Superiority of newly released sorghum varieties for enhancing farm level genetic gains in Tanzania

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Importance of improved varieties in sorghum farming systems

Sorghum has a high composition of starch which is a good source of energy as well as higher protein levels that are higher than those found in a cereal like maize. The sorghum system in Tanzania is mostly dominant in Central Zone, Lake Zone and Western Zone which are in semi-arid areas. Most of these regions are characterized by drought, short rainfall duration, unreliable, and erratic rains. This has resulted in crop failure, food shortage and unstable grain prices (Timu *et al,* 2014). To address these constraints, the Government of Tanzania in collaboration with other development partners and seed companies released a dozen improved sorghum varieties over the past decade. These varieties contain desirable traits such as they are high yielding (ranging 2.0-3.5ton/ha), have resistance to pests, are stress tolerant that is they can grow in areas within 0-1500 meters above sea level and 300-1500 mm rainfall, and take 100 to 120 days to mature. Moreover, improved varieties have the ability to tolerate striga infestation which is a major problem to sorghum farmers during production phase (Table 1). Improved varieties also have better nutrient content to cater for the problem of malnutrition.

Recently released varieties like *TARISOR 1* and *TARISOR 2* can resist striga infestation, a parasitic weed which contributes up to 100% crop loss. At the same time these two varieties are tolerant to birds, a major threat to sorghum production nowadays. Variety like *Macia* is a short plant type, which is advantageous for easy harvesting and bird scaring, and also has higher starch content and lower tannin content compared to other improved varieties, making it suitable for poultry feeding. *Wahi* and *Macia* are tolerant to leaf blight disease, which is caused by fungus, attacking the seedlings and causing them to wilt and die. Furthermore, some of these varieties are used in brewing (opaque beer and distilled alcohol) due to low tannin composition. These traits can help farmers to obtain high yield which in turn will secure not only food for their family but also surplus for commercial use. As most of the improved sorghum varieties are short duration taking 100 to 120 days to maturity, they can perform better in semi-arid regions with short rainfall duration and enable farmers to harvest within a short period of time. This will avoid the coincidence of the crop development period during peak weather hazards. This justifies putting in place mechanisms for their effective availability for farmers to enhance genetic gains.

Level of farmer seed demand attendance

Tanzania produced 808,541 tons of sorghum grain in 2018 (FAOSTAT, 2021). Demand for improved variety seeds by farmers varies depending on the traits, seed price and availability of these seeds during planting season. It is estimated that the potential demand for certified seeds is about 6,323 tons. However, for the past four seasons, certified seeds made available to farmers have been lower than the amount demanded (Table 2). This constraint has pushed farmers into using seeds of old varieties since they are readily available during planting time. This is an indication that there is an opportunity in the seed sector to produce enough seed of desirable traits and make them available to farmers through effective mechanisms.

Cost benefit analysis of recently released sorghum varieties

Cost of production varied across varieties and depended on the agronomic practices that farmers use. Despite the production cost, the cost benefit analysis shows that farmers can make enough profit from growing sorghum regardless of the variety. Optimum yield (1.0-1.7ton/ha) obtained per hectare was low compared to the optimum yield expected (2.0-4.0ton/ha) from each variety. Unreliable market and low selling price also reduce the profit margin that farmers make. Data from research institutes, seed companies and QDS producers showed that various categories of seed producers made higher benefits despite higher production costs (Table 3). The price for pre-basic seeds ranged from 8000TZS/kg-10000TZS/kg. Seed companies were selling certified seed at 3000Tshs/kg. QDS producers sold seed from 1000TZS/kg-1500Tshs/kg.

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Table 1: Released varieties and their agronomic characteristics

