

## CIMMYT Internal Discussion Paper

### Developing a gender intentional strategy for deployment of Male sterility (Ms44) mutant gene seed production technology for Africa

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## Abstract

Are there differences in men's and women's access to and use of fertilizer and hybrid maize seed in eastern and southern Africa? This article explores the issue through a systematic review of the extant literature on gender and fertilizer use in maize production and on gender and hybrid maize adoption. Moreover, if differences exist, what will be the best strategy to deploy nitrogen use efficient (NUE) maize hybrid technology/seed in the region. The findings show that indeed a gender gap in fertilizer use exists. We find that there is strong evidence of a significant gender gap in the use of chemical fertilizer in SSA, with men adopting the technology more than women. Studies on the adoption of improved maize varieties (hybrids) show unclear gender-related trends, possibly because most studies use the sex of the household head or farmer to represent gender. For the deployment of NUE maize hybrids to be gender-intentional,

stakeholders such as breeders, extension agents, seed companies, agro-dealers and governments need to take into account factors that hinder women from taking up the technologies, which include economic factors, knowledge and information, access and social norms and culture.

**Keywords:** chemical/organic fertilizer; gender, Africa; agricultural productivity; hybrid maize seed

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## 1.Introduction

Africa urgently needs a Green Revolution to address the mounting challenges of population growth, unemployment, food insecurity, climate change and declining soil fertility. Since researchers estimate that about 50% of the productivity gains experienced by Asian farmers during the Green Revolution can be attributed to the increased use of chemical fertilizer alone (Hopper, 1993; Tomich et al., 1995), increased use of chemical fertilizer is recognized as one of the central drivers of agricultural productivity. The average use of inorganic fertilizer in sub-Saharan Africa (SSA) has been estimated at 14 kg ha<sup>-1</sup> in SSA, as opposed to 141 and 175 kg ha<sup>-1</sup> in South Asia and Latin America, respectively (Asfaw and Adamassie, 2004). A recent study by Sheahan and Barrett (2017), based on nationally representative data covering 22,565 households from the Living Standard Measurement Study Integrated Surveys on Agriculture Initiative (LSMS-ISA) for six SSA countries, namely Niger, Nigeria, Ethiopia, Malawi, Tanzania, Uganda, found that the application of inorganic fertilizer may be low in aggregate, but is not uniformly low across these six countries.

Crop production in rural SSA is faced with the challenge of declining soil fertility (De Groote et al., 2018) that compounds the problem of underproduction of food in the region. The primary cause of soil degradation in SSA is the expansion and intensification of agriculture in an effort to feed the region's growing population (Tully et al., 2015). The article by Tully et al. (2015) goes on to note that certain soils in SSA are losing their ability to provide food and essential ecosystem services, and we know that soil fertility depletion is the primary cause of this. One of the ways to improve soil fertility is by the application of organic manure, a practice adopted

more by women, or by the application of mineral or chemical fertilizer, adopted and purchased more by men (Nkonya and Moore, 2015).

However, in Africa, where women account for between 24% and 56% of agricultural labor (Palacios-Lopez et al., 2017), the widely documented gender gap in agricultural productivity, estimated to be between 20% and 40% globally, presents a sobering picture (Mukasa and Salami, 2015; FAO, 2011).

According to FAO (2011), if women and men had the same access to productive resources, women's yields would increase by 20-30%, which would raise total agricultural output in developing countries by 2.5-4% and lead to a 12-17% decline in the number of undernourished people. Moreover, the low use of fertilizer reduces food and nutrition security and also reduces the uptake and availability of other key nutrients for plant and human nutrition (Pasley et al., 2019 and 2020). For instance, low fertilizer application reduces the Provitamin A maize content of biofortified maize (Ortiz-Covarrubias et al., 2019). Against this background, more attention needs to be paid to assessing and addressing gender gaps in the use of chemical fertilizer.

Thus, in the present situation, we need to find other avenues that could complement the existing ones to increase maize yields and production in the region to meet its demands. It has been documented that nitrogen (N) is an essential nutrient for plant growth and development and an important factor determining maize grain yield (Fox et al., 2017). Developing maize varieties that use nitrogen more efficiently can therefore make a significant contribution in increasing yields and food security (De Groote et al., 2018).

Since 2010, CIMMYT and her partners – DuPont-Pioneer, Kenya Agricultural Livestock and Research Organization, and the Agricultural Research Council of South Africa, under the Improved Maize for African Soils (IMAS) project, have been working to develop maize varieties that are nitrogen-efficient. One of these Nitrogen Use Efficient (NUE) varieties is Ms44. Male sterility (Ms) is one of the options considered to provide that solution. Ms44 is a one dominant mutant gene that renders the male flower infertile (De Groote et al., 2018; Fox et al., 2017; Loussaert et al., 2017). Studies that have been carried out by breeders and agronomists in greenhouse and field trials have shown that the Ms44 male sterile plants reduce tassel growth and improve ear growth by delivering more nitrogen to the ear, resulting in a 9.6% increase in the number of kernels. As a result, hybrids carrying the Ms44 allele demonstrate a 4–8.5% yield advantage under N-deficient soils, a 1.7% yield advantage under drought, and a 0.9% yield advantage under optimal growth conditions, relative to the yield of conventional varieties (Fox et al., 2017). Furthermore, growing a blend of male sterile and male fertile plants can improve grain yield under a range of growing conditions, including those where drought and low N limit crop yield (Loussaert et al., 2017).

