's social network. Being a CBO member, visiting a religious house, being a village leader, and owning a mobile phone are all associated with significantly higher likelihood to receive seed aid.

4.2 Impact of seed aid

This second analysis instead assesses the effect of seed aid on agricultural production, and more specifically on maize production. To do so, we considered only farm households that identified maize as their main crop and that actually produced some maize during 2021.

Our analysis proceeds in assessing changes in maize production that are attributable to farmers' utilization of seed aid as opposed to locally recycled and market-sourced seed varieties. According to our data, commercial seed varieties available at local markets are rarely purchased and used by sampled farmer households—only 3% of the farm households indicated to make use of these seeds. Their effect on maize production can be thus considered as negligible and our analysis can be therefore considered as a comparison of the effect attributable to seed aid versus that of locally recycled seed varieties.

We estimate the effect of seed aid on three outcome indicators: i) maize productivity or yield, measured in Kg of maize produced per hectare; ii) total maize production, in Kg of maize produced per farm-household; iii) total size of land cultivated with maize, in hectares. Since freely distributed seeds are supposed to go through quality control and certification processes, they are expected to have higher germination rates than local seeds, whose high yielding traits tend to be lost as a result of non-scientific seed selection (or recycling) over time. Farmers receiving seed aid are therefore assumed to have larger harvests, due to either higher yields or more land cultivated with maize, than otherwise similar farmers.

These effects are estimated using inverse-probability-weighted regression adjustment IPWRA (Wooldridge 2010; Manda et al., 2019). This doubly-robust method allows for the estimation of a treatment effect on the treated by combining inverse probability weighting with a multivariate ordinary least squares (OLS) regression model. Both models specify the same set of covariates (X) to control for potential selection bias. A Probit model is used to predict the probability for a farm household to receive seed aid, and thus to compute their propensity scores $\hat{p}(X)$. Seed aid receivers are then assigned a weight of one and those that did not receive seed aid are assigned a weight of $\frac{\hat{p}(X)}{1-\hat{p}(X)}$ (Hirano and Imbens, 2001). As such, this model estimates weighted differences in outcomes between seed aid receivers and non-receivers. In the OLS model, the dummy variable identifying seed aid receivers is instead specified as the main independent variable of interest to explain outcomes, ceteris paribus (or given the effects of all other independent variables). The advantage of combining OLS with inverse probability weighting, by using the inverse probability scores as weights in the regression, is that only one of the two models need to be correctly specified. However, we cannot exclude that both models are affected by residual selection bias, or self-selection bias associated with unobserved farm-household characteristics, such as farmers' willingness and ability to receive seed aid.

Figure 2 shows the distribution of estimated propensity scores for seed aid receivers and non-receivers. There is sufficient overlap between the two curves, suggesting that seed aid receivers and non-receivers are indeed similar and therefore comparable, with regard to observed farm household characteristics (X). Seed aid receivers only had a slightly higher probability of receiving seed aid, and only one farm-household was not included in the estimation, because it fell outside the common support area. The Probit regression results that are used to calculate the propensity scores are included in the Appendix.

