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Tools in the making: the co-construction of gender, crops, and crop breeding in African agriculture

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ABSTRACT

Crop breeding for development has a relatively long tradition of including the perspectives of women and men farmers. However, the lack of adoption and development impacts of improved crop varieties, particularly in African countries, has led to a growing interest in novel ways of making crop breeding more responsive to the needs, preferences, and demands of different social groups of women and men in agriculture. However, many questions remain about how best to render crop breeding *gender-responsive*, in terms of both methodological and institutional innovations. In this paper, I investigate how gender-responsive crop breeding is practiced and negotiated, and with what effects, through an ethnographic case study of the Gender + Tools: a set of gender-responsive decision-support tools developed by the CGIAR Gender and Breeding Initiative. Using perspectives from feminist technoscience studies, I explore how the Gender + Tools take on several performative roles through which gender, crops, and crop breeding become co-constructed: as a diagnostic and screening tool, a communication and marketing tool, and a management tool. The paper provides insights that can help support and improve gender-responsive and transformative crop breeding, while also expanding the scope of feminist technoscience studies to the underexplored topic of development-oriented crop breeding in Africa.

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Introduction

In the wake of two World Wars, the first international agricultural research centers (IARCs) were established through concerted efforts by such organizations as the United States Department of Agriculture, the Food and Agriculture Organization of the United Nations, the World Bank, the Rockefeller Foundation, and the Ford Foundation (e.g., Byerlee & Lynam, 2020; McCalla, 2017). This later grew to a total of fifteen IARCs that today constitute the world's largest agricultural research and innovation system, the CGIAR Consortium of International Agricultural Research Centers (previously the

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Consultative Group on International Agricultural Research). In an attempt to modernize agriculture and combat global hunger, most notably in developing countries, the first IARCs, and later the CGIAR, focused their efforts predominantly on increasing agricultural output and food production through agronomic and technical innovations (Kholová et al., 2021).

This became epitomized by the Green Revolution, which saw the introduction of high-yielding and disease-resistant varieties of cereals, together with fertilizers, pesticides, "good" agricultural practices, and policy measures (e.g., Borlaug & Dowswell, 2005; Dubin & Brennan, 2009; Perkins, 1990). The plant varieties were assumed to be scale neutral, thus limited attention was paid to the unique geopolitical, socioeconomic, and cultural conditions under which people farmed (see, e.g., Fischer, 2016). As noted by Kholová et al. (2021), it was further believed that "increased productivity automatically leads to greater profitability and improved well-being of the farmers and farm laborers" (p. 5161). Since then, crop breeding has been characterized by a production paradigm oriented principally toward agronomic traits, notably yield increase and stability, disease resistance, and abiotic tolerance (e.g., Braun et al., 1996; Gauch & Zobel, 1997; Kholová et al., 2021; Wagaw et al., 2021).

However, while the Green Revolution undoubtedly helped increase food production, studies have also demonstrated the negative environmental and social impacts of agricultural modernization (e.g., Chamala, 1990; Fresco, 2015; Kansanga et al., 2019; Kerr, 2012; Kilby, 2019; Patel, 2013; Siobha, 2007). Many women have been among those whose constraints and needs have been afforded less consideration as plant varieties have been designed, developed, and disseminated. Indeed, productivist selection and evaluation criteria may not fully capture the needs and preferences of diverse social groups in agriculture. For instance, due to gender differences in status, rights, and labor, men are traditionally more concerned with productivity and market-related traits, while women express greater preferences for quality characteristics (e.g., Marimo et al., 2020; Teeken et al., 2021; Weltzien et al., 2019). Failing to meaningfully engage with gender is believed to contribute to low levels of adoption and development impacts of improved crop varieties, including in African countries (e.g., Acevedo et al., 2020; Fisher & Carr, 2015; Smale et al., 2018; Thiele et al., 2021).

In the late 1970s and early 1980s, as part of a broader "participation agenda" strongly supported by the international donor community (e.g., Chambers et al., 1989; Farnworth & Jiggins, 2003; Sumberg et al., 2012; Thiele et al., 2001), crop breeding programs started to engage with and consult both men and women farmers through such approaches as participatory varietal selection (e.g., Farnworth & Jiggins, 2003; Sperling et al., 2001). Still, many of these studies have been designed in ways considered inadequate for capturing the full range of gendered preferences and demands (e.g., Voss et al., 2021). For instance, farmers have commonly been invited to evaluate released or soon-to-be-released crop varieties grown under favorable conditions at or close to harvest, which excludes evaluation criteria related to "processing, cooking, post-harvest storage, or performance under less ideal conditions" (Voss et al., 2021, p. 398).