Variety	Release year	Agronomic characteristics
TARISOR 1	2021	800-1500m altitude, adapted to mid altitude. Striga and bird tolerance; High grain yield; Good for food and brewing; High carbohydrate content and low tannin
TARISOR 2	2021	800-1500m altitude, adapted to mid altitude; Striga and bird tolerance; High grain yield; Good for food and brewing
Rakodzi	2019	Maturity 110 days
SC Shaku	2019	Maturity 116 days
Shirikure	2019	Maturity 116 days
Vumba	2019	Maturity 114 days
PAC 537	2014	High yield and pearly white grain; Yield 3-3.5 tons/ha, with 600-1500m altitude
PAC 501	2014	High yield and pearly white grain; Yield3-3.5 tons/ha, with 600-1500m altitude
NACO SH 1	2013	Maturity (120 days), White grains, recommended to areas with 0-1200m altitude, light fertile soils; Yield ranges from 4.5-5.5 tons/ha
NACO SH 2	2013	Maturity (120 days); White grains, recommended to areas with 0-1200m altitude, light fertile soils; Yield ranges from 3.0-3.5
Naco mtama 1	2012	Maturity (120 days), white grains; Recommended to areas with 0-1200m altitude and light fertile soils; Yield ranges from 3.0-3.5 tons/ha; Seed rate: 7.5- 8.75kg/ha
Sila	2008	Maturity (110-130 days); White grain, tolerant to leaf blight, drought tolerant, recommended to areas with 600-1500m a.s.l; Yield ranges from 3.5-4.0 tons/ha; Seed rate: 7.5- 8.75kg/ha
Hakika	2002	Early maturity (105 days), white grains; Tolerant to drought and Striga; Recommended to areas with 600-1500m a.s.l,200-500mm rainfall and light fertile well drained soils; Yield ranges from 2.5-3.0t/ha; Seed rate: 7.5- 8.75kg/ha
Wahi	2002	Early maturity (100 days), white grains, plant height 1.4-1.5m; Tolerant to drought leaf blight and striga; Recommended to areas with 600-1500m a.s.l,200-500mm rainfall and light fertile well drained soils; Yield ranges from 2.0-2.5 tons/ha; Seed rate: 7.5- 8.75kg/ha
Macia	1998	Maturity (120 days), white grains and high yield; Tolerant to leaf blight; Recommended to areas with 0-1300m a.s.l, 600-1500mm rainfall and light fertile well drained soils; Yield ranges from 3.5-4.0tons/ha; Seed rate: 7.5- 8.75kg/ha
Pato	1997	Maturity (120 days), white grains with red spots and high yield; Tolerant to leaf spot but susceptible to leaf blight; Recommended to areas with 600-1500m a.s.l, 500-1200mm rainfall and light fertile well drained soils; Yield ranges from 3.0-3.5tons/ha; Seed rate: 7.5- 8.75kg/ha
Tegemeo	1978	Maturity (120days), white grains and high yield; Susceptible to leaf blight and smuts; Recommended to areas with 600-1500m a.s.l, 500-1200mm rainfall and light fertile well drained soils; Yield ranges from 3.0-3.5tons/ha; Seed rate: 7.5- 8.75kg/ha
Serena	1960	Early maturity (105-115 days); Drought resistant, recommended to attitudes 600-1500m a.s.l, brown medium sized grains; Yield ranges from 3.0-3.5; Seed rate: 7.5-8.75kg/ha

Source: TOSCI (2022); AGRA (2016)

Table 2: Demand and availability of sorghum certified seeds

Year	Estimated Demand (tons)	Available seeds (tons)
2015/2016	6047	401.31
2016/2017	6127	203.40
2017/2018	6302	78.40
2018/2019	6323	64.30

Source: FAOSTAT (2021); Ministry of Agriculture (2019)

Feedback from various value chain actors on preferences of recently released sorghum varieties

Overall, the most preferable and motivating traits by farmers include high yields (48.2%), drought tolerance (10.8%) and early maturity (9.6%). They also indicated pests' infestation (50.6%) as the major challenge they face. Farmers asserted that birds cause damage in sorghum fields especially when the crop is at soft dough state. National and international research institutes and

Table 3. Profitability of seed production per category of seed produce					
Seed class	**Producers**	**Varieties**	**Costs**	**Revenue**	**Gross benefit**
Certified	Private seed companies	Macia	6064186	11250000	5185814
QDS	QDS producers	NACO Mtama 1	390285	3980000	3589716
		Macia	447507	4200000	3752493
		Wahi	451508	3360000	2908493
Pre-basic	Research institute	Hakika	704590	9600000	8895410
		NACO MTAMA 1	706590	11200000	10493410
		Wahi	704590	9600000	8895410

private seed companies are developing varieties that have the desirable production and market traits. These reiterate the necessity to have appropriate mechanisms in place for farmers to derive substantial genetic gains and income.

Policy recommendations for the seed sector development in Tanzania

Intensive awareness creation activities to enhance farmers knowledge and introduction to relevant varieties. We recommend various promotion and awareness creation activities, e.g., demonstration plots, farmer field days and technological briefs (leaflets and brochures), radio and TV shows, seed fairs, agrishows, etc.

More inclusive practices involving all key actors, e.g., extension officers, researchers, seed producers, agro-dealers, non-governmental organizations, policy makers, grain aggregators (processors and traders) and the general public.

Tailored and intensive capacity building for farmers. Training package on good agronomic practices required to attain the expected genetic gains of improved varieties should go in hand with allied technologies especially appropriate seed rate, variety choice based on agro-ecology, planting date, spacing and other good agricultural practices to ensure that optimum yield is attained.

Enhanced production and availability of quality sorghum seeds at the farm gate. There is a need for diversified and multi-stakeholders oriented seed production and distribution of improved varieties to reach more farmers including the ones in remote areas.

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