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Sorghum production constraints in smallholder farming in Matabeleland North Province of Zimbabwe

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ABSTRACT

Sorghum is a widely produced versatile climate smart staple grain crop in many parts of Africa but its adoption remains as low as 37%. Thus, this study sought to determine constraints in sorghum production in three selected districts in Matabeleland North province of Zimbabwe. An exploratory human based survey was carried out following a cross-sectional study design amongst 150 smallholder sorghum farmers in the three selected districts. Data on constraints in production was collected and analysed descriptively and inferentially using Chi-square test and multinomial logistic regression. Majority of the farmers (65.8%) participating in sorghum production women. There was no significant association between farmers' knowledge, level of education and age. Unavailability of seed arose as one major constraint influencing yields for sorghum farmers. Other identified constraints were susceptibility to pests (57.9%), labour constraints (40.4%), lack of markets (38.6%) and postharvest losses (31.6%). Striga (42.4%), fall army worm (FAW) (37.1%) and loose long smut (36.1%) were the most common weed, pests and disease mentioned by farmers respectively. Quelea birds were also mentioned as a menace. Multinomial regression indicated no association between location and the production constraints in the districts under study. There was a huge gap on good agronomic practices and adoption of improved production technologies to improve food and nutrition security through sorghum production.

Key words: diseases, pests, sorghum, production, Zimbabwe

RÉSUMÉ

Le sorgho est une culture de base polyvalente et intelligente face au climat largement produite dans de nombreuses régions d'Afrique, mais son adoption reste faible, à hauteur de 37 %. Cette étude visait à identifier les contraintes à la production de sorgho dans trois districts sélectionnés de la province de Matabeleland Nord au Zimbabwe. Une enquête exploratoire basée sur des données humaines a été menée en utilisant un plan d'étude transversal auprès de 150 petits producteurs de sorgho des trois districts sélectionnés. Les données sur les contraintes de production ont été collectées et analysées de manière descriptive et inférentielle à l'aide du test du khi-carré et de la régression logistique multinomiale. La majorité des agriculteurs (65,8 %) participant à la production de sorgho étaient des femmes. Les résultats ont montré qu'il n'y avait pas d'association significative entre les connaissances des agriculteurs, leur niveau d'éducation et leur âge. L'indisponibilité des semences est apparue comme une contrainte majeure influençant les rendements des producteurs de sorgho. D'autres contraintes identifiées étaient la sensibilité aux ravageurs (57,9 %), les contraintes de main-d'œuvre (40,4 %), le manque de marchés (38,6 %) et les pertes post-récolte (31,6 %). Les mauvaises herbes, ravageurs et maladies communs affectant le sorgho étaient la mauvaise

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herbe Striga, la chenille légionnaire d'automne (FAW) et le charbon nu, mentionnés respectivement par 42,4%, 37,1 % et 36,1 % des agriculteurs. Les oiseaux Quelea ont également été mentionnés comme une nuisance. La régression multinomiale n'a révélé aucune association entre l'emplacement et les contraintes de production dans les districts étudiés. Il existe un important fossé en matière de bonnes pratiques agronomiques et d'adoption de technologies de production améliorées pour renforcer la sécurité alimentaire et nutritionnelle grâce à la production de sorgho.

Mots clés: Maladies, Ravageurs, Sorgho, Production, Zimbabwe

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is the third prominently produced crop in Zimbabwe and a staple cereal in the drier and hotter southern parts of the country, which receive 350-650 mm of rainfall annually (Amadou *et al*., 2013; Chadalavada *et al*., 2021; Khalifa and Eltahir, 2023). Poor agronomic practices, soil nutrient deficiencies, as well as other abiotic stresses like heat and drought, generally contribute to low yields even in known hardy crops grown in semi-arid tropics of Africa like sorghum and millets (Este *et al*., 2019; Ncube *et al*., 2021). Sorghum is mostly grown by smallholder farmers under rain fed conditions using traditional methods with minimal inputs (Ncube *et al*., 2009; Yadav *et al*., 2016; Derese *et al*., 2018). Despite the increasing dietary, industrial and biofuel demands of sorghum, its production and productivity has remained low (Silas *et al*., 2021). Low yields are largely caused by a blend of unfavorable edaphic, climatic and agronomic factors (Begna *et al*., 2022). Farmers prefer to use retained seeds of uncharacterized sorghum landraces and do not invest on certified seeds for improved varieties, fertilizers and pesticides to manage pests and diseases, which results in poor management of pests and diseases and many more poor agronomic practices (vom Brocke *et al*., 2010; Kutyauripo and Mutombo, 2020). Inherent soil infertility is certainly another significant limitation in crop production in Zimbabwean semi-arid areas (Dunjana *et al*., 2018; Silas *et al*., 2021).