This is part of the reason why crop breeding programs frequently "overlook quality traits considered indispensable for full adoption of a modern variety by women

producers, but considered secondary to performance by breeders" (Polar et al., 2021, p. 6; also see Thiele et al., 2021). This oversight is further exacerbated by fragmented studies and other methodological constraints of gender-responsive breeding (e.g., Ashby & Polar, 2019; Polar et al., 2021; Voss et al., 2021; Weltzien et al., 2019). For instance, Polar et al. (2021) note how "[s]tudies of gender differences in trait preferences are limited by reliance on simple comparisons of men and women, with no consideration of intersectional characteristics, and by widely different methodologies, which hampers generalization" (p. 6). Moreover, partly due to institutional and interdisciplinary power dynamics within agricultural research organizations (e.g., Cernea & Kassam, 2006; Resurrección & Elmhirst, 2020), there has been limited space for social scientists, including gender specialists, to influence priority-setting and varietal design, as their input has been considered most relevant later in or in the aftermath of the crop breeding process, such as during adoption studies and impact assessments (e.g., Ashby et al., 2013; Jiggins, 1986).

Thus, many questions remain about how best to render crop breeding *gender-responsive*, in terms of both methodological and institutional innovations, to ensure that "the perceptions, interests, needs and priorities of women and men (which differ because of their different roles and responsibilities in farming) will be considered in planning and decision-making" (Ashby & Polar, 2021a, p. 2). In this article, I aim to explore how novel approaches to gender-responsive crop breeding are practiced and negotiated in ways that co-construct gender, crops, and crop breeding. I do so through an ethnographic case study of the Gender + Tools (G + Tools), which is a set of gender-responsive decision-support tools developed by the CGIAR Gender and Breeding Initiative (GBI). The Tools help organize existing sex-disaggregated data to support gender-responsive priority-setting and decision-making, most notably during varietal design. In 2020, I participated as the G + Tools were piloted in several African-based breeding programs of the CGIAR. The findings were analyzed using a theoretical framework drawing on feminist technoscience studies, which foregrounds the mutually shaped relationship between gender and knowledge production and technological innovation, taking both human and non-human actors, and discursive and material factors, into account.

The paper starts by presenting the theoretical framework and the methods and materials, followed by the origin story and description of the GBI and the G + Tools. In the discussion, I identify several performative roles of the G + Tools through which gender, crops, and crop breeding become co-constructed: as a diagnostic and screening tool, a communication and marketing tool, and a management tool. The paper provides insights that can help support and improve gender-responsive and transformative crop breeding, while also expanding the scope of feminist technoscience studies to the underexplored topic of development-oriented crop breeding in Africa. The paper is particularly timely given the renewed attention and commitments to gender equality and women's empowerment in agricultural research for development over the last decade, including within crop breeding.

Theoretical framework

Over the last few decades, feminist scholars of technoscience have demonstrated the mutually shaped, contingent, and dynamic relationship that exists between technoscience

and gender (e.g., Berg & Lie, 1995; Cockburn & Ormrod, 1993; Gill & Grint, 1995; Horowitz & Mohun, 1998; Kirkham, 1996; Oudshoorn et al., 2004; Rommes et al., 1999; Wajcman, 2004). Among others, they have developed the concept of *gender scripts* to describe how scientists, technologists, and engineers—often based on their own social embodiment and embeddedness—incorporate gender ideologies and values into the material and symbolic design of technical artifacts (e.g., Akrich, 1992; Friz & Gehl, 2016; Rommes, 2002; Van Oost, 2003). In turn, such scripts may shape the agency of the users by delegating particular gendered statuses, motives, interests, competencies, roles, and responsibilities. For instance, consider a hypothetical example where a senior male breeder trained in productivist paradigms, in anticipating what farmers need (who for a long time were assumed to be men), selects a genetically encoded agronomic trait that confers higher yield and marketability at the cost of taste, texture, and early maturity. He may further choose to test the experimental variety in favorable conditions under which men more so than women farm (e.g., good soil quality). While not the intention of the breeder, once this variety is disseminated, it may come to strengthen men's position in farming and the marketplace, while condemning women to a comparative disadvantage, thus shaping the roles and responsibilities of, and relations between, men and women.

Just as important, however, has been the emphasis on how different types of users themselves shape technologies. Here, *interpretative flexibility* and *de-scription* may come into play, which refers to the different ways in which users may interpret, appropriate, modify, or even reject scripts to create new meanings and uses of technology (Akrich, 1992; Pinch & Bijker, 1984). One might imagine a scenario where, for example, women farmers use the crop variety described above for purposes other than those intended by the crop breeder, such as for livestock feed. Interpretative flexibility and de-scription may be highly gendered, as gender performances are negotiated in relation to technical and material artifacts, as well as social actors and institutional configurations of power.

In my analysis, I employ the concept of gender scripts to conceive of how men and women in agriculture become constructed in gendered ways through the G + Tools. As such, the G + Tools do not simply describe gender identities and relations but are indeed performative in that they take an active part in the construction of gender (also see Mukhopadhyay & Prügl, 2019). As such, I use post-human performativity, which moves beyond a largely discursive understanding of (gender) performance (Butler, 1990, 1993), to consider performance as constituting "material and discursive, social and scientific, human and non-human, and natural and cultural factors" (Barad, 2003, p. 808). Additionally, I use interpretative flexibility and de-scription to better understand how users of the G + Tools may interpret and appropriate the G + Tools differently.