Information from the current field experiments show that the largest performance benefit of 50% Ms hybrids using Ms44 is the yield advantage under low fertility conditions (Olsen et al., 2016). In most African countries, improving NUE is critical for food security as farmers cannot afford to apply more N fertilizer (Fox et al., 2017). This paper presents a review of the literature on the use of chemical fertilizer and hybrid maize by men and women smallholder farmers in eastern and southern Africa. The objective is to answer these questions: do men and women have equal

access to fertilizer and hybrid maize seed? If not, would the male sterility genetic system (Ms44) that increases yield in both low-nitrogen and drought environments in conjunction with the proprietary Seed Production Technology (SPT) benefit men and women differentially, based on existing evidence of how gender affects the use of fertilizer and hybrid maize seed in sub-Saharan Africa.

The discussion is organized as follows: following the section on methodology, the second session of the paper provides the findings from research done. Specifically, the first part (part 1) of the of section 3, which is the results section, the paper summarizes the discussion on gender and agricultural productivity and examines how input use contributes to the gender gap in agricultural productivity. Parts 2 and 3 explore the literature on gender and fertilizer use in maize production and gender and hybrid maize adoption to address the following questions: Are there differences in men's and women's access to and use of fertilizer and hybrid maize seed in eastern and southern Africa? What factors are responsible for gender differences in fertilizer and hybrid maize access and use? What barriers and challenges do women maize producers face in accessing and using fertilizer and hybrid maize seed? Part 4 discusses the strategies and approaches being used to improve women's access to and use of chemical fertilizer and hybrid maize seed. Part 5 proposes recommendations for specific stakeholders to promote the adoption of Ms44 Seed Production Technology for Africa (SPTA)-produced hybrid technology, and to address gender-related constraints to technology adoption. The final section is the conclusion.

## 2. Methodology

The literature on gender and fertilizer use in maize production in eastern and southern Africa was identified through an internet search to find referenced journal articles, reports, policy briefs and grey literature on the topic. Articles were also identified from electronic databases (Web of Science, African Journal Online, Science Direct, Taylor and Francis), using primary search terms and keywords “gender AND fertilizer AND sub-Saharan Africa”; “gender gap”; “fertilizer”; “adoption of fertilizer”; “agricultural productivity”; “access to credit”; and “maize production”.

The literature search yielded more than 30 publications that specifically related to fertilizer use in maize production in sub-Saharan Africa (SSA). About ten other articles were found that were related to fertilizer but not necessarily to maize production. We used similar electronic databases to study the effect of gender relations on the adoption of seed, using primary search terms and keywords “gender and adoption of improved maize varieties in sub-Saharan Africa”; “gender and farm inputs”; “adoption of improved varieties of seed and gender relations”; and “sex-disaggregated data and adoption of improved maize seed”. The literature search yielded 20 publications that were specifically related to the adoption of improved maize seed in SSA. The majority of publications for both searches were articles in peer-reviewed journals and official reports.

### **3. Findings**

#### **Part 1: Gender and agricultural productivity**

An extensive literature dating from the 1970s addresses the questions “are there differences in male and female agricultural productivity or technical efficiency?” and “do women have the potential to be as productive as men if they have the same access to productive resources” (see Doss, 2015 for a review of this literature). According to the UN, the annual cost of the gender

gap in agricultural productivity is huge: US\$105 million in Tanzania, US\$100 million in Malawi, and US\$67 million in Uganda (UN Women et al., 2015). While results have in general been mixed, studies that apply production or profit functions find no significant differences in male and female agricultural productivity or technical efficiency after controlling for access to inputs and for characteristics of plots, households and farmers (Adeleke et al., 2008 on maize; Tiruneh et al., 2001 on wheat; Adesina and Djato, 1997 on rice; Moock, 1976 on maize). These studies generally conclude that gender differences in productivity are due to differences in access to resources. Other studies, however, find that productivity differentials are driven by crop differences between men and women (Githinji et al., 2014; Peterman et al., 2011) and country-specific conditions (Mukasa and Salami, 2015). Similarly, studies that examine technology adoption generally conclude that although male farmers tend to adopt technologies faster than women farmers, gender per se is not statistically significant in explaining adoption (Peterman et al., 2010; Jagger and Pender 2006; Doss, 2001). Factors commonly recognized as enabling technology adoption and found to be statistically significant include education, size of plot, fertilizer use, and access to extension services, agricultural information and credit, which all tend to be statistically correlated to the gender of the farmer or household head (Fisher and Carr, 2015; Fisher and Kandiwa, 2014; Smale, 2011; Doss and Morris, 2001). Policy recommendations based on this empirical evidence support improving women's access to resources and services including fertilizer, other agricultural inputs and credit.

The literature concerning gender and agricultural productivity has come under recent criticism with regard to data sources, methodology and analytical approaches. The majority of the data on gender and agricultural productivity derives from case studies based on non-nationally