Mwamahonje *et al*. (2021) concurs that low sorghum yields in most parts of sub-Saharan Africa are salient due to poor agronomic practices and inherently nutrient deficient soils, in addition to other abiotic factors such as drought and extreme temperatures (Mavhura *et al*., 2015). Nitrogen is the most limiting macro nutrient in crop production especially in soils that receive less or no soil nutrient replenishments at all (Parra-Londono *et al*., 2018). Other soil fertility elements impacting on low yields in sorghum production include deficiency of micronutrients and soil acidity especially in areas dominated by sandy soils (Abdelhalim *et al*., 2019; Zandalinas *et al*., 2023). Downy mildew disease, insect pests like stalk borer, army worm, smuts and weeds such as *striga asiatica* commonly known as striga or witch weed also cause severe losses in sorghum (Wanga *et al*., 2022). Poor agronomic practices such as the use of unimproved landraces susceptible to pests and diseases characterized by poor yields and nutrient composition in grain and stover for livestock feed (Ouedraogo *et al*., 2017; Magaisa *et al*., 2022).

Average grain yield of sorghum under smallholder farming ranges from 0.5-0.7 tonnes per hectare while commercial yields can yield an average of 2-3.5 tonnes per hectare (Khalifa and Eltahir, 2023). Yields are low mainly due to limited access to information on farming and poor adoption of new technologies as farmers use traditional farming practices and none or little investment on inputs (Matsa and Manuku, 2013; Mwamahonje *et al*., 2021). A study in Zimbabwe indicated that 50% of farmers adopted basin conservation agriculture as their principal tillage technique, with the remaining farmers using conventional techniques (Makuvaro *et al*., 2014). Less than 50% of farmers employed any type of water harvesting techniques, farmers rarely rotate their crops, some farmers combine sorghum and maize, and apply fertilizer and manure rates that are far below recommended levels (Worku *et al*., 2020).

Productivity has stayed below 0.5 t/ha in Zimbabwe under smallholder farming which is below the estimated average yield of 3-5 t/ha that can be produced under rain-fed agriculture (Magombeyi *et al*., 2018); Diallo *et al*. (2018) identified some of the reasons for low adoption of improved sorghum varieties as lack of consultative approach, limited knowledge on varieties, and lack of improved varieties adapted to specific environmental conditions

as well as inadequate supply of seed to farmers among other constraints. Labour intensiveness, limited technical support and access to marketing information, lack of certified seeds have been pointed out as the major constraints to sorghum production (Kutyauripo and Mutombo, 2020; Magaisa *et al*., 2022).

Choice of sorghum varieties by farmers is not based on empirical evidence due to poor research extension-farmer linkage and poor information dissemination (Derese *et al*., 2018). There is little knowledge on farmers' views and perceptions on trait preferences of improved sorghum varieties. This information is needed to direct sorghum breeding programs (Mofokeng *et al*., 2016; Diallo *et al*., 2018). Farmers are not well informed on the sorghum landraces and improved varieties available in gene banks across the globe (Mukondwa *et al*., 2021). Limited full profiling of physiochemical attributes of the sorghum genotypes on anti- nutritional factors like tannin, colour and diversity in sorghum, are some of the factors influencing choice of sorghum varieties of late (Xiong *et al*., 2019; Saithalavi *et al*., 2021).