Figure 2. Density plot of propensity scores

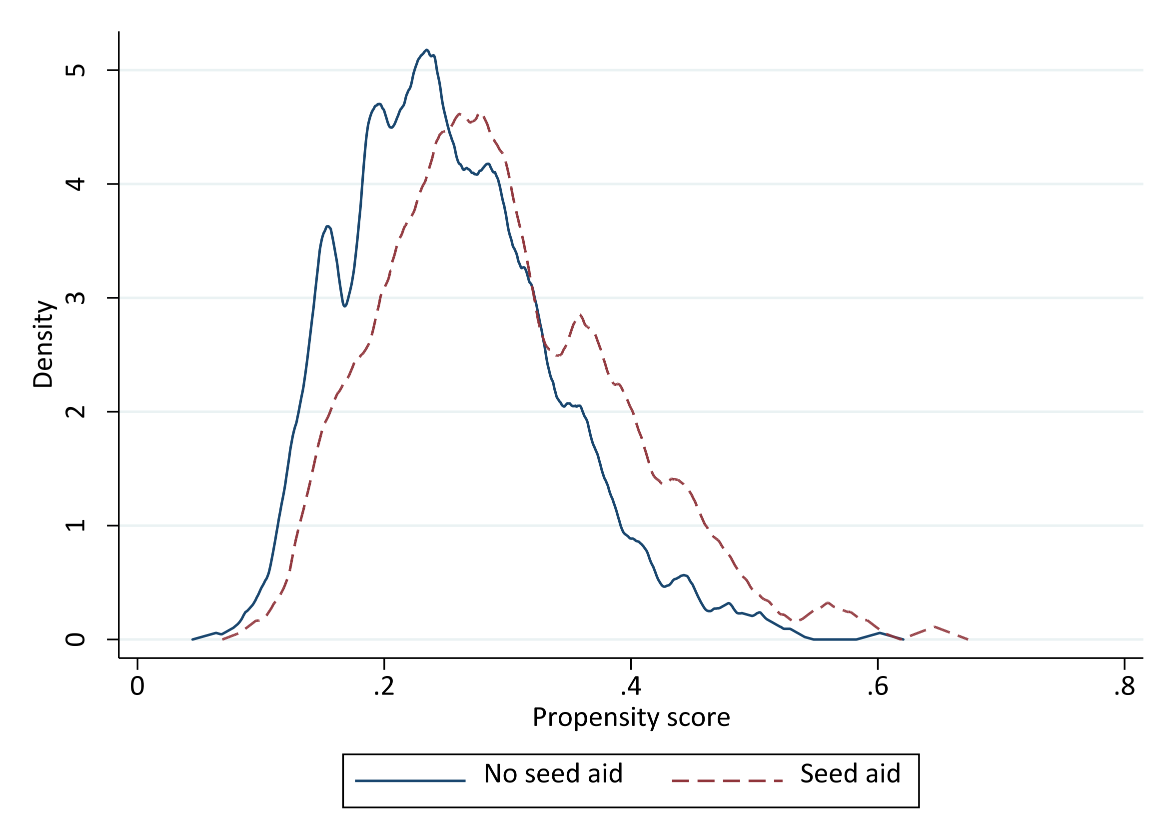

Table 3. Average treatment effects on the treated (ATET)

Outcome indicators	Treatment status		ATET
	Non-receivers	Receivers	
Maize productivity (Kg/ha)	1155.6 (55.51)	1215.1 (81.39)	95.86 (107)
Maize production (Kg)	1309.5 (47.50)	1513.9 (151.33)	281.7 (197.0)
Land under maize cultivation (ha)	1.57 (0.048)	1.62 (0.061)	0.079 (0.074)
Observations	909	326	1235

*Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

An over-identification test for covariate balance, shows a balance in covariates ($Chi^2 = 17.17, p = 0.7006$)

Results of the IPWRA estimation are presented in Table 3. We find no significant difference in maize productivity between farm-households that received seed aid and those that did not. These results do not reject the null hypothesis that certified and freely distributed seeds have more or less the same effect on maize yields as local seed varieties. Seed aid also has no significant effect on the total amount of maize produced by farm-households. This means that seed-aid receivers would have harvested similar quantities if they had not received seed aid. Finally, the absence of a significant effect on land under maize cultivation indicates that seed aid receivers did not increase their land area under maize cultivation. These results suggests that seed aid substituted, rather than supplemented, household's other seeds.

Table 4. Robustness checks

Outcome Indicators	ATET estimated through different techniques				
	PSM One-to-one matching	PSM Kernel matching	Naïve T-test	Naïve OLS	IPWRA Alternative specification
Maize productivity (kg/ha)	92.5 (131.9)	92.4 (114.6)	21 (109.6)	85.4 (105,8)	70.97 (95.8)
Maize production (kg)	255.1 (266.5)	244 (167.9)	216 (142)*	249.8 (139.9) *	202.6 (153.3)
Land under maize cultivation (ha)	0.13 (0.10)	0.12 (0.15)	0.17 (0.097)**	0.067 (0.069)	0.059 (0.064)
Observations	*1,236*	*1,236*	*1,236*	*1,236*	*1,258*

*Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

In table 4, we check the robustness of our results by running alternative propensity score matching models (with different matching algorithms) and naïve comparisons based on t-tests and unweighted OLS regression. We also test an alternative or over-specification of our IPWRA model, which included additional variables that were not clearly exogenous, such as the extent to which farmers use other inputs (i.e. fertilizer and pesticides). All these alternative estimations resulted in very similar findings to those results presented in Table 3.

5. Discussion

Our data shows that international seed aid is distributed on a large scale across the green belt of South Sudan, reaching almost a third of local and semi-subsistent farm-households. Internally displaced households and returnees are more likely to receive seed aid, but other vulnerable households affected by shocks and food insecurity do not seem to have preferential access to seed aid. A farmer's social network appear to be the most important factor explaining access to seed aid. Farmers who are also village leaders, members of community based organizations and religious congregation, as well as owners of mobile phones are significantly more likely to receive seed aid. As such, our data suggest that seed aid distribution is not selectively targeted. In theory seed aid distribution should be better targeted to seed-deprived farmers, however the imposition of restrictions or conditions to seed aid access is in practice expected to increase the risk of wrongful discrimination and exclusion.