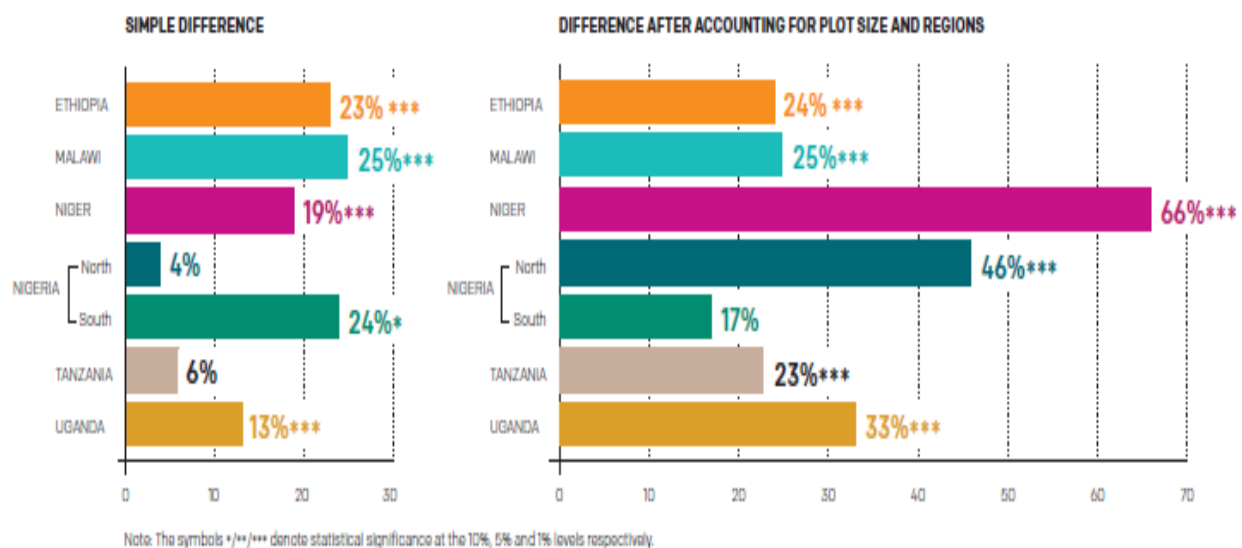
representative samples and methodological differences that make it difficult to compare findings and arrive at externally valid results. Doss (2015) argues that the debate about gender and agricultural productivity is in itself flawed due to problems with defining and measuring women's "productivity", and challenges in conceptualizing the gendered structure of agriculture and food systems. A case in point is the assumption made in some studies that inputs or choice of crops are exogenously determined, which may not necessarily be true when gender is taken into account (Doss, 2015). Comparing the productivity of men and women farmers who may grow different crops based on their gender and have different access to land and other productive resources calls for analyses and statistics that consider these complexities. While researchers use several different ways to measure agricultural productivity, the two most popular being output per unit of labor and land, most approaches are not designed to measure separately the productivity of men and women farmers. Finally, a key but often overlooked conceptual issue in the discussion around gender and agricultural productivity relates to who is defined as a farmer, and which farms/plots are being compared. The majority of studies compare agricultural productivity between male- and female-headed households, which is problematic because such analyses compare two different types of household structures, overlook production by women farmers in male-headed households, which constitutes the majority of women in SSA (Doss, 2015; Ali et al., 2016; Peterman et al., 2011) and often ignore differences between single women heads of households (widows, divorcees) and married women who head households in the absence of their husbands.

Recent studies have tried to address these issues using more sophisticated methodological approaches and modes of analysis. For example, a number of studies assess technology adoption and agricultural productivity by individual male and female farmers living in the same household

(defined variously as the owner of the plot, the manager of the plot, or the person providing the day-to-day labor for the plot or crop) (Fisher and Carr, 2015; Ali et al., 2016; Fisher and Kandiwa, 2014; Smale and Mason, 2012). However, researchers continue to grapple methodologically with the challenges of measuring the productivity of individual farmers who contribute to farms jointly managed by husbands and wives, and the contribution of women to men's farms and vice versa (Doss, 2015). Decomposition techniques such as the Oaxaca-Blinder decomposition allow researchers to identify how much of the productivity gap is due to gender differences in access to inputs (endowment effect) and how much is due to gender differences in returns to these inputs (structural effects) (see Doss 2015 for a review). Studies that use Oaxaca-Blinder decomposition analysis find that in some countries, even when women have access to the same amount of inputs as men, a gender gap in agricultural productivity still exists. A much-cited World Bank study on gender and agricultural productivity in six of the most populous SSA countries (Ethiopia, Tanzania, Malawi, Uganda, Niger and Nigeria) provides an example of the kind of in-depth analysis generated by Oaxaca-Blinder decomposition analysis (O'Sullivan et al, 2014). The study found that controlling for plot size and geographic factors significantly increased the gender gap in agricultural productivity when this was observed from a simple comparison of average male and female productivity from, for example, 13% in Uganda to 25% in Malawi, to 23% in Tanzania and 66% in Niger. Notably, Ethiopian women farm managers experienced smaller improvements in yields relative to men when they applied the same amount of fertilizer and used oxen for farm activities (O'Sullivan et al, 2014). While access to advisory services was not associated with the gender productivity gap in Ethiopia, access to these services generated better returns for male than for female farmers. The authors suggest that these findings may be due to gender differences in knowledge of appropriate farming techniques due to unequal

access to extension services and other sources of information, or to timing of use. On the other hand, women’s lower use of inputs (e.g. improved seed, chemical fertilizers) in Malawi accounted for more than 80% of the gender gap in agricultural productivity. Other factors that contributed to the gender gap in agricultural productivity in the target countries included quantity and efficiency of farm labor (Niger, northern Nigeria), land ownership, quality and access (Ethiopia, Niger) and the burden of domestic and childcare responsibilities (Ethiopia, Malawi, Niger).

FIGURE 1: Gender Gaps In Agricultural Productivity, by Country



Source: O’Sullivan et al., 2014.