Methods and materials

The paper is based on ethnographic fieldwork conducted in Nairobi, Kenya, from August 2019 until March 2020, as well as data collected digitally until the beginning of 2021. Nairobi was selected as the field site as the city hosts several CGIAR offices and research stations.[1] My access was secured through an agreement with Kenyatta University. Before my arrival, I had little knowledge of the GBI, and it was not until a

few weeks into my stay that I was made aware of the G + Tools and their piloting by a key informant, who put me in touch with the project organizers. I was welcomed to participate in the piloting project, and I was further asked to carry out some consultative tasks on behalf of the organizers (mainly writing workshop reports). Additionally, I conducted open-ended and semi-structured interviews with several of the piloting participants, as well as with natural and social scientists from the broader gender and breeding community, along with donors, governmental policy and decision-makers, and non-governmental organizations. A total of 48 interviews conducted with 42 informants were carried out. I also interacted with the G + Tools themselves and reviewed other documents and resources produced and used by the relevant actors. Electronically transcribed interviews and observational notes were analyzed using qualitative content and thematic analysis. The research was approved by the relevant ethical committees, paying particular attention to privacy protection and how to maintain analytical integrity while filling a practical and paid function.

The origin story of the GBI and Gender + Tools

In the period between 2013 and 2015, Jacqueline Ashby—then the senior advisor for gender research and coordinator of the CGIAR Gender and Agriculture Research Network at the CGIAR System Management Office—observed that progress in the integration of gender into annual workplans of crop breeding research was proving exceptionally slow compared to other research areas. Her discussions with gender researchers concluded that poor integration of gender research into breeding, a pivotal and strategic domain of CGIAR research, would be a serious handicap to the overall credibility and efficacy of gender research in the CGIAR. As a result, the Gender and Agriculture Research Network prioritized gender and breeding as a cross-system initiative. In 2015, the Network began organizing a dialogue between breeders and gender researchers and established a Coordinating Committee to plan two international workshops on Gender, Genomics, and Breeding to be hosted in 2016 and 2017, which would further give rise to the GBI.

The first workshop identified that a critical stage in which gender dimensions could be integrated was when crop breeders were setting objectives, prioritizing traits, and selecting parental lines (Ashby et al., 2018; Ashby & Polar, 2019; also see Tufan et al., 2018).[2] Breeders often develop crop varieties based on an *ideotype*, which describes the ideal plant variety and its traits (Donald, 1968), while the *breeder's index* lists, weighs, and ranks all the traits of interest based on a set of selection criteria (e.g., the level of genetic advancement over time and economic weight). As indicated in the introduction to this paper, yield is typically the highest-ranking trait.

Most I spoke to argued or agreed that (senior) breeders have most of the decision-making power in developing the ideotypes and in determining which traits make it onto the breeder's index and their comparative ranking and that most do so in an informal manner. Comparably less attention has been devoted to how the design of the ideotype and trait prioritization involves a choice about who to prioritize—producers or processors, marketers or consumers, men or women, young or old, landowners or tenants, rural or urban, poor or middle-income.

Consequently, if the priority-setting and decision-making process became more responsive to different user needs and demands, and one could find ways of systematically incorporating social and gender targeting even at the very earliest stages of varietal design, this could help move gender beyond just being an add-on considered during late-stage variety evaluation, adoption studies, or impact assessments. This thinking aligned with a growing trend in public crop breeding, namely *demand-led* or *market-led* crop breeding, where market intelligence helps inform varietal design, development, and dissemination (Persley & Anthony, 2017). The approach originates in the private sector and entails a formalized breeding process that consists of several stage gates. This framework provided a background against which the GBI would come to conceptualize the possible entry points for social sciences and gender research in crop breeding (see, e.g., Orr et al., 2018; Ragot et al., 2018).

In the CGIAR, market-led crop breeding is spearheaded by Module 1 of the Excellence in Breeding Platform (EiB); a platform established in 2017 to oversee a "modernization" process meant to help accelerate "new variety development and enabling the more widespread adoption and use of new varieties (…), enabling small-scale farmers to move from subsistence production to farming as a profitable business" (CGIAR System Council, 2018, p. 2). This is to be achieved through, among others, new breeding technologies and more market-driven varietal design that takes into consideration the needs and demands of men and women across the entire agricultural value chain, meaning "all the processes involved in the production, processing, and marketing of a product from its inception to its final use" (Pyburn & Kruijssen, 2021, p. 32). One of the central concepts of EiB's approach is the *product profile* (Mashonganyika, 2018), which can be considered a more elaborate and market-informed version of the ideotype. Thus, the EiB became a relevant partnering organization to the GBI considering its role as the coordinating platform for innovation in breeding, particularly in fostering the use of tools for market-led crop breeding across the CGIAR.