Small grain production is becoming less preferred by farmers due to labour intensiveness in land preparation, weeding, bird scaring, harvesting and grain processing (Nhiwatiwa *et al*., 2017; Vhumbunu, 2022). Migration of able bodied population to urban areas and neighboring countries, HIV and Aids and COVID pandemics have negatively impacted on availability of labor force needed for some of the labour intensive practices like land preparation, application of manure, weeding, scaring of birds, harvesting and post harvesting processing associated with millets production (Waithaka *et al*., 2007; Silas *et al*., 2021; Nyasha *et al*., 2023). Furthermore this has been exacerbated by reduced herds of cattle that are a source of draught power and manure due to drought and poor pastures owing to climate change and variability induced recurring drought and heat episodes (Musara *et al*., 2021). Rural communities' in marginal areas dominated by resource poor elderly, women and children headed families have been exposed to severe food insecurity, malnutrition and poor livelihoods (Mutami, 2015). Thus, this study sought to determine constraints in sorghum production in selected areas of three marginal districts in Matabeleland North province of Zimbabwe with a view to increase awareness that may stir support from all the stakeholders concerned with policy implementation, inputs, knowledge and technical assistance in reviving sorghum production and livelihoods especially in marginalised areas of Zimbabwe and beyond.

MATERIALS AND METHODS

Study site. The study was conducted in three sites namely; Lupane, Nkayi and Tsholotsho districts of Matabeleland North province of Zimbabwe (Figure 1). The three districts were selected based on their potential and prevalence in production of sorghum and representatives of dry and hot parts of Zimbabwe. Lupane district, which is located in the center of the province at 20° 09′ 52.37″ S and 28° 34′ 04.07″ E, experiences high temperatures ranging from 32-35°C and an annual rainfall of 350-400mm (Makuvaro *et al*., 2014). Sandy soil predominates among surface soil types, followed by loamy sand and sandy clay (Mukungurutse *et al*., 2018). Nkayi district is an agricultural region that is primarily rain-fed and is located in the province's eastern most part (Latitude: -18° 49' 59.99" S Longitude: 28° 49' 59.99" E). Due to low and variable rainfall (450 - 650 mm annually) with an average maximum temperature of 29.6ºC hence frequent droughts, farmers continue to be vulnerable to climate change. Tsholotsho (19° 46' 0" S, 27° 45' 0" E) lies in the province Southeast and is highly characterized by variable rainfall and average annual temperatures of 27.8ºC and poor soils which often form barren unproductive lands. Soil types in Tsholotsho district are Kalahari sands that cover 70% of the district and mean annual rainfall is in the range of 450-500 mm (Mupepi *et al*., 2024). The farming system in Tsholotsho, Nkayi and Lupane districts is predominantly subsistence mixed crop and livestock farming under rainfed agriculture. Cereal crops commonly grown are maize and small grains such as sorghum and pearl millet, legumes and sunflower. Population for Ward 29 in Nkayi was 5279 from 1231 households, ward 22 in Tsholotsho had 7250 individuals from 1450 households and ward 20 in Lupane had 5135 people from 1027 households.

Study design. An exploratory human based survey was conducted following a cross-sectional study design. One ward was selected in each of the three districts and these were Wards 20, 29 and 22 in Lupane, Nkayi and Tsholotsho, respectively. Fifty

(50) respondents were selected from each ward thus a total of 150 smallholder sorghum farmers who were purposively selected from the three wards. Selection of sorghum farmers was done with the aid of extension workers in the wards.