Findings based on nationally representative data on the adoption of hybrid maize in Malawi (often used as a proxy for gender productivity difference) also highlight the complexity of factors contributing to gender-differentiated agricultural productivity (Fisher and Kandiwa, 2014). In

contrast with smaller sample surveys, which found that gender differences in the adoption of hybrid maize in Malawi disappeared after controlling for access to key resources and services (land, labor, capital, extension services, and markets), this study shows that gender significantly influenced the decision to grow hybrid maize after controlling for those factors. After controlling for resource-related factors, female household heads had an 11% lower probability and wives in male-headed households a 12% lower probability of growing hybrid maize than male household heads. Access to complementary inputs such as fertilizer was among several reasons for lower female adoption rates; other possible explanations were that women did not appreciate the traits of the maize varieties distributed and were more risk-averse than men.

Despite methodological, conceptual and measurement challenges, this brief review of the literature on gender gaps in agricultural productivity shows that women farmers in many regions of the world experience disadvantages that often result in lower productivity and inefficiencies.

## **Part 2: Gender and fertilizer use in SSA**

While fertilizer demand in sub-Saharan Africa (SSA) is projected to grow annually, at 3% of global fertilizer consumption, the total volume of fertilizer in SSA is expected to remain low relative to other parts of the world (AGRA, 2016). Analysts have advanced several explanations for low fertilizer use in SSA including the following: limited and untimely supply of fertilizer; high costs; liquidity and credit constraints; lack of knowledge and skill in using fertilizer; uncertainty about returns from fertilizer use due to risks such as price volatility, pests and diseases; climate change; and limited access to output markets to ensure a return to investing in

fertilizer (AGRA, 2016; Morris, 2007). Use of chemical fertilizer varies considerably across and within countries and by crop. For example, Ethiopia and Malawi are above the SSA average reported by FAOSTAT, while Niger, Nigeria, Tanzania, and Uganda all fall below (Sheahan and Barrett, 2014).

There is strong evidence of a significant gender gap in the use of chemical fertilizer in sub-Saharan Africa, where women play a significant role in crop production (Lambrecht et al., 2016; Sheahan and Barrett, 2014; Chirwa et al., 2011; Peterman et al., 2010). For example, 55% and 89% of male-headed households, compared to 26% and 74% of female-headed households in a sample of maize-producing households in western Kenya applied urea and di-ammonium phosphate (DAP) respectively (Sheremenko and Magnan, 2015). In Uganda, 2% of male plot managers compared to 0.4% of female plot managers applied fertilizer (Ali et al., 2016). Another study in Uganda found that male heads were between 49% and 70% more likely to adopt inorganic fertilizer than female heads (Diirro et al., 2015). A 2017 endline survey in a longitudinal study found that 63% of male maize farmers in Malawi used chemical fertilizer compared with 54% of female farmers (Djurfeldt et al., 2019). On the other hand, based on descriptive statistics, studies in Kenya and Ethiopia found no significant differences in the percentage of plots managed by individual men and women and jointly managed where fertilizer was used (Aguilara et al., 2015; Ndiritu et al., 2014).

A decade after the World Bank identified a gender gap in fertilizer use (World Bank, 2009), no systematic national or global data sets comparing fertilizer use by gender exist. As a result, much of the literature that explores the gender dimensions of fertilizer use derives from country-specific case studies, particularly from major maize-producing countries in eastern and southern

Africa, notably Malawi, Kenya and Tanzania (Djurfeldt et al., 2019; Gine et al., 2015; Kilic et al., 2015; Ndiritu, et al., 2014; Mapila et al., 2012; Chirwa et al., 2011; Alene et al., 2008), with a smaller number of studies on Ethiopia, Uganda and South Africa (Aguilara et al., 2015; Ali et al., 2016; Essa and Nieuwoudt, 2001). Researchers have also examined gender differences in fertilizer use in West Africa (Tankari, 2018; Thériault, et al., 2017; Beaman et al., 2013).

One of the few studies based on nationally representative data covering 22,565 households from the Living Standard Measurement Study Integrated Surveys on Agriculture Initiative (LSMS-ISA) for six SSA countries (Niger, Nigeria, Ethiopia, Malawi, Tanzania, Uganda) found that in all the countries, male-headed households were significantly more likely than female-headed households to use chemical fertilizer and other modern inputs (Sheahan and Barrett, 2014). Exceptionally, Machina and colleagues observed higher female than male use of chemical fertilizer among participants in an input support program in Zambia (Machina et al., 2019), in contrast with an earlier study showing that gender of the household head was the most significant factor influencing fertilizer use among Zambian farmers, with male-headed households more likely than female-headed households to use fertilizer (Mapila et al., 2012).

Like the literature on gender and agricultural productivity, discussions about gender and fertilizer use grapple with conceptual issues regarding the unit of analysis and which farmers are being compared. While most, especially older studies, compare male- and female- headed households, some studies provide a more detailed categorization of female farmers by collecting data on fertilizer use by women farmers in male-headed households, and distinguishing between households headed by single women and households headed by married women with an absentee

husband (Machina et al, 2019; Aguilara et al., 2015; Ali et al., 2016; Chirwa et al., 2011; Uttaro, 2002; Ohlsson et al., 1998).

Determinants of fertilizer demand and use by farmers in SSA fall into four types of groups: economics (price, access to credit/cash); knowledge and information; access; and perception. Socio-cultural factors constitute a fifth set of characteristics rarely discussed in the literature. Aside from gender, studies also control for household- or plot-manager characteristics such as age, literacy/education level, off-farm employment, labor availability, membership of producer organizations, as well as farm characteristics such as land size. These factors have an important gender dimension which influences men and women farmers' willingness and ability to purchase fertilizer and use it. We discuss below the gender dimensions related to economics, knowledge, access, perception, and socio-cultural factors that influence fertilizer access and use in SSA.