While Ashby pinpointed the need for and marshaled resources to support proactive dialogue among breeders and gender researchers, it was the sustained commitment of a larger ensemble of people, post-docs, organizations, funding, conceptual understandings, and crops that enabled the GBI to gather momentum. In 2017, the initiative was formally handed over to the Research Program on Roots, Tubers, and Bananas (RTB) and the International Potato Center (CIP), whose leadership was critical given RTB-CIP's own investment in and experience with gender-responsive breeding. Among others, CIP had been an early pioneer of participatory research (Thiele et al., 2001), while "RTB has paid explicit attention to gender in its program" (Thiele et al., 2022, p. 12).

A question remained, however: we now know when and where in the breeding cycle social considerations, including gender, can usefully be integrated, but how? This gave rise to a discussion on the need for a set of tools that could help inform decision-making in crop breeding. Over the course of a few years, this culminated in the creation of the Gender+ (G+) Toolbox, which is meant to inform decision-making in breeding in ways that systematically take gender and other social differences into account.

The Gender + Toolbox

The G + Toolbox is a digital toolbox that consists of the G + Customer Profile Tool, the G + Product Profile Query Tool, the Standard Operating Procedure (SOP), and the G + Report. A social scientist with gender training is meant to take a leading role in applying the Toolbox, albeit in a co-managed relationship with a breeder, whereas major product advancement decisions are to be made in the larger crop breeding team. The SOP explains in a stepwise manner how to use the G + Tools and identifies key questions, topics for discussion, and decision points, along with suggestions for gender analysis and other action points (Ashby & Polar, 2021b). The G + Report describes the outcomes of using the G + Tools, including a record of key decisions informed by gender analysis (Polar & Ashby, 2021).

Inspired by consumer marketing, the G + Customer Profile Tool assists breeding teams in segmenting, targeting, and profiling the market or customer segments in which the crop breeding program operates, thus providing an improved understanding of who the "customers" are, taking gender into account (Orr et al., 2021).[3] The G + Product Profile Query Tool, in turn, helps evaluate the gender impact of traits listed in the product profile, as well as potentially identify additional traits that should be included from a gender perspective (Ashby & Polar, 2021a). Polar et al. (2022) note how "[s]coring is similar to the nominal index that breeders often use to assign a value for disease tolerance to a variety" (p. 488). Scores are generated using a "Do No Harm" and "Positive Benefits" scoring matrix, where each trait is evaluated according to its impact on (i) the use of unpaid farm labor, (ii) on-farm or off-farm employment or other forms of income generation, (iii) input use, and (iv) control over produce, by-products, sales, income, or other direct benefits from the crop variety in question (Ashby & Polar, 2021a). Additionally, the trait is scored according to whether women and men perceive it negatively or positively, which further helps reveal whether there is a conflict of opinion. If there is insufficient data available to generate a score, a warning signal is used. Breeding teams are then advised to proceed product advancement with caution.

At the very least, the breeding program should avoid potentially harmful traits, while the decision to proactively target one or more traits that may benefit men and women will be a program management decision. By doing so, the GBI argues that crop breeding could potentially become gender transformative, particularly if a so-called "game changing" trait is included (Ashby & Polar, 2019). As explained by Ashby and Polar (2019): "'Game-changing' traits, such as 'earliness,' can be transformative by altering the design of a proposed variety in order to overcome a critical obstacle identified by the gender screening that specifically disadvantages women producers (such as late planting due to chronic delays in land preparation) or to optimize a desired benefit of especial benefit to women producers (such as shortening the 'hungry season')" (p. 20).

Piloting the Gender + Tools

In 2020, prototypes of the G + Tools were piloted in a project organized and co-funded by the GBI and EiB. Two CGIAR breeding programs were initially selected to

participate in the piloting: beans in Zimbabwe and cassava in Nigeria. Additionally, two CGIAR breeding programs joined on their own initiative: the sweet potato program in Uganda joined at beginning of the piloting, while the cereals and lentils program in the Central and West Asia and North Africa region joined a few weeks into the project. The breeding programs were selected for piloting based on the availability of relevant sex-disaggregated data (e.g., data on trait preferences), as well as the presence of an interdisciplinary team consisting of a gender specialist, crop breeder, and an agricultural economist (Polar et al., 2022). The piloting was meant to last from March until October of 2020, starting with the "Knowledge-Sharing and Planning Workshop" and rounding off with the "Evaluation and Learning Workshop", both to be arranged in Nairobi. In between workshops, each team would pilot the Toolbox at their respective research organization.