In addition to this, we find that internationally sourced and freely distributed seeds do not contribute to the intensification nor the expansion of maize production. This means that the international seeds distributed by aid agencies substitute rather than complement local reserves of recycled seeds, with no major implications in terms of overall seed quality. Most farmers perceive imported seed aid varieties as poorly adapted to local agro-ecological conditions and farming practices, resulting in generally low germination rates. The untimely (late) distribution of seed aid is also a common concern among farmers.

In addition to all this, the Seed Trade Association of South Sudan (STASS) is raising growing concerns about the disruptive effect of international seed aid distribution on local seed markets. As long as seed aid agencies will continue to procure most seeds from abroad, South Sudanese seed producers will have limited opportunities to grow their business. A gradual shift towards local seed procurement by humanitarian agencies could instead provide a strong economic incentive to South Sudanese seed producing companies. A gradual shift towards local procurement has also the potential to improve the adaptation of seed aid varieties to local agro-ecological conditions and farming practices, and shorten the seed aid supply chain as well as delivery costs and time. The long term goal is undoubtedly to phase out seed aid distribution and replace it with a more efficient and sustainable market-based system. To ensure the inclusion of local seed producers in emerging seed markets, short- and mid-term governance must however be more explicitly geared in favor of local seed aid procurement practices.

In conclusion, this study substantiates and validates the hypothesis that poor seed aid governance—associated with free and ill-targeted distribution of internationally procured seeds—can indeed hamper the development of local agricultural and seed markets. It is however important to recognize that the validity of this conclusion has both internal and external limitations. First of all, our study was confined to the green belt of South Sudan, and did not take into account farm-households that would have liked to produce maize, but could not to do so because they had no access whatsoever to any kind of seeds. Instead, we reasonably assumed that seed aid distribution in other and less favored parts of country, as well as to seed-deprived farmers can only have a positive impact. By doing so, we inevitably limited the external validity of our analysis and conclusion to seed-secure maize farmers from the green belt of South Sudan. Second, the internal validity of our analysis is limited by: a) the absence of baseline data measuring farmers' performance before the introduction of seed aid; and b) the non-random selection of treatment and control farm-households. These two hard-to-avoid limitations could have in theory confounded our attempt to identify and attribute the impact of seed aid on farm-households.

The limitations of this study thus bind us to nuance our recommendations for the way forward, which also need to take into account the complex political environment of South Sudan and the East African region. Caution shall prevail over swift governance reforms, given that the seed aid industry creates employment and income both in South Sudan and in neighboring countries. Still, gradual governance reforms aiming to enforce and expand the procurement of local seeds by humanitarian agencies are also expected to favor the sustainability of the seed aid industry over time. This is because local procurement practices justify the distribution of seed aid also outside and beyond emergency situations.

However, the shift from international to local procurement is expected to confront seed aid agencies with additional costs and risks. The role of STASS is to mitigate these disincentives faced by humanitarian agencies by ensuring transparency and accountability in local seed procurement processes. Humanitarian agencies have already agreed that 25 percent of the seeds they distribute in South Sudan should be locally procured, but this target remains to be reached. This is because the demand for seeds coming from humanitarian agencies remains unpredictable and biased in favor of international suppliers that can deliver large quantities of certified seeds at a short notice and for a low price. As well as because the actual volume, quality and price of locally produced seeds remain unclear. Hence, the role of STASS is to improve information flow across humanitarian agencies and national seed producers, and hold both parties accountable in achieving the 25 percent target and in raising such a joint target gradually over time.

Finally, the sustained upscaling of seed production within South Sudan will require the establishment of a National Agricultural Research System (NARS) that can ensure the selection and dissemination of foundation seeds that are better adapted to local agro-ecological conditions and farming practices. The investments needed for the establishment of a South Sudanese NARS and related seed breeding, testing, grading, certification and extension services may be substantial, but justified by the high and largely untapped agricultural potential of South Sudan.

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Appendix:

Table 5. Covariate balance summary

Covariate balance summary			Raw	Weighted
		Number of obs	1,235	1,235
		Treated obs	326	618
		Control obs	909	616
	Standardized differences		Variance ratio	
	Raw	Weighted	Raw	Weighted
Tenure security	-0.113	0.003	1.128	0.996
Number of months of adequate household food provision	0.077	-0.001	0.899	1.027
Household head age < 35	-0,005	0.012	0.999	1.001
Household head is female	-0.096	0.022	0.894	1.024
CBO membership	0.170	-0.123	0.911	1.005
Household size	0.055	0.0119	1.409	1.259
Dependency ratio	0.173	0.010	1.567	1.068
Religious household	0.141	-0.000	0.755	1.000
Village leadership	0.179	-0.002	1.250	0.996
Household head is educated beyond primary school	-0.013	-0.002	0.993	0.998
House ownership	0.061	0,0197	0.726	0.903
Mobile phone ownership	0.010	-0.003	1.518	1.241
Motorbike ownership	-0.037	-0.027	0.974	0.990
Radio ownership	-0.090	0.010	1.021	0.997
Children in school	-0.009	-0.009	1.016	1.014
Land owner (ha)	0.071	0.004	1.386	1.103
County = Juba	0.095	-0.002	1.736	0.985
County = Yambio	-0.045	-0.006	0.945	0.992
County = Nzara	-0.133	0.026	0.904	1.019
County = Torit	0.007	-0.027	1.046	0.846

Table 6. Overidentification test for covariate balance

Overidentification test for covariate balance	
H0: Covariates are balanced:	
Chi2(21)	17.1724
Prob > chi2	0.7006

Table 7. Probit model estimates of treatment status, maize sample

VARIABLES	(1)
Household has land rights	-0.142 (0.0944)
Months of adequate food provision before planting season	0.0913 (0.0626)
Household head age < 35	-0.0370 (0.0809)
Female-headed household	-0.0815 (0.0944)
CBO membership	0.268*** (0.0872)
Household size	0.00569 (0.00882)
Dependency ratio	0.00142** (0.000555)
Households regularly visits religious house	0.289** (0.117)
Village leader	(0.0932)
Household head is educated beyond primary school	-0.0850 (0.0874)
House ownership	0.324 (0.213)
Phone ownership	0.0530* (0.0321)
Motorbike ownership	-0.0692 (0.0903)
Radio ownership	(0.0825)
Children are attending school	-0.140 (0.0997)
Land owned (ha)	0.00472 (0.0134)
County = Juba	0.306 (0.250)
County = Yambio	-0.0859 (0.124)
County = Nzara	-0.163 (0.111)
County = Torit	0.0515 (0.237)
County = Magwi	-
Constant	-1.831*** (0.509)
Observations	1,313

Table 8. Naïve OLS regression used as robustness check

VARIABLES	(1) Maize yield (kg/ha)	(2) Total maize production (kg)	(3) Land for maize cultivation (ha)
Seed aid (y/n)	85.41	249.8*	0.0673
	(105.8)	(139.9)	
Household has land rights	168.7	455.9***	0.171**
	(118.4)	(156.6)	(0.0764)
Months of adequate food provision before planting season	-252.4***	-55.87	-0.0644
	(75.03)	(99.22)	(0.0473)
Household head age < 35	-184.6*	-255.8**	-0.00897
	(98.10)	(129.7)	(0.0643)
Female-headed household	5.154	-72.66	0.0129
	(114.0)	(150.8)	(0.0746)
CBO membership	-102.0	-331.0**	-0.243***
	(107.0)	(141.5)	(0.0695)
Household size	-8.552	37.05***	0.0200***
	(10.80)	(14.28)	(0.00718)
Dependency ratio	0.225	-0.395	-0.000925**
	(0.687)	(0.908)	(0.000453)
Households regularly visits religious house	206.9	159.2	-0.0693
	(135.2)	(178.8)	(0.0894)
Village leader	206.5*	376.7**	-0.0559
	(115.3)	(152.5)	(0.0762)
Household head is educated beyond primary school	-7.507	4.323	-0.0665
	(105.3)	(139.3)	(0.0692)
House ownership	138.4	199.7	0.303*
	(250.8)	(331.7)	(0.160)
Phone ownership	45.44	-20.42	-0.0132
	(41.08)	(54.33)	(0.0263)
Motorbike ownership	97.26	30.16	0.190***
	(109.4)	(144.6)	(0.0715)
Radio ownership	-208.4**	-27.79	0.0501
	(100.8)	(133.2)	(0.0659)
Children are attending school	168.4	-65.48	-0.0654
	(122.6)	(162.1)	(0.0798)
Land owned (ha)	-27.16	126.6***	0.317***
	(17.35)	(22.94)	(0.0112)
Juba	-	-	-0.702***
			(0.268)
Yambio	930.1***	821.6*	-0.451**
	(325.9)	(431.0)	(0.204)
Nzara	1,070***	1,444***	-0.432**
	(310.0)	(409.9)	(0.196)
Torit	2,860***	1,591***	
	(412.4)	(545.4)	
Magwi	158.7	881.0**	0.330*
	(312.9)	(413.8)	(0.189)
Constant	1,831***	-313.6	1.018**
	(656.8)	(868.5)	(0.400)
Observations	*1,235*	*1,235*	*1,312*
R-squared	*0.141*	*0.107*	*0.540*