**Economic factors:** The high cost of fertilizer in SSA (on average USD 800-1200/MT at the farm gate) (Jain &Jha, 2015; Jayne et al., 2013) and lack of cash or credit to purchase agricultural inputs are important constraints to fertilizer use by smallholder farmers. Because women have fewer income-generating opportunities than men, less time to engage in such activities, and generally earn less than men from off-farm employment, they often have less money for purchasing fertilizer and other agricultural inputs. The importance of financial constraints to fertilizer adoption was highlighted in an experiment that resulted in Malian women increasing the amount of fertilizer and complementary inputs used on their rice plots when provided with fertilizer grants (Beaman et al., 2013). The higher use of fertilizer by *de facto* female household

heads in western Kenya compared with single female heads of households may be due to the former group's access to cash from their husbands (Ohlsson et al., 1998). Women may also face gender-related barriers to accessing credit as they are less likely than men to belong to membership-based organizations, particularly formal ones such as producer organizations that facilitate access to credit, fertilizer and other inputs and services (Kaaria et al., 2016; Tanwir and Safdar, 2013). Furthermore, in some societies, access to credit is influenced by a woman's marital status, with married women having less access to credit than female heads of household (Fisher and Carr, 2015).

**Knowledge and information:** Evidence showing how women's more limited access to advisory services contributes to their lower use of fertilizer is supported by an extensive literature on gender differences in access to extension services (Ragasa et al., 2013; Meinzen-Dick et al., 2011; see Petrics et al. 2015 for a review). Contact with and frequency of extension contact, which enhances knowledge, information and training on fertilizer and market linkages, is positively associated with fertilizer use through its effect on the increased productivity of available inputs, and indirectly through increased use of fertilizer and other resources (Alene et al., 2008). In Malawi, participation in training and study tours significantly increased fertilizer use by a factor of 3.3 (Mapila et al., 2012). Data from Ethiopia and Malawi showing the contribution of gender differences in returns to fertilizer use to the gap in agricultural productivity suggest that women farmers in these countries may be applying fertilizer incorrectly or at the wrong time and/or be using inferior quality fertilizer (O'Sullivan et al., 2014). A Ugandan study attributed lower maize productivity and fertilizer use by female heads of household to more limited contact with extension and less market integration (Larson et al.,



2015). Limited access to extension services was also a factor explaining lower adoption of fertilizer by female-headed households in Kwa Zulu Natal, South Africa (Essa and Nieuwoudt, 2001). Evidence suggests that unless specific efforts are made to involve women, they are less likely than men to participate in events that promote and provide training on fertilizer (e.g. agricultural shows, field days, demonstrations) due to time and mobility constraints and restrictions, childcare responsibilities and limited access to transportation (Manfre et al., 2013).

**Access:** Fertilizer supply channels include extension services, commercial suppliers e.g. agro-dealers, producer organizations and farmer groups. Constraints related to accessing fertilizer include late delivery, poor quality of fertilizer, difficulty in reaching the distribution/sale point due to long distance, poor roads, lack of transportation, packaging quantities etc. Empirical evidence shows that women face greater constraints than men in accessing fertilizer. Due to their heavy agricultural and domestic workloads, in addition to cultural restrictions on their mobility in some societies, women farmers are often less able than men to travel to purchase fertilizer and other agricultural inputs from commercial sources and may lack funds for transportation (Njuguna et al., 2016; David, 2015; CIMMYT, 2014). As noted earlier, women are less likely than men to belong to producer organizations that facilitate access to credit and fertilizer, but may be more likely to join farmer groups, which may also distribute credit and inputs. Women farmers also have gender-related needs that tend to be overlooked by fertilizer suppliers. Female farmers, who typically manage smaller plots and have less cash than male farmers, may find it more economical to purchase fertilizer packaged in smaller quantities (Okello et al., 2012). Lower female literacy rates may make it difficult for women to get information about fertilizers

and to read instructions on fertilizer packages, particularly if they are written in the official language.

**Perception:** As with other agricultural technologies, farmers' willingness to purchase and use fertilizer is determined by their perception of fertilizer, their evaluation of the potential gains from using it, and access to information and training on fertilizers. Attitudes and perceptions partly explain the correlation found in some studies between educational level and fertilizer use (Marenya et al., 2015), with gender differences being important in some cases. More than 30% of surveyed farmers in Mozambique, Malawi and Tanzania, 55% of whom were women, believed that fertilizer was bad for the soil (Mapila et al., 2012). The researchers attribute the higher proportion of women holding this misconception to their lower levels of education and limited exposure to training on fertilizer.

**Socio-cultural factors:** Socio-cultural factors may influence fertilizer use by men and women. Some studies show that, where households cultivate a mix of individual- and household-managed plots, fertilizer application rates may vary by plot due to intrahousehold and gender dynamics. In situations in which agricultural decisions are jointly made by spouses, and cash and credit are scarce, women may depend on their husbands to access fertilizer. A study in the DRC that found higher adoption of fertilizer when both spouses participated in a fertilizer extension program, compared with adoption rates for women who participated alone, suggests that in some contexts, gender and intrahousehold dynamics should be taken into consideration when targeting farmers for increasing the use of fertilizer (Lambrecht et al., 2016). Recommendations from this study include the need for fertilizer programs to identify which household members are involved in decision making about fertilizer use, even where women are the principal plot managers, and the need to target all relevant household members (see O Campos et al., 2016 for a discussion of

how the choice of gender variable matters in the analysis of agricultural productivity). In some societies, land inheritance customs affect fertilizer use. A Zambian study found that in villages where widows were prohibited from inheriting land, couples applied 13-18% less fertilizer, and were less likely to leave land fallow and to use intensive tillage techniques (Dillon and Voena, 2017). Researchers concluded that the possibility of land expropriation upon widowhood discourages households from investing in fertilizer and other land- and soil-improvement techniques even when husbands are alive.