Just as the world started to realize the severity of what would become a global pandemic, the GBI and the EiB managed to organize the "Knowledge-Sharing and Planning Workshop". The workshop brought together just under 20 social and natural scientists from across the African continent and beyond, most of whom represented the beans, cassava, and sweet potato piloting teams. The four intense days of workshopping consisted of a mixture of presentations given by the GBI, the EiB, and the participants, along with some initial attempts at applying the Toolbox. Additionally, an icebreaker activity had the participants pick their favorite crop varieties and explain why their mum would love it, to which most of the responses reflected women's role in household food and nutrition security and food preparation. While this exercise highlighted the importance of quality traits for the acceptance and adoption of crop varieties (e.g., texture, color, taste, aroma, and cooking properties), it also reproduced the traditional image and narrative of women as "mothers" and "food-makers" and further envisioned "her" interests, knowledge, and competencies as associated with such roles and responsibilities.

Following the workshop, the cassava, beans, and sweet potato teams returned to their respective breeding organizations to pilot the G + Toolbox and to make recommendations for ways to revise and improve the Tools, as well as suggestions on how to adapt the G + Tools to the EiB product profile development framework. Having to adapt the Tools to the EiB framework did, however, leave some of the piloting participants feeling that they were having to retrofit the Tools in a way where gender became, as before, an add-on. Others said that the piloting became more about adjusting the EiB framework than refining the actual G + Tools, but this was nevertheless considered an important outcome of the piloting project.

As the Tools rely on existing data, their use was relatively unaffected by the COVID-19 pandemic. However, as working conditions changed for all participants, the piloting project experienced delays. As a result, the piloting project got an extension until the end of the year and the "Evaluation and Learning Workshop" was turned into a series of online meetings, workshops, and other types of digital interactions extending from September to December 2020.

Discussion

Next, using the concept of gender scripts, I explore how the G + Tools take on several interrelated, performative roles through which gender, crops, and crop breeding become co-constructed: as a diagnostic and screening tool, a communication and marketing tool, and a management tool. Indeed, while most of the piloting participants used the Tools more or less according to the SOP, many expressed their own set of ideas of what the Tools actually are, what they do, and what aspects were most useful about them. In other words, they exercised interpretative flexibility and description. What also surfaces through this analysis are instances where potential users of the Tools may come to reject the G + Tools.

Diagnostic and screening tool

In rendering crop breeding gender-responsive, there is a need to "diagnose" and make visible the diverse knowledge, skills, challenges, desires, needs, and preferences of various groups of women and men in relation to their crops, and to screen crop traits according to their differential social impacts. One of the most important outcomes of using the Tools was highlighting the pivotal roles that women play along the entire agricultural value chain, not only as producers, but as consumers, processors, traders, and marketers. In other words, women—in all their complexity—are essential "customers" of crop breeding programs, and consequently, their knowledge, constraints, demands, and preferences are central in informing the crop breeding process. However, a major obstacle faced by the piloting teams in correctly diagnosing the needs and preferences of men and women and in screening the gender impacts of traits, was the lack of up-to-date, good quality, and representative data, thus reflecting the broader methodological challenges mentioned at the beginning of this paper. In commenting on the G + Tools, a crop breeder noted:

> How in the world are we supposed to answer these questions? A lot of the public sector breeding programs for these food security crops do not know the answer to these questions. Especially with [the] customer profiling tool. You know, "what % of the market is occupying this". That information is unknown. Period.

While the Tools stress the importance of making decisions based on sound evidence, crop breeding teams may feel a need to resort to unrepresentative data to fill information gaps. The piloting teams would in some cases, admittedly so, compensate by making inferences and educated guesses from studies conducted elsewhere or at other times. Relying on unrepresentative data can have the unintended effect of constructing and scripting men and women users, including their relationships with crops, according to binary and heteronormative gender stereotypes that do not reflect, among others, gender in its intersection with other social factors (e.g., Crossland et al., 2021; Teeken et al., 2021). For instance, echoing the "why my mum would love it" exercise, women were often described as mostly concerned with household food and nutrition security, and as preferring traits associated with such activities as cooking (also see Mukhopadhyay & Prügl, 2019). Men, in turn, were commonly described as mostly motivated by commercial and economic interests, and thus preferring traits related to productivity and marketability.

While such gendered representations may in many instances hold "true", unless based on sound empirical evidence and holistic methodological research approaches, they may stand in danger of reproducing snapshot-nature understandings and biases, stylized "facts" about men and women in agriculture, and gender stereotypes and myth (e.g., Almekinders et al., 2019; Doss et al., 2018; Goebel, 2003; Leach, 2007). Further down the line, once a variety has been developed with input from the G + Tools, such socially constructed users and gender stereotypes may become materialized in the crop itself, which in turn may shape the agency, behavior, and relations of men and women in agriculture, as per the concept of gender scripts.