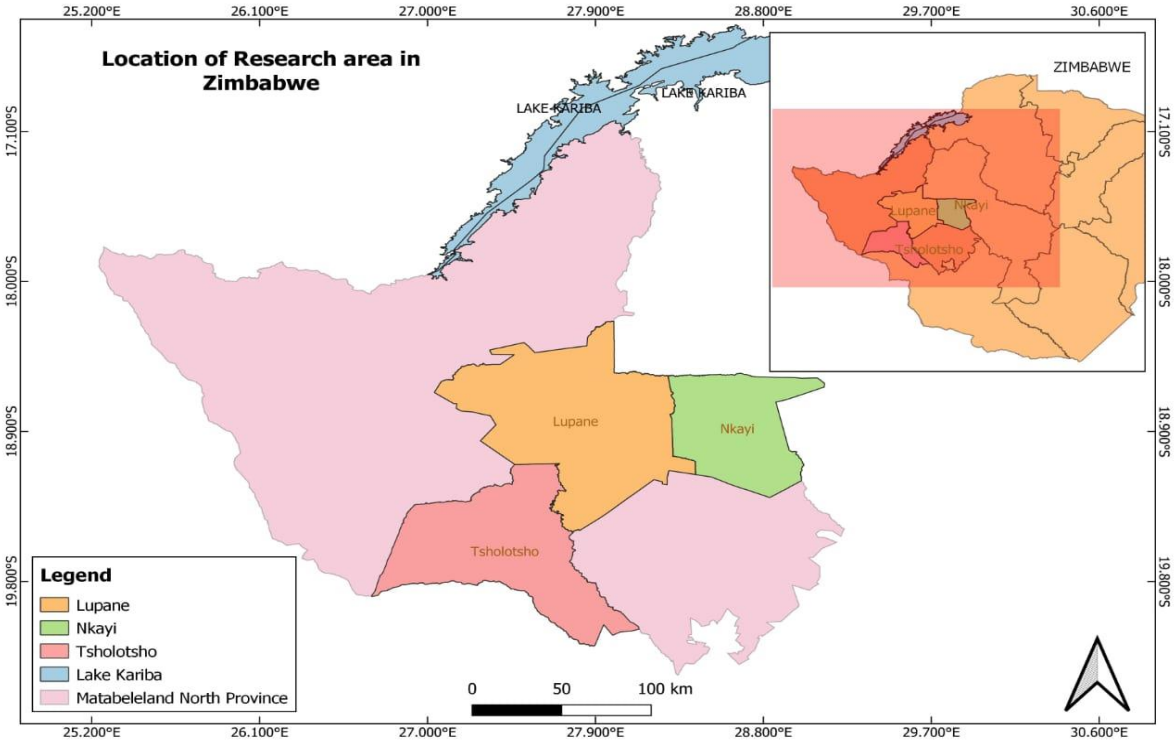

Figure 1. Geographical map showing study area (Lupane, Nkayi and Tsholotsho) Districts in Matabeleland North Province, Zimbabwe.
Source: Developed through GIS Mapping

Data collection and analysis. Data on demographics, preferred agronomic practices, production constraints and utilization of sorghum was collected from respondents (sorghum farmers) using a semi structured questionnaire that was administered using a face-to-face interview in the three districts. Respondents were first debriefed about the rationale of the study and the intended use of the data for academic purposes then informed consent was sought from all the participants. Furthermore, the researcher guaranteed the respondents on confidentiality of the information and upheld anonymity of respondents by not including any of their personal details in the questionnaires. Pretesting of questionnaire was done with 10 respondents in Nkayi district and necessary adjustments were made before administering the three districts.

Qualitative data were collected then coded according to categories, entered and analyzed using Statistical Package for Social Sciences (SPSS) version 21. Themes on farmers' demographics, agronomic practices, uses and constraints in sorghum production were used to summarize data in tables and pivot charts in the form of frequencies and proportions. Furthermore, independence Multinomial logistic regressions were performed to test for independence of association between constraints and location at 5% level of significance of the test.

RESULTS

Demographics of respondents (gender, age, marital status and level of education) in three selected districts of Matabeleland north of Zimbabwe. Female farmers had high (65.8%) participation in sorghum production compared to male farmers (34.2%) (Table 1). Farmers aged 41-50 years made up to 32.3% of the respondents. The least group was the less able bodied and productive elderly farmers aged above 79 years with 2.6%. The highest percentage of farmers engaged in sorghum production were married (71%) and the lowest was in the category of the divorced with 1.9% (Table 1). On the

level of education, majority of the respondents attended up to secondary education (66.5%), 7.7% did not have formal education while 1.3% had attended up to tertiary level.

Table 1. Demographic information of the respondents

Demographic		Frequency	Percentage (%)
Gender	Male	53	34.2
	Female	102	65.8
Age	18-20 years	11	7.1
	21-30 years	8	5.2
	31-40 years	12	7.7
	41-50 years	50	32.3
	51-60 years	31	20.0
	61-65 years	27	17.4
	65-70 years	11	7.1
	Above 79 years	4	2.6
Marital status	Married	110	71.0
	Single	14	9.0
	Divorced	3	1.9
	Widowed	28	18.1
Education	None	12	7.7
	Primary	38	24.5
	Secondary	103	66.5
	Tertiary	2	1.3

Farmers experience in sorghum production. Majority (47.9%) of respondents had 6-8 years of experience in sorghum production. Furthermore, 10% of the respondents had over 15 years of experience and 12% with the least number of years of experience of less than or equal to two years in sorghum production (Figure 2).