### **Part 3: Gender and hybrid maize seed use in SSA**

Studies on the adoption of hybrid maize varieties show unclear gender-related trends, possibly because most studies use the sex of the household head or farmer to represent gender. For instance, Ricker-Gilbert and Jones (2015) and Bezu et al. (2014) found no significant difference in the adoption of maize varieties between male- and female-headed households. Other studies have found male-headed households to be more likely to adopt improved maize varieties than female-headed households (Wambugu, et al., 2018; Lunduka et al., 2017; Wang et al., 2017; Kassa et al., 2013). Fisher and Kandiwa (2014) found that female-headed households were 11 percent less likely to grow modern maize varieties than male-headed households. Determinants of farmers' adoption of hybrid maize seed in SSA can be grouped into three groups: economic (price, access to credit/cash); knowledge and information; and access.

***Economic factors:*** Women's more limited access to cash and credit may mean that they cannot afford to purchase hybrid maize seed every season. The significant gender gap in the adoption of drought-tolerant (DT) maize in male-headed households in Uganda was largely due to married women's more limited access to credit for buying fertilizer and seed (Fisher and Carr, 2015). A

study of Kenyan agro-dealers found that limited availability of cash is the probable reason why women farmers tend to purchase seed of the least expensive varieties from agro-dealers (Okello et al., 2012).

**Knowledge and information:** A large body of global evidence shows that approaches and methods used by extension/agricultural advisory services (both public and private sector) and other actors in disseminating seed and promoting new varieties are typically biased toward male farmers (Petrics et al., 2015; Manfre et al., 2013). Kassa et al. (2013) found that access to extension and total livestock units had a positive effect on adoption of improved maize for both male- and female-headed households. Researchers in Uganda found that female household heads were less likely than male household heads to be aware of DT maize varieties, and those in the youngest and poorest categories were the least likely to adopt this technology (Fisher and Carr, 2015).

**Access:** It is widely recognized that seed availability can encourage varietal adoption, while limited seed availability and access can stop or even reverse the adoption process. Evidence suggests that women face not only the challenge of finding cash to pay for hybrid maize seed, but also gender-related mobility constraints related to travelling to purchase seed. Results from a CIMMYT-led pilot study in 10 seed markets across eastern Kenya show that men and women engage with markets for improved maize seed differently. Men were twice as likely as women to buy maize seed from agro-dealers in major centers; women were more likely to purchase maize seed from agro-dealers located in rural areas (CIMMYT, 2014). Another study in Kenya found that women farmers in female-headed households (*de jure* and *de facto*) obtained seed of different crops (maize, sorghum, millet, various legumes) from 4-7 sources compared with on average 16 seed sources accessed by male-headed and male-managed households, and travelled

an average of 4.9 km to obtain seed compared with 13 km for male-headed households (Njuguna et al., 2016).

#### **Part 4: Approaches to improve women farmers' access to fertilizer and hybrid maize seed**

Improving women's access to and use of inorganic fertilizer and hybrid maize seed requires a two-pronged strategy: (i) addressing gender barriers related to women's education, land rights, market access, participation in producer organizations, access to labor-saving tools and equipment, child care facilities etc.; and (ii) using approaches that focus on improving access to and use of fertilizer access and hybrid maize seed. While both strategies are necessary to address gender gaps in fertilizer and hybrid maize use, it is beyond the scope of this paper to assess what impact efforts to address gender barriers have had on women's use of fertilizer and hybrid maize seed. The following discussion examines two approaches that aim to address gender inequalities in access to fertilizer and hybrid maize seed: farmer input support programs and strengthening the capacity of agro-dealers.

**Input subsidy programs:** The high cost of fertilizer and smallholders' lack of cash or credit to purchase agricultural inputs are the rationale for the farmer input support programs (FISP) that have been carried out in several SSA countries since the 1970s. Some input subsidy programs specifically target female-headed households (in Malawi and Zambia) in an effort to boost food security among the poorest farmers, while some programs require recipients to co-pay some of the costs of the technology package.

There is mixed evidence on the impact of input support programs on women's access to and use of fertilizer and on outcomes of agricultural productivity and income (see Jayne et al., 2018 for a review). Assessing the gendered impacts of FISP on fertilizer is further complicated by exogenous factors that affect voucher and fertilizer use, such as lack of knowledge about how to use fertilizer (Carter et al., 2013), and the practice of selling vouchers (Gine et al., 2015). Researchers in Tanzania found that fertilizer use increased significantly among FHHs in some villages where vouchers were distributed, but not among male farmers, presumably because men were more likely to have used fertilizer before the voucher program began (Gine et al., 2015). However, many female heads did not participate in the program because they could not afford the top-up to cover the remaining 50% of the fertilizer cost. Studies in Malawi found that while FHHs were just as likely to receive a fertilizer voucher as MHHs, the average number of fertilizer vouchers received and redeemed was statistically lower for female-headed households than for male-headed households (Kilic et al., 2015; Karamba and Winters, 2015). By contrast, a study in Zambia reported that a higher proportion of female than male plot-managers accessed fertilizer from the farmer input support program and commercial sources, and that higher quantities of basal and top-dressing fertilizers were applied by female managers (Machina et al., 2019). Access to FISP, however, did not proportionately raise crop productivity for female-managed plots, implying that female farmers faced other non-input constraints to increased productivity. Based on similar findings in Malawi, Karamba and Winters (2015) warn that if persistent gender-related inefficiencies in agriculture are not addressed, input programs "could exacerbate the gender gap and make female farmers worse off as compared to their male counterparts" (p. 370).