Communication and marketing tool

The Tools were also perceived as a communication device, as they supported gender specialists in presenting gender data and input in ways that were tangible to more quantitatively-inclined researchers. More specifically, through standardization and the use of ordinal values, as well as marketing concepts, the Tools translate complex gender issues and dimensions in ways that adhere to the practices, language, and values of crop breeders as well as agricultural economists. The Tools and their outcome were also considered important in building and making investment cases to attract funding from donors that have an interest in gender equality and women's empowerment. A few interviewees even referred to gender more as a "selling point" for the larger project of social inclusion in crop breeding, where other intersecting social factors were often considered just as, if not more, important than gender (e.g., age, regionality, poverty level, and educational level). As expressed by a social scientist:

> I think our entry point is gender because … Everybody has to do it, right? So, if we made it the Social Inclusion Product Profile Query Tool, maybe that wouldn't get the same buy-in or same level of interest from the donors as the gender one.

This raises a broader question about the extent to which the G + Tools, and gender-responsive crop breeding more generally, may essentialize needs and demands along gender lines, which can be further exacerbated by the lack of intersectional trait and varietal preference data (but do see, e.g., Teeken et al., 2021).

Moreover, in using concepts and frameworks from consumer marketing (Orr et al., 2018), and in their reference to men and women in agriculture as "customers", the G + Tools appear to have a servicing role to markets. Thus, while not referred to as such by the piloting participants, some may come to question whether the G + Tools are, in fact, a marketing tool. By including gender and other social factors as variables, the Tools allow further micro-segmentation and the identification of (underserved) market segments, and thus the creation of crop varieties more highly tailored to different gendered "customers". Consequently, the Tools may participate in the construction and performance of markets (Callon et al., 2007), and script men and in particular women in agriculture as market actors and as "untapped markets" and "valuable investments" (also see, e.g., Lyon et al., 2019).

The conflation of gender and markets can be seen in relation to a broader market liberal model and "neoliberal agenda", in which the private sector has gained growing prominence in driving agrarian change since the mid-1970s (e.g., Fuglie, 2016; Kilby,

2021; McMichael, 2009; Moran, 2014; Moseley et al., 2015; Sumberg et al., 2012). The neoliberal agenda is evident in, among others, the changing donor climate of agricultural research and development: while funding by traditional bilateral and multilateral donors has declined, funding by private donors and philanthropic foundations (or philanthrocapitalists) has increased (e.g., Haydon et al., 2021; Herdt, 2012; Pingali, 2012; Pingali et al., 2016). Consequently, private sector donors, such as the Gates Foundation, now exhibit substantial agenda-setting and decision-making power, also in driving and shaping the market-led and gender agendas, as expressed by most informants (also see, e.g., Ewell, 2021; Farhall & Rickards, 2021).

Many feminist scholars have pointed out how the neoliberal agenda has resulted in an instrumentalization and neoliberalization of gender equality and women's empowerment, which may strengthen capitalist values, interests, and institutions of power (e.g., Boyd, 2016; Cornwall, 2018; Cornwall et al., 2008; Cornwall & Rivas, 2015; Gregoratti et al., 2018; Grosser & McCarthy, 2019; Prügl, 2015; Wilson, 2011, 2013, 2015). This is evident in the "efficiency argument for gender equality" (e.g., Berik, 2017; Chant & Sweetman, 2012; Esquivel, 2017; Roberts & Soederberg, 2012), which has become strongly articulated by organizations such as the Gates Foundation (e.g., Bill and Melinda Gates Foundation, 2012; Farhall & Rickards, 2021; Fejerskov, 2017). According to the efficiency argument, women are prevented from reaching their "full potential" due to inequalities in access to resources and markets, among others (e.g., Food and Agriculture Organization of the United Nations, 2011; World Bank, 2012). Thus, reducing "gender gaps" and empowering women, such as through market integration (e.g., Gengenbach et al., 2018), are framed as a way of achieving enhanced efficiency, economic performance, and development outcomes. Melinda Gates herself explains how gender equality needed to be cast in terms of efficiency to convince Bill Gates of including gender in the work of the foundation (Gates, 2019). In their turn to market logic, then, the Tools may thus be seen as producing values that are part of the larger, neoliberal valuation machinery and mode of governing in agricultural research and development (also see Mukhopadhyay & Prügl, 2019). This poses some important questions, such as what will happen to people, crops, and crop traits that are not considered "valuable", "marketable", or "investable" enough?

Management tool

Finally, the G + Toolbox attempts to manage institutional and interdisciplinary (gendered) power relations and negotiations. Indeed, the G + Toolbox is itself scripted in ways that shape the agency, behaviors, and relations of the users of the Tools. For instance, the SOP suggests when and what questions to ask and topics to discuss, and by and with whom. As mentioned, a social scientist with gender training is meant to take a leading role in applying the Tools. Implicitly, there is a move toward strengthening the voice of (women) gender specialists; the need of which was vocalized several times by the piloting participants and other informants. Encouragingly, one of the participants noted how this was the first time since she started her position as a gender specialist that the breeders had engaged in conversations about gender and crop traits. Another gender specialists found that the Tools had reinforced her ability to

influence people to move in a particular direction without having to directly tell them to do so. Additionally, an earlier contributor to the development of the Tools told a story of where they had used aspects of the G + Product Profile Query Tool together with breeders to critically scrutinize a series of traits, upon which even yield was questioned as the Tool helped highlight how enhanced yield may increase drudgery for women (e.g., due to increased labor requirements associated with harvesting). This was considered ground-breaking due to the almost unquestionable status of yield.