Figure 2. Farmer experience based on the number of years in sorghum production

Major constraints in sorghum production. Susceptibility to pests, labour constraints and unavailability of seed were cited by the farmers that were interviewed as the prominent constraints in sorghum production as evidenced (Figure 3). Less productive farmers who obtained less than a tonne were less affected by challenges such pests, growing period and marketing. The most productive farmers

who obtain more than 4 tonnes seem to be affected mostly by unavailability of seeds (75% of the respondents) and pests (100%). Labour constraints affected all the farmers despite their productive capacity

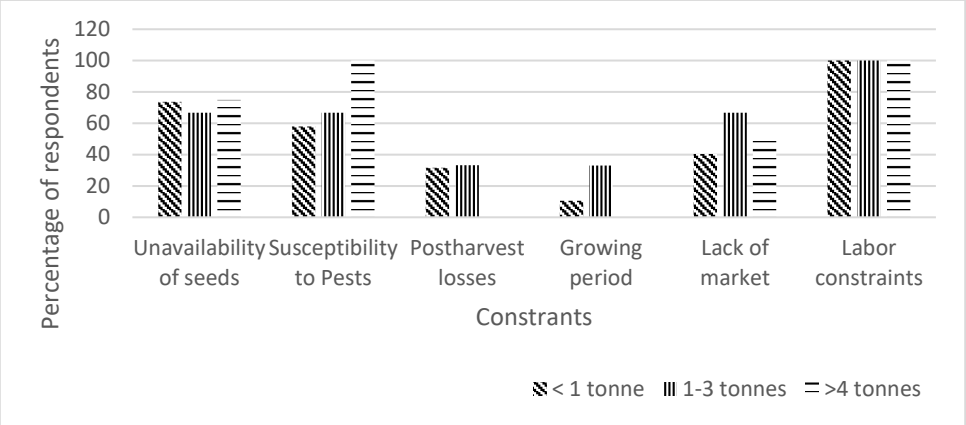

Figure 3. Constraints affecting sorghum farmers in Matabeleland North of Zimbabwe categorized according to yield output

Problematic pests and weed affecting sorghum production. Major pests affecting sorghum in the study areas emerged as fall armyworm (FAW), aphids and stalk borer (Figure 4). Sorghum is also prone to attack by quelea birds. The parasitic red flowered (*Striga asiatica* L.) commonly known to as striga or witch weed (Isona in the local language) is the only weed that emerged to be problematic.

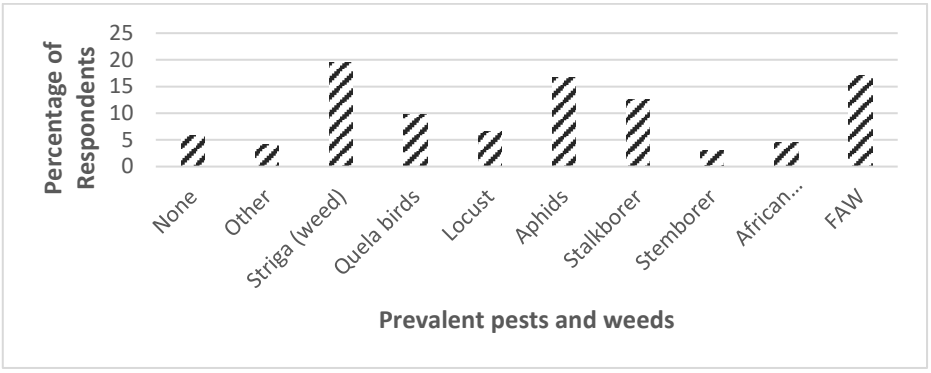

Figure 4. Major pests and weeds affecting sorghum

Major diseases affecting sorghum production. Loose long smut and head smut with 49.3% and 27.2% respectively were identified as problematic diseases (Figure 5). The least common disease that affects sorghum was ergot with 4.4%.