A study in Malawi suggests that subsidized fertilizer programs that target food security may increase fertilizer use on women-controlled plots and encourage greater female involvement in decisions about the allocation of fertilizer. Chirwa and Dorward (2013) found that while plots controlled by women in both FHHs and MHHs were less likely to use fertilizer compared with male-controlled plots, fertilizer use was to some extent determined by where households obtained fertilizer – from the subsidized program alone, from commercial sources alone, or from both sources. In purely subsidized households, the application of fertilizer did not differ by gender of the plot manager, which implies that the allocation of subsidized fertilizers in such households was efficient. The researchers attribute this finding to the involvement of both spouses in making decisions about the use of subsidized fertilizer, which could be a response to the program’s focus on subsistence maize production, a responsibility that lies in women’s domain. The availability of commercial fertilizer also increased the likelihood of fertilizer use on plots controlled by women. An important conclusion from studies on the gendered impacts of fertilizer subsidy programs is that while such programs can improve women’s access to fertilizer and have a positive effect on agricultural productivity for both men and women farmers, they have little effect on reducing the gender gap in agricultural productivity.

**Strengthening the capacity of agro-dealers:** Several organizations, including the Alliance for a Green Revolution in Africa (AGRA), the International Fertilizer Development Center (IFDC) and CIMMYT support the professionalization and development of African agro-dealers as part of an indirect approach to increasing the supply and subsequent use of fertilizer. The African Fertilizer and Agribusiness Partnership (AFAP) established in 2012 by AGRA and IFDC works to provide development support for the fertilizer market and build the capacity of agro-dealers in

thirteen SSA countries ([www.afap-partnership.org](http://www.afap-partnership.org)). While AFAP does not specifically address gender-related constraints in accessing fertilizer, its approaches have been instrumental in reducing the price of fertilizer and improving farmer access – key constraints faced by women farmers. Hallmarks of the AFAP program include “the hub and spoke system” that links larger agro-dealers with more remote providers, constructs larger storage facilities, and provides supporting credit and grants for agro-dealers (AGRA, 2016).

CIMMYT has invested in building the capacity of agro-dealers to be responsive to gender differences in fertilizer demand, through a training program that encourages agro-dealers to recognize men and women farmers as customers that may have different needs, and to address women’s specific needs. A manual developed specifically for agro-dealers provides suggestions on how to take gender into consideration in promoting an agro-dealer business by, for example, reducing fertilizer packaging size, using local language and pictures on fertilizer packages, providing information verbally on how to apply fertilizers, finding ways to make fertilizer more affordable for women, involving more women in demonstrations and field days by setting gender targets, and providing childcare (Adam et al., 2019 (a)). To date, the impact of efforts to strengthen the capacity of fertilizer suppliers more broadly and to improve their responsiveness to gender gaps in access to fertilizer have not been assessed.

## **Part 5: Recommendations for the gender-intentional promotion of NUE maize technology**

**Breeding programs:** One common past shortcoming in most breeding systems is the lack or less consistent involvement of women farmers in the identification of important traits. This can lead to rejection by women farmers when the improved seeds lack traits that women value. Thus, it is important for breeders working on NUE maize seed to be gender-responsive in their work, ensuring that women are involved in their operations throughout the whole process from seed



production through to consumption, i.e., before planting (when making breeding lines), before harvest, and during the post-harvest evaluation (cooking and processing) (Adam et al., 2019 (b)).

**Extension providers:** There is a need for policies to prioritize tailoring extension services to women's needs and to use social networks to spread agricultural knowledge. Agricultural training and advice should be brought to women's doorsteps through farmer field schools that are gender-responsive (Adam et al., 2019 (c)) and mobile phone applications, and female volunteer farm advisors identified who can spread information within women's social network.

**Seed companies and agro-dealers:** Gender training should be provided to seed companies and agro-dealers on how to be gender-responsive in their approaches to promoting newly introduced seed, e.g. making sure that their promotional budget is gender-sensitive (see Adam et al., 2018); ensuring that a specific promotional approach is tailored to a specific gender group (see Kandiwa et al., 2018 and Adam et al., 2019 (d)); packaging seeds in small quantities (1 kg) that can reasonably be afforded by farmers with meager means, especially women. An innovative marketing approach employed by Victoria Seeds Ltd. to reach men and women smallholder farmers in remote areas and in local markets is the use of a *tuk-tuk* (three-wheeled)-based mobile seed shop.<sup>1</sup> These mobile shops have been used to deliver seed to 42 northern districts in Uganda, specifically targeting villages that are remote and have accessibility issues. The mobile shop method and a further two methods described below have already been documented in Adam et al., (2019 (e)). The second method is the use of female lead farmers as village seed information points and seed retailers by Meru Agro and AMINATA Seeds in Tanzania, and the third is the use of women farmers' groups and associations to disseminate information on seeds

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<sup>1</sup> The Access to Seeds Index 2019 - Eastern and Southern Africa report, ranked Victoria Seeds Ltd sixth out of 22 seed companies and highlighted the seed company's commitment to its inclusivity agenda to support women smallholder farmers.

and marketing. Meru Agro and AMINATA Seeds in Tanzania, and Victoria Seeds in Uganda distribute open-pollinated maize varieties (OPVs) through women farmers' associations or groups; the groups receive trainings on agronomic practices and seed management, and group members can access seed on credit. The approach addresses challenges related to access to cash to purchase improved seed, time and mobility constraints, and cultural restrictions regarding women's social interactions. As group members, women can also access inputs collectively (Okello et al., 2012).