Still, several spoke of difficulties in getting the attention and sustaining the involvement of crop breeders, and at times also agricultural economists, in using the Toolbox. Tellingly, few crop breeders and biophysical researchers were present during the digital meetings despite being invited, including some of those who had been present during the initial "Knowledge-Sharing and Planning Workshop" (crop breeders may, however, be prevented from attending meetings due to conflicting responsibilities in the field or in the laboratory). As such, the digital meetings were dominated by social scientists and one of the participants noted in a later interview how, during the piloting, they were often "singing to the choir". This echoed a worry expressed by another participant that, for system-wide behavioral and cultural change to be achieved, "we can't have individual gender experts having individual conversations". Consequently, despite the recognition by the project organizers and participants of the need to ensure that crop breeders felt ownership in developing and using the Tools, the Toolbox was predominantly piloted by social scientists. The lack of input from and engagement by biophysical researchers may have the unintended effect of making the Tools less intelligible for use in cooperation with crop breeders, which may limit the extent to which the Toolbox will effectively be able to inform priority-setting and decision-making in crop breeding.

Furthermore, through conversations with people from the wider gender and breeding community, it became clear that some gender researchers had reservations about the Tools. Among others, the G + Tools can be seen as performing an integrative or gender accommodating approach, where gender is included as a variable or a component to be integrated into biophysical research and innovation (van der Burg, 2019). While an integrative approach represents a strategic way of promoting gender-responsiveness as it helps demonstrate the tangible benefits of gender research to biophysical scientists (also see Kunz & Prügl, 2019), it may be less well-equipped at unveiling the relational nature of gender and supporting gender transformative change, as in the case of a gender strategic or system approach (van der Burg, 2019).

Relatedly, some informants argued that the Tools stood in danger of operationalizing gender issues too much. As one researcher commented: "It toolizes it [gender]". Others feared that the Tools would promote a "culture of box-ticking" where, without having to leave the office, breeding teams using the Tools could get a "gender approval stamp". By not being "out there", and interacting with "people in the ground", the Tools may come to passivate agrarian women and men and further increase the "distance" between scientists and beneficiaries. Some of these comments can be seen in relation to criticism of gender mainstreaming, which in many cases has simplified and bureaucratized gender to such an extent that it absolves "organizations from doing anything substantive about

gender discrimination that arises out of inequalities in power relations" (Arora-Jonsson & Leder, 2021, p. 15; also see Arora-Jonsson, 2014).

Indeed, others argued that the complexity, contingency, and highly qualitative nature of social and gender dimensions do not allow for standardization and ordinal valuation. As one informant put it: "it is not just a yes/no answer and, you know, that nice decision tree". Tellingly, during the piloting, a discussion revolved around whether vine yield should be avoided, as it could increase drudgery for women, or targeted as vine yield could provide women with a source of animal feed and represent a potential future business opportunity. This example demonstrates the nuance and ambiguity of determining the gender impact of traits and how it is rarely black and white and straightforward. Then again, a social scientist who participated in the piloting project stated:

> Looking at the process whereby breeders do trait prioritization; these are numbers, right? (…) You have to be willing to sort of come down to a single yes/no. And the social scientists [have] chronic difficulties with that because everything is contextual, everything is contingent, you know.

Thus, it appears necessary to strike a balance and make a tradeoff between the need to generalize/standardize and specialize/contextualize. Additionally, although the Tools are meant to be adaptable enough to accommodate a wide range of crops and breeding contexts, there were those who considered the Tools as having largely been designed for perishable root and tuber crops. In other words, the Tools produce not only gender but also particular kinds of crops (or rather particular plant-people relations). As such, a social scientist proclaimed: "That is why I, politely enough, refuse to be a part of that family. Because it doesn't work for everybody. Don't force me to use it the way it is". This comment echoed a broader reservation whereby some felt that the GBI, since having become hosted and coordinated by RTB-CIP, had become inward-looking. As one social scientist expressed it: "in the institutional life of the initiative, things have changed in a way that (…) not all crops and all people have been involved in the same way". A crop breeder further argued:

> That's why I felt [the piloting] is a little premature because we haven't had enough reflections on these tools. They have been very top-down, very like: "Here it is. Here is how we are going to apply it." (…) It is the usual; not co-creating something, and that is a community that is pretty closed. I felt like that was another sentiment of, like, inclusiveness. There weren't enough people in the room that should have been in the room.