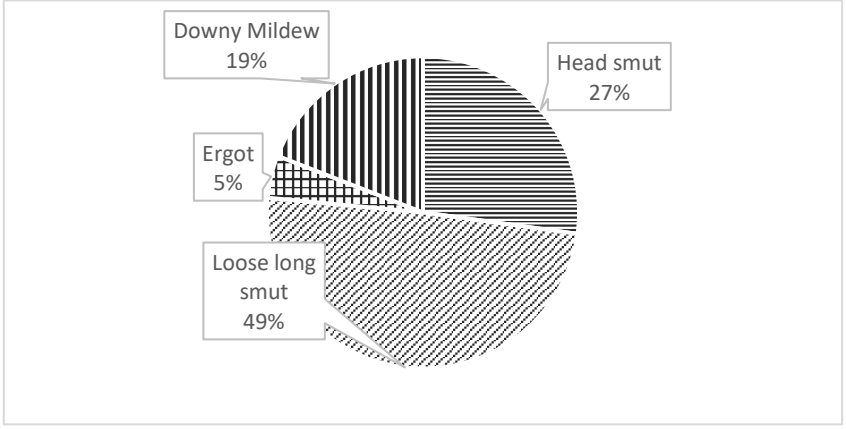

Figure 5. Prevalent diseases affecting sorghum

Control measures for pests and diseases. Most farmers (37%) use cultural methods to control pests and diseases in sorghum production and an almost matching proportion of the respondents (35%) use pesticides (Figure 6). The least identified way to control pests was that of taking no action at 8%.

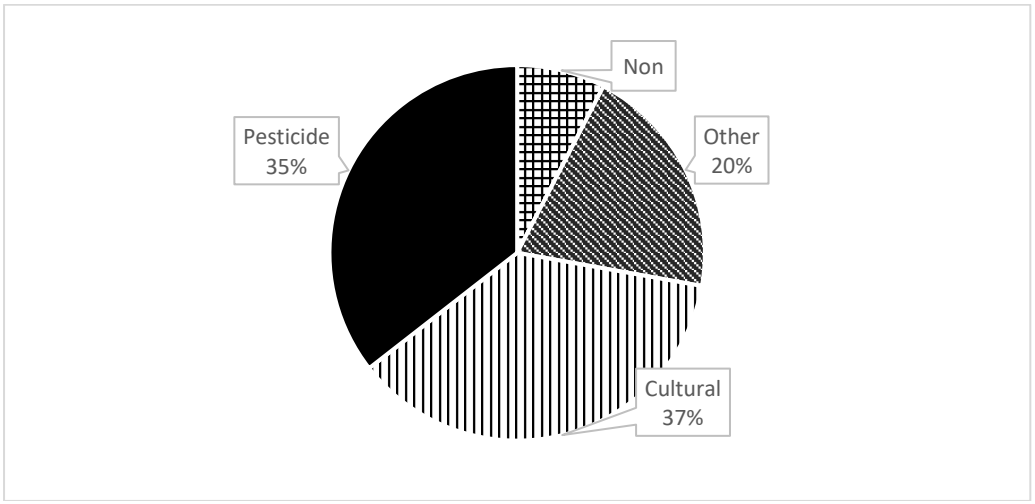

Figure 6. Methods used by farmers to control pests in sorghum production

Several control measures employed by farmers to manage birds revealed with the most dominant being scaring and omission of : were use of resistant varieties at 37.3% and 36.2% (Figure 7). The least mentioned control measure was the cultural method mentioned by slightly above 5% of the respondents which was equal to the respondents that did not specify the methods they use and was categorized as other.