**Role of FISP:** The use of FISP can assist in providing means for women and marginalized farmers to access technology and other farm inputs.

**Social norms and culture:** In order to address deep-rooted socio-cultural norms, there is a need to educate male farmers through gender training about the importance of making sure that their wives are able to voice their opinions, can be co-managers of the household main plots, and can participate in making decisions about the purchase of farm inputs, so that women are not left behind. These trainings can take place in farmer's organizations. The role of village leaders also needs to be noted; they can be involved in campaigns to make sure that women are involved in all matters of decision-making when it comes to the use of NUE maize technology, other farm inputs and the whole maize value chain in general.

#### 4. Conclusion

The literature indicates that female farmers are disproportionately disadvantaged compared to male farmers in terms of access to fertilizer, hybrid maize seed, credit, and prime agricultural land, among other human and social factors, thus female farmers may preferentially benefit from NUE maize technology. However, for the benefit to be fully experienced by women farmers, there is a need to address a double hurdle: the adoption by women of hybrid maize seed and their

adoption of fertilizer must both be increased. For this double challenge to be overcome, all stakeholders – breeders, extension agents, village heads, seed companies, agro-dealers, government and non-governmental organizations – need to create agricultural agendas that are gender responsive.



## Summary of salient literature on gender and inorganic fertilizer use in maize production in Eastern and Southern Africa

Source and year	Country	Unit of observation	Analysis	Key findings
Ahmed et al., 2017	Eastern Ethiopia	Male and female headed households	Adoption rate	Female-headed households are less likely to adopt inorganic fertilizer. Literacy, large farm size, frequency of extension contact, training and membership in FO were positively associated with fertilizer adoption; age was negatively associated with fertilizer use
Aguilar et al., 2015*	Ethiopia, nationally and regionally representative sample	Male and female managed plots in MHH and FHH	Oaxaca-Blinder decomposition to calculate endowment and structural effects on productivity differentials	Male and female manager use similar rates of fertilizer but women see smaller yield improvements from fertilizer use compare to men
Ali et al., 2015*	Uganda	Male and female managed plots in MHH and FHH	Oaxaca-Blinder decomposition to calculate endowment and structural effects on productivity differentials	Women were significantly less likely to use fertilizer and other inputs and applied significantly smaller quantities of fertilizer. 2.1% of male managers applied fertilizer compared to 0.4% of female managed. They also had less contact with extension services.
Chirwa et al., 2013	Malawi, 14 districts	Male and female managed plots in MHH and FHH	Adoption rate	Women controlled plots in both FHH and male headed households are less likely to use fertilizer compared with male controlled plots. The likelihood of applying fertilizer to women controlled plots were higher in HHs that used commercial fertilizer. Subsidized programs appear to reduce the gender bias in fertilizer use because both spouses are involved in making decisions about the use of subsidized fertilizer based on the argument that this program is supposed to boost subsistence maize production (thereby giving women a greater voice in the decision)
Essa and Nieuwoudt, 2001	Two wards in KwaZulu Natal	Male and female headed household	Adoption rate	FHH less likely than male HH to adopt hybrid maize and fertilizer possibly because women have less access to productive resources, credit and extension services
Gine et al., 2015*	Tanzania, Meru District	Male and female household heads growing maize and rice	OLS regression	Fertilizer use increased significantly among FHH in some villages who received vouchers but not among men. FHH that received input vouchers showed increase in yields and outputs sold in most categories of villages sampled. Many FH could not afford the top up (to cover the remaining 50% of input cost) and therefore did not participate in the program.
Larson et al., 2015*	Uganda	Male and female headed households	OLS regression	FHH less likely than MHH to use fertilizer. Limited contact by FHH with extension and less market integration contributes to lower fertilizer use and lower maize productivity
Machina et al, 2019	Zambia, nationally representative sample	Male and female managed plots in MHH and FHH	Adoption rate	A higher proportion of female managers accessed subsidized and commercial fertilizers and used more basal and top dressing fertilizers than male managers. Despite equal access to credit, female managers accessed larger amounts of credit compared to male managers. Male managed plots had a 34kg/ha yield advantage over female-managed plots. Access to FISP does not disproportionately raise crop productivity for female-managed plots, implying that FISP alone is not sufficient to address the gendered

				productivity gaps in agriculture.
Sheremenko and Magnan 2015	Kenya, five districts in Eastern and Western parts of the country	Male and female headed households	Probit and truncated normal models	MHH have higher adoption of fertilizer; FHH are constrained by lack of income and credit
Smale 2011	Kenya, 24 districts nationwide	Male and female headed households	Regression model	MHH have higher use of hybrid maize and fertilizer and higher maize productivity compared with FHH possibly due to having better access to capital.
Utaro, 2002	Malawi, Zomba District	Male and female managed plots in MHH and FHH	Decision tree modelling to understand adoption of hybrid maize and fertilizer	Married women were as likely as men to access and use fertilizer but were more likely to have access to fertilizer than female heads of household by a margin of 62% vs 45%. 55% of FHH did not use any fertilizer on their crops compared to 38% of married females and 33% of male farmers. Price of hybrid maize seed and fertilizer more of a constraint for women than men

\*Study covered other crops in addition to maize







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