To address this inclusion/exclusion issue, the organizers of the piloting project had extended invitations to participate in the piloting widely in their networks. This was also the reason why Nairobi was selected to host the piloting workshops, as it is a hub for CGIAR offices and research stations in Africa. At the "Knowledge-Sharing and Planning Workshop", representatives from several breeding programs were present, some of whom did not participate further in the piloting process. This could reflect the lack of time and resources to do so and/or possibly reservations about the Tools. Indeed, what surfaces through this analysis is how the gender research community itself exhibits different schools of thought, which in some cases may result in de-scription and rejection of the G + Tools.

Conclusion

Crop breeding teams are increasingly being asked to develop crop varieties that are more socially inclusive and responsive to gender. However, many questions remain about how best to render crop breeding gender-responsive, in terms of both methodological and institutional innovations. In this paper, I explored how novel approaches to gender-responsive crop breeding are practiced and negotiated, and with what effects, through an ethnographic case study of the G + Tools. Using the concept of gender scripts, interpretative flexibility, and de-scription, I demonstrated how the G + Tools co-construct gender, crops, and crop breeding through several interrelated performative roles.

As a diagnostic and screening tool, the G + Tools diagnose what is or needs to be known about men and women farmers and other user groups, including their gendered status, rights, and roles, and screen crop traits according to their expected social impact. Importantly, the Tools help highlight the significance of women as essential "customers" of crop breeding programs and thus the importance of taking their knowledge, skills, challenges, and demands into consideration. However, in relying on existing data, which are sometimes outdated and unrepresentative, the Tools may stand in danger of constructing men and women and their relationships with crops according to binary and heteronormative gender stereotypes.

The Tools also perform the role of a communication device by translating complex gender dimensions in ways that adhere to the language, practices, and values of crop breeders, agricultural economists, and philanthrocapitalist funders. While this can be a strategically important way of making gender tangible in a highly biophysical and donor-driven organization, such as the CGIAR, the turn to a market logic may result in the perception that the G + Tools are a type of marketing tool, which in turn may script men and in particular women as market actors and as "untapped markets" and "valuable investments". This raises important questions about who and what will be considered "valuable", "marketable", and "investable" enough, as well as the ways in which feminist goals may become instrumentalized and depoliticized as gender and market-led approaches become increasingly conflated.

Finally, the Tools attempt to manage institutional and interdisciplinary power relations and negotiations by strengthening the position and voice of gender specialists (many of whom are women) relative to crop breeders (many of whom are men). However, while the need to include crop breeders as well as agricultural economists in developing and using the Tools was thoroughly recognized, albeit not always achieved, I suggest that the Tools may fail to manage intradisciplinary negotiations and resistance within the gender research community itself.

The paper expands the scope of feminist technoscience studies to the underexplored area of crop breeding for development in Africa, demonstrating how a co-constructive and post-human understanding can provide insights into how gender, crops, and crop breeding become mutually shaped through the practices and tools of gender-responsive crop breeding. The findings can also be important in informing current and future practices of gender-responsive and transformative crop breeding, such as by taking into account critiques raised by other gender researchers (e.g., on the adaptability of the Tools, the institutional openness of the GBI, and how the Tools may promote a culture of

box-ticking), by considering complementary measures to ensure active participation by crop breeders and agricultural economists, and by being mindful of the performative roles that the G + Tools play in the (re)production of gender, crops, and markets, among others. The findings of the article are particularly timely given the renewed attention and commitment to gender equality and women's empowerment in agricultural research for development over the last decade, including within crop breeding.

Notes

1. Nairobi hosts, among others, the International Center for Tropical Agriculture (CIAT), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Institute of Tropical Agriculture (IITA), the International Livestock Research Institute (ILRI), the International Potato Center (CIP), the International Rice Research Institute (IRRI), the International Maize and Wheat Improvement Center (CIMMYT), and World Agroforestry (ICRAF).
2. Generally, a breeding program consists of five main stages: (i) setting goals and priorities; (ii) creating or identifying variability for relevant traits; (iii) selecting experimental varieties; (iv) testing and evaluating experimental varieties; (v) variety release, seed production, and distribution.
3. The GBI defines the customer as "the growers who use the breeding product (crop varieties or animal breeds), and the other value chain actors, like traders, processors, or consumers who use one or more of the end-products" (Orr et al., 2021, p. 5). The customer segment is defined as "[a] group of users who have both a common set of constraints and a common, unique and relatively homogenous need (demand) for a breeding program product" (Orr et al., 2021, p. 19).

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Ethical approval

Approved by the Norwegian Centre for Research Data (reference number: 422305).

Disclosure statement

In accordance with Taylor & Francis policy and my ethical obligation as a researcher, I am reporting that I was hired as a consultant on behalf of the Gender and Breeding Initiative (GBI). The consultancy involved assisting in the writing of two workshop reports. While the consultancy provided material for the research, it may have affected the research process albeit not in ways that significantly affected the methods, theory, or interpretation of the material. In agreement with the supervisor team and the faculty, the potential conflicts were deemed manageable.

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