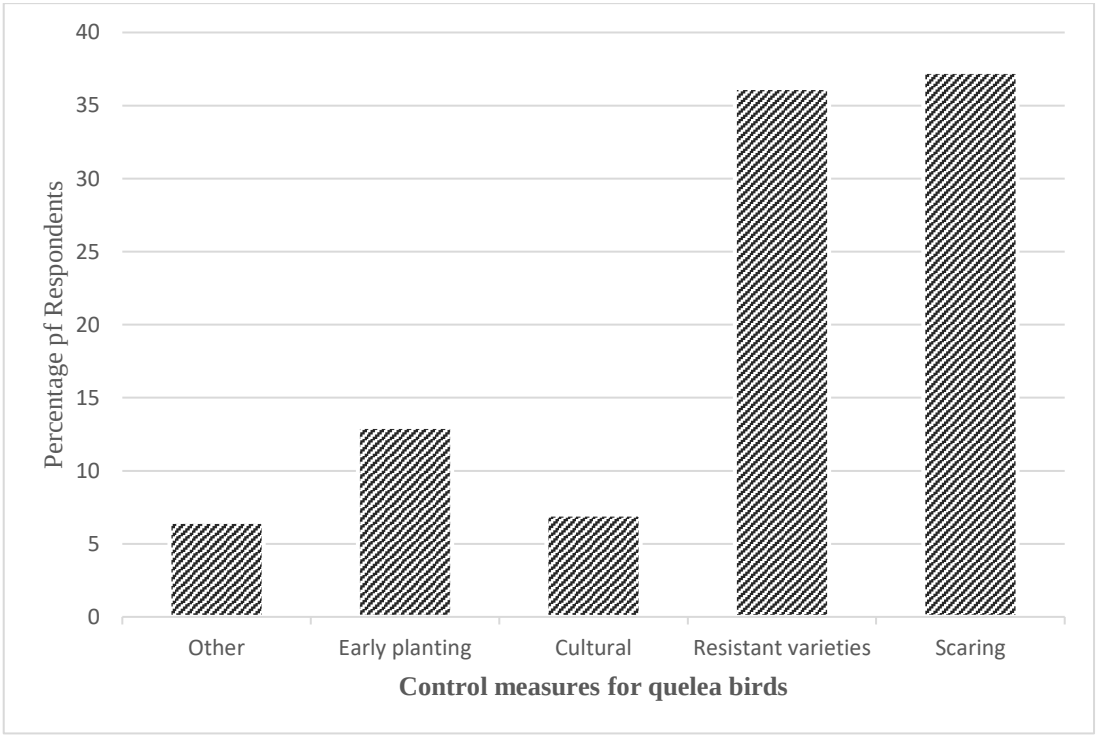

Figure 7. Methods used by farmers to control birds in sorghum production

Relationship between location and constraints in sorghum production. Multinomial logistic regression results revealed that there was no significant ($p>0.05$) association between location (districts) and constraints experienced by farmers in sorghum production which include shelf life, susceptibility to lodging, labour constraints, marketing, and availability of seed.

DISCUSSION

Demographics of respondents (gender, age, marital status and level of education). Most sorghum farmers are females possibly because most able-bodied men migrate to urban areas and neighboring countries for employment and women remain farming in homesteads (Mutami, 2015; Dangarembwa, 2019). Most of the respondents who took part in the study were between 40 and 50 years of age. Possibly, this age group is still active and able bodied to do laborious tasks and very few elderly farmers aged above 70 years as they are less able bodied and productive (Matsa and Manuku, 2013). The noted variance in years of experience in sorghum production can be due to resilience building against climate change and variability whose recurrence has continued to surge (Blake, 2009). There has been a number of stakeholders' interventions focusing on promoting production of small grains as a climate resilience strategy under dryland cropping by communal farmers in the past decade (Magaisa *et al*., 2022; Vhumbunu, 2022). This has been confirmed in various studies that the Government of Zimbabwe through working with international organizations such as FAO and ICRISAT have been promoting production of small grains in arid and semi-arid areas of Zimbabwe since small grains play a vital role in ensuring food and nutrition security (Othieno and Shinyekwa, 2011; Tsusaka *et al*., 2015; Nyasha *et al*., 2023). Just a small percentage of farmers had more than 15 years in sorghum production indicating decreasing adoption of a practice passed from elderly generation of farmers with vast experience. Source of information on sorghum production is mainly through local extension officers and other experienced fellow farmers which shows that there is limited knowledge on good agronomic practices in sorghum production which could contribute towards low yields with farmers getting less than a tonne (Makuvaro *et al*., 2014). Results could be indicative of existence of a relationship between knowledge, experience and yield in sorghum production (Kutyauripo and Mutombo, 2020).

Constraints affecting yields in sorghum production. The revealed unavailability of seed as a major restriction influencing sorghum production in the study is consistent with a study by Munyaka *et al*. (2015) that revealed limited access to inputs in the production of small grains. Farmers harvesting low yields in sorghum are those cultivating small areas of land, this could be due to limited resources and are experiencing a number of constraints including unavailability of seed, labour constraints and postharvest losses (Mutami, 2015). Labor constraints in small grain production seem to be limiting the majority of farm operations, including land preparation, weeding, bird scaring, harvesting, and grain processing (Mutami, 2015).

Farmers harvesting higher yields of sorghum are aware of the importance of use quality seed for improved varieties (Matsa and Manuku, 2013). For optimal productivity, farmers require adequate scientific knowledge, abilities, and skills (Musara *et al*., 2021). Results on farmers who experience less challenges of post-harvest losses and are not affected by the shortened growing period indicate that these farmers could be using improved seed varieties of sorghum that are early maturing, high yielding, less susceptible to pests and diseases and well experienced in good agronomic practices (Makuvaro *et al*., 2014). Small grains have a limited formal and informal market for farmers to sell excess harvest thus the observed limited access to markets as a challenge (Kutyauripo and Mutombo, 2020). Sorghum is a state-controlled commodity and is only sold to Grain Marketing Board (GMB) which is a limiting factor to link farmers to the private sector (Silas *et al*., 2021). The results of the current study suggested poor agronomic practices including poor pests and disease management, use of retained seed due to unavailability of certified seed locally contributing to poor productivity. Other constraints that have been raised in other similar studies (Mwamahonje *et al*., 2021; Nyasha *et al*., 2023) which include lack of diverse processing technology (Mutami, 2015) and consumer preferences did not come up in the current study however constraints like low yields from sorghum, lack of inputs and lack of government support seem to be very common across most sorghum producing areas.

Problematic pests, diseases and weeds affecting sorghum production. Fall Armyworm a devastating pest at vegetative stage of most cereals identified in the current study as one of the biotic factors limiting sorghum production in dry regions of Zimbabwe was also revealed by Silas *et al*., (2021) and Chamunorwa *et al*. (2021). Ousseini *et al*. (2022) emphasized the use of regional landraces that are prone to Striga weed which was also identified as a significant barrier limiting sorghum productivity. Striga is more prevalent in infertile soils that dominate the areas of study (Nasidi *et al*., 2019). The results of the present study are consistent with study findings, which showed that Striga infestation and bird damage were the main biotic obstacles to high sorghum yields in Tanzania (Mrema *et al*., 2017). The pests and disease that affect sorghum were found to be identical in Nkayi and Lupane districts because they are located in the same agroecological area (IV), which has the same rainfall patterns, temperatures, and vegetation. This also explains the lack of relationship between location and constraints that was observed in the study. Furthermore, the spatial proximity also mean less socioeconomic variations. The only existing variations may be in disease incidences and severity probably due to varying micro climates within the districts in the same agroecological regions. In the face of climate change induced weather vagaries outbreaks of pests and diseases is expected to increase.

Loose long smut was found to be the most common disease in sorghum, followed by head smut and sorghum downy mildew (Nasidi *et al*., 2019). Spread of these diseases especially smut could be due to use of retained seed which is a common practice in sorghum production by farmers (Este *et al*., 2019). Farmers were found to be growing mainly local landraces seed which was inherited from generation to generation promoting spread of such diseases (Kutyauripo and Mutombo, 2020).

Control measures for pests, diseases and weeds. Farmers mostly use cultural methods to control pests and diseases. Farmers lack skills on Integrated Pest Management (IPM) to minimize effects of pests in sorghum. Farmers do not practice IPM (combination of cultural, biological and chemical control methods) in sorghum production with the assumption that small grains are less susceptible to pests and diseases. Farmers use several methods to scare birds and some are cultural, however, several studies have shown that bird scaring is laborious to farmers resulting in farmers dedicating small areas to sorghum production (Nyasha *et al*., 2023). Most of the varieties grown by farmers are more susceptible to weevils and have a short shelf life hence the postharvest losses. Due to low yield realized by the farmers and limited knowledge on improved varieties farmers may not be aware of the shelf life of sorghum grain according to variety.

CONCLUSION AND RECOMMENDATIONS

Socioeconomic factors such as gender, age and educational level had a notable contribution towards constraints of sorghum production. Most of the interviewed farmers were between the ages of 41-50 years and had completed secondary school education. The most problematic weed was striga, disease and pests affecting sorghum production in the three study sites were identified as striga, loose long smut, and stalk borer and fall army worm respectively. Unavailability of inputs especially seed for improved varieties and labour constraints came out as the major constraint influencing yields for sorghum farmers and it is essential to promote local community seed production to improve availability of sorghum seed locally. Capacity building on IWM, IPM, use of labour-savingtechnologies, implementing programmes to improve marketing such as contract farming arrangements and capacitation on post-harvest handling management in sorghum production is paramount to improve productivity. Farmers should scout for pests and diseases more frequently to minimize yield losses. Sorghum production and productivity can be increased through the adoption of good agronomic practices in semi-arid regions of Zimbabwe.

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DECLARATION OF CONFLICT OF INTEREST

The authors have no conflict of interest to disclose.

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