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Farmers' Perceptions of Rain-Fed Wheat Production Constraints, Varietal Preferences and their Implication to Rain-fed Wheat Breeding in Zambia

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Abstract: Wheat (Triticum aestivum L.) is one of the most important widely grown food crops worldwide. In Zambia, it is an important cereal crop, second after maize. However, its production amongst the small-scale farmers has declined over the years. To determine the causes of this decline, a participatory rural appraisal was conducted in Mpika district in Zambia as a case study to assess farmers' perceived constraints and preferences of rain-fed wheat varieties. Focus group discussions, semi-structured questionnaires, scoring and ranking were used. The results showed that wheat is produced both for food and income generation. The average wheat fields were 0.48 ha, with yields averaging 1.5 t ha -1. The major production constraints are lack of improved seed, bird damage, termites, lack of markets and diseases with spot blotch being the most important. Farmers preferred a white coloured grain cultivar, high yielding, resistant to diseases, termite attack and bird damage.

Keywords: Wheat; wheat production constraints; Farmers' preferences.

1. Introduction

Wheat *(Triticum aestivum* L.*)* is one of the most important and widely grown food crops in the world. In Zambia, it is the second most widely grown cereal crop after maize, with an average annual production of 183 856 t yr-1 compared to millet (48 482 t yr-1), rice paddy (32 976 t yr-1) and sorghum (24 780 t yr-1) [1]. In Zambia, wheat is produced both during summer rainy season (November to April) and cool dry season (May to September) under irrigation. Summer wheat production is dominated by small-scale farmers whose yield ranges from 1 to 2 t ha^{-1} [2]. This low yield is attributed to the increased occurrence of rainy season wheat disease complexes and abiotic stresses such as aluminium toxicity [3]. Leaf spots and head blights are the common diseases on rain-fed wheat during the rainy season [4, 5]. Their predominance is due to high humidity (85%), prolonged wetness of wheat foliage during the regular rainfall and dew which promotes fungal infection.

However, the major constraint to a successful rain-fed wheat production in Zambia is the spot blotch disease [4]. Most of the wheat varieties grown do not have adequate resistance to the disease [1]. Yield losses of over 85% due to spot blotch have been reported and occasionally, under severe attack, complete crop loss results [4]. The disease also lowers the grade and quality of the wheat grain.

Nonetheless, the rain-fed wheat breeding programme in Zambia, like many Sub-Saharan Africa (SSA) countries, has placed much emphasis on expanding production, with little or no reference to social and cultural factors [6]. This has meant that wheat varieties have previously been given to farmers without prior knowledge as to whether they performed well in farmers` fields or had qualities preferred by the farmers as a consequence, the yields have been very low.

Participatory research is one of the strategies that enables researchers to identify problems faced by local communities and assist in finding solutions as the local people are actively involved in the process [7]. Plant breeding programmes have used participatory rural appraisal (PRA) techniques such as focus group discussion, ranking and scoring and key informant interviews to elicit useful information pertaining to existing production

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constraints and farmer preferred traits [8]. The PRA techniques when used effectively can identify farmer-acceptable varieties, thereby overcome the constraints that cause farmers to grow old or obsolete varieties [6]. It is common knowledge that utilisation of these techniques increases the delivery of desired outputs from a plant breeding programme [9, 10].

Further, research costs at the commencement of the plant breeding programmes can be reduced and adoption rates increased. In addition, wheat production is likely to increase when farmers adopt new varieties identified in participatory research as the programme will have involved the farmers in selecting their preferable varieties according to their socio-economic needs and disseminate them in ways that would enable the farmers to benefit from improved varieties. It is important therefore that farmers` perceived constraints and preferences are considered at the commencement of a plant breeding programme [11, 12]. Thus, a study was undertaken to i) assess farmers' perceptions' of rain-fed wheat production, ii) establish farmers' production constraints to rain-fed wheat and management strategies and, iii) identify farmers' wheat varietal preferences.

2. Materials and Methods

2.1 Study Area Description

The study was conducted in Mpika district of Muchinga province of Zambia because of the district`s potential of rain-fed wheat production by small-scale farmers. In this district, two areas, Mufubushi latitude 12º06.624′ S and longitude 31º14.635′ E, 1409 meters above sea level (masl) and Mpika Main latitude 11º47.994′ S and longitude 31º27.202′ E., 1375 masl were used for the survey. These areas are located in Region III, a high rainfall region which normally receives over 1250 mm rain per annum from November to April [13] (Figure 1). The district has several soil types but the dominant one is Acrisol (clay-rich) [14]. Mpika district also has an annual average maximum temperature of 30.0ºC and an annual minimum temperature of 10.1ºC [13].

2.2 Selection of Farmers

The villages and farmers involved in the formal and informal participatory rural appraisal (PRA) interviews were selected with the help of the local agricultural extension officers. The farmers were chosen, based on their farming knowledge, in particular wheat production. The farmers were selected from 13 villages (Table 1).

3. Data Collection and Analysis

The survey was conducted by a multi-disciplinary research team consisting of a plant breeder, a socio-scientist and agricultural extension officers from the Department of Agriculture, Ministry of Agriculture. The interviews were conducted in the local language of the farmers. To ensure that the farmers provide as much information as possible and avoid any biasness in the responses, specific objectives of the study were not mentioned to farmers, rather only the broad objective of the exercise.

Primary data sources were obtained using PRA techniques such as focus group discussions, semi-structured questionnaires, ranking and scoring [15]. Focus group discussion was used to identify common problems facing the rain-fed wheat small-scale farmers in these areas as described by Cavestro [16]. The focus group discussions comprised both men and women. The discussion was guided by open ended and semi-structured questions which covered issues related to wheat production constraints, solutions on how to manage wheat production constraints, characteristics preferred by farmers in summer rain-fed wheat cultivars, type of wheat they would like to grow, availability of wheat markets and other general information. During the discussions farmers also scored and ranked major crops grown in their area and wheat production constraints. According to Adebo [17] PRA scoring and ranking assists to identify group and individual priorities. During the group discussions, women spoke freely in the presence of their male folks. The individual interviews with the farmer enabled them to express themselves freely without the influence of other farmers. In addition, it helped to identify individual farmers' priorities. Secondary data was obtained from the district extension offices of Mpika. Statistical Package for Social Scientist (SPSS) version 16.0 was used to analyse the data.

4. Results

4.1 Social Economic and Environmental Characteristics of Mufubushi and Mpika-Main Areas

4.1.1. Demography

About 84.7% of the farmers interviewed were married. Additionally, 20.3% of the respondents were below 35 years old. Those between the age of 36 to 55 years and above 55 years were 55.9% and 23.0%, respectively. In terms of education, most of the farmers (98.3%) attended formal education. It was observed that the majority (59.3%) of the farmers in the study areas attended primary level education with Mufubushi having the highest number (60.8%) than Mpika-Main (50.0%). Those who attended junior and senior secondary level education were 18.6% and 22.0%, respectively, across the study areas.

4.1.2. Farm Sizes and Land Preparation

The average land size per farm household was 15.6 hectares with 1.5 ha and 68 ha as minimum and maximum, respectively. The farm sizes used for farming ranged from 0.75 ha to 5.5 ha with an average of 4.83 ha. The most common farming implements owned by most household were the hand hoes owned by 94.9%, axes (61.0%) and ox drawn ploughs (23.7%). In terms of method of land preparation, 64.4% of the households in Mufubushi and Mpika-Main areas prepared their land for farming activities using hand hoes while 16.9 % used ox drawn ploughs and 18.6 % use both hand hoes and ox drawn ploughs. Furthermore, 98.3 % of the households indicated that they produced enough food through to the next harvest season. Ninety-three percent of farmers accessed agricultural information through agricultural extension workers.

4.1.3. Food and Cash Crops Grown By Farmers

Ninety-six percent of the respondents identified maize as the major crop grown as it was their staple food. Other major crops included groundnuts, beans, sunflower, soybeans, cassava, and finger millet (Figure 2). Bambara groundnuts, paprika, rice, sugarcane, sweet potatoes, Irish potatoes, bananas, vegetables, green maize and star grass were grown as minor crops in both areas. Sunflower and soybeans were grown as cash crops while beans and groundnuts were mainly grown as intercrops in maize, cassava and finger millet fields. Beans was ranked as the second most important crop after maize in Mufubushi area while in Mpika-Main groundnuts was ranked second most important crop also after maize (Table 2). This confirmed the ranking during group discussions.

However, though wheat was not listed amongst the top seven major crops, farmers disclosed that it was the most desired crop in almost all the households in the study area. This was confirmed by the number of people who approached the research team for wheat seed after the group discussion. Out of the 59 respondents 39 (66.1 %) were involved in wheat production. These farmers indicated that wheat was a dual purpose crop, that is, it was used mainly as a cash crop as well as for home consumption.

4.2. Wheat production in Mufubushi and Mpika-Main

In Mufubushi and Mpika-Main, wheat was mainly grown during summer season as a rain-fed crop. Both men and women, youths and adults were involved in wheat production. Coucal (amber coloured variety), a wheat variety introduced to the area in the late 1980s by Zambia-Canada (Zam-Can) wheat project, was the only variety grown. The wheat fields ranged from 0.25 ha to 3.0 ha, with the average being 0.48 ha. Farmers reported yields of 0.2 - 4.0 t ha^{-1} with an overall mean of 1.25 t ha^{-1}. Most farmers (69.2%) planted wheat in December and the rest planted in January and November. The crop was planted in rows and hand drilling was the most popular sowing method in the study area. More than 53.8% of the farmers used hand hoes to control weeds while 46.2% used both chemicals and hand hoe weeding. Both basal and top dressing fertilizer were applied to enhance wheat growth and production.

Over the past 25 years, there has been a reduction in wheat production in these two areas. Many farmers (86.0%) attributed this reduction to lack of availability of improved wheat seed in the area. Lack of readily available local markets for wheat was another cause for the reduction in wheat production.

4.3. Wheat Production Constraints As Perceived By Farmers

Wheat production constraints identified by farmers are presented in Table 3. Bird damage as the most limiting factor to wheat production, followed by termites and then Weeds. They revealed that bird damage was serious during the milk dough stage of wheat seed production and hence required constant scaring to protect it from bird damage. The majority of farmers, 96.6%, indicated that they resorted to physical bird scaring as there was no other way of protecting their wheat from birds. The investigations showed that farmers found bird scaring increasingly onerous as it required constant scaring for a minimum of three weeks per season. Although termites were a problem, 61.3% of the farmers did not apply chemicals nor other protective measures to control them, while 25.8% and 12.9% applied chemicals and wood ash, respectively, to reduce termite damage. It was observed that farmers believed that poor soils and dry spells were the main causes of termite damage.

Weeds were ranked the third most important constraint. Most of the farmers (53.8%) relied on hand hoe weeding while 46.2% used both chemicals and hand hoe weeding. The farmers that depended on hand hoe weeding reported weeding to be time consuming, tedious and unpleasant as it required several weedings to control the weeds. Further investigation revealed that weeding in wheat fields required skill to differentiate wheat from weeds especially during early stages of wheat growth. Lack of reliable markets was ranked fourth as a wheat production constraint. Table 4 shows farmers views on how wheat marketing could be improved in their area. Other important production constraints identified by farmers were diseases, bad weather (dry spells/drought), labour involved in harvesting and threshing of wheat, and red ants (they believed that red ants sucked sap from wheat plants hence weakening the plant).

4.4. Farmers' Perception about Spot Blotch Disease and Management Strategies

During group discussions, farmers used descriptive rather than specific names to identify diseases affecting their rain-fed wheat crop. However, with the help of pictures during discussions, they were able to identify various diseases affecting the wheat crop in their area. Generally, results from the formal survey indicated leaf spot (spot blotch), black powdery heads (smut) and sticky heads (ergot) as the most common diseases. During the same group discussions, farmers indicated that leaf spots were seen earlier in the growth stage of wheat compared to black

powdery heads and sticky heads which came in later during heading. About 90.9% farmers mentioned leaf spot to be the most prevalent disease affecting the wheat crop during the rainy season. Eighty-one percent of the farmers indicated that spot blotch appeared in their fields during the flowering stage, while 18.1% witnessed the disease at the maturity stage. Fifty-four percent of the farmers mentioned soil type to be the major cause of spot blotch disease while 45.5% considered dry spells to be the cause. They further pointed out that after the dry spells, more leaf spots were observed on leaves and sometimes stems.

Farmers adopted some control measures to reduce the effect of spot blotch. These included, uprooting diseased plants practised by 63.6% of farmers. They viewed that removing diseased plants was a better way of minimizing the spread of the disease to other plants. However, uprooting diseased plants was reported to be tedious and time consuming. About 9.0% of the farmers attempted to apply lime to the soil with a view of reducing the amount of disease inoculums in the soil. Eighteen percent tried early planting to minimize disease pressure while 9.1% removed infected leaves to try and reduce spot blotch disease. Farmers indicated that lack of financial resources as the reason why they did not apply any chemicals to manage the disease. Nevertheless, no clear effective spot blotch management strategies emerged during the formal interviews and during the focus group discussion.

When farmers were asked to show the management option they thought would be effective to control spot blotch disease, they believed that practices such as crop rotation, early planting and applying chemicals could help control the disease and increase wheat yield. Most farmers pointed out that they thought these methods could be effective as they had tried other methods but with no success. Furthermore, some farmers mentioned that yields in the presence of spot blotch were much lower compared to yields in the absence of the disease (Figure 3).

4.5. Wheat Cultivar Preferences

Coucal (amber coloured variety) was the only wheat variety introduced to the farmers in Mufubushi and Mpika-Main in the past fifteen years. Despite having one variety, farmers had their own preferred traits of an 'ideal' wheat variety. White colour was the most preferred characteristic by the majority of the farmers (61.6%) (Figure 4). A visit to the local market also revealed that the white coloured grain type was the most preferred grain colour. Farmers gave several reasons why they preferred white type of wheat among them; they consumed wheat as a whole grain therefore preferred the white type to amber (red) while others took wheat to local gridding mill to make wheat flour for making local buns. They indicated that the flour colour from the local millers depended upon the colour of wheat grain taken there, as no further processing was done. However, less than 30% of the farmers preferred amber type of wheat. It is understood that these were sensitized that the amber type was highly nutritious and good for prevention of cancer. The second most preferred traits were high yield and disease resistance. Other traits preferred by farmers included resistance to termite and bird damage, and drought tolerance (Figure 4).

5. Discussion

The farmers relied principally on family labour for all farm activities in the study areas as it was cheap and readily available. These findings are in line with findings of [18] who reported that families were a key component of family labour amongst small-scale farmers. The family labour comprised both men and women. There was no gender biasness regarding agricultural activities among men and women in the area. Additionally, no discriminatory gender-based responsibilities associated with culture barred women from participating in agricultural activities. The effective participation of both men and women would influence wheat production positively at household and community level. Besides, both youth and adults participated in wheat production as observed from the range of the age group of the respondents, 16 to 55 years old. Literacy levels among the farmers in the study area is high (98.3%). Their ability to read and write makes it easier for this group of farmers to learn and understand skills for increased wheat production. Literacy in farming households is essential as it reduces risk aversion and increases comprehension and chances of adoption of new agricultural technologies [19]. However, land allocated to rain-fed wheat was relatively small. Lack of appropriate farm implements may have resulted in most of these farm households in the study area not to utilize the available land for wheat production. Nonetheless, through discussion with agricultural extension staff, it is hoped that the animal draught power will be introduced to mitigate against inadequate farm power, thereby increasing use of farm land and improving wheat production.

The lack of improved varieties was one of the main factors that caused many small scale-farmers to abandon summer wheat production. Coucal was the only wheat variety grown by the farmers for the past fifteen years. This indicates that, there have been very little or no progress in breeding for new rain-fed wheat varieties. This clearly shows the need for wheat breeders to develop new improved rain-fed varieties to improve the production of rain-fed wheat.

Lack of a good seed source was also cited as a limiting factor to rain-fed wheat production and forces farmers to save seed or source it from neighbours. A reliable supply of rain-fed wheat seed from both private and public sectors is required for sustainable summer wheat production amongst small-scale farmers. Drought, bird and termite damage were other factors limiting rain-fed wheat production amongst small-scale farmers. Farmers failed to combat these limiting factors causing low yield. The provision of drought tolerant varieties, varieties resistant to bird and termite damaged would help provide solution to these problems.

Lack of readily available local markets for wheat seed and grain was also an important constraint for farmers involved in wheat production. The presence of appropriate markets and the increased access to such markets would greatly transform wheat production as farmers would be able to purchase wheat seed and sell their harvest without

problems. Readily available local markets are actually an incentive for farmers to increase wheat production as more land would be used for production [20]. Furthermore, [21] indicated that availability of markets is one of the major drivers for agricultural growth as it helps farmers to get cheaper inputs and higher output prices.

Disease and weed pressures were other constraints for summer wheat production mentioned by the farmers. This further suggests development and introduction of appropriate cultivars tolerant to different disease complexes and weed pressures. Amongst the diseases, leaf spots (spot blotch) was ranked highest. This is in agreement with the findings of Mukwavi, *et al.* [5] and Mooleki [3] who reported the prevalence of spot blotch during the rainy season. However, farmers were not aware of the causes of spot blotch disease. It is likely that that the seed they recycled was the major source of the inoculum for the disease. Infected seeds accelerates the spread of the disease as they provide pathogen inoculum to the growing plant [22, 23]. Nonetheless, some farmers were cognizant of the effect of the disease on wheat grain yield but lacked information on effective management strategies. The farmers opted to adopt control measures that they thought would help them manage the disease, such as removing infected leaves, use of agricultural lime and also uprooting diseased plants. None of the methods they adopted achieved the desired effect on the disease. Henceforth, sustainable management options such as use of resistant wheat varieties must be promoted and disseminated to the farmers. According to Naitao and Yousan [24] a more feasible, sustainable and effective way to control diseases on small-scale farmers' fields is breeding for resistance. From the survey, it was observed that farmers were informed about farming practices with regard to wheat, such as land preparation, sowing and also harvesting but lacked information on crop protection.

Though farmers had previously accessed crop information from the various projects operating in the area, information is currently limited and not frequently updated. There is urgent need to strengthen linkages between the frontline extension staff in area and the national research institutions (wheat team), with the later train extension workers on wheat production so that they could also provide wheat production information to farmers to help improve the production of rain-fed wheat in the areas. Fashola, *et al.* [25] reported that the force to increase crop productivity depended upon the linkages between the research workers, extension workers and the farmers. In addition, Roling [26] indicated that extension workers were vital in the flow of information to farmers to increase crop productivity. Furthermore, on-farm and on station wheat field days could significantly help in promoting rain-fed wheat production as wheat farmers could gain knowledge in the production of wheat by seeing the crop in the field [27].

Nevertheless, farmers preferred a wheat variety that would be high yielding with white coloured grain, resistant to termite, resistant to bird damage, disease resistant, and drought tolerant. Farmers indicated that having a variety resistant to the aforementioned biotic and abiotic stresses would greatly improve their household food security, nutrition and incomes. Farmers also preferred to have a wide range of wheat varieties other than Coucal in order to have a wider choice.

6. Conclusion

The study established that wheat was a desired crop in almost all the households in the study area. It was a dual purpose crop, and that both men and women, youths and adults are engaged in rain-fed wheat production. Wheat was grown by a few farmers (66.1% of the respondents) and the land-sizes allocated to wheat were small. This was mainly due to lack of good varieties with only one variety (Coucal) introduced in 1988 being grown. Furthermore, the variety lacks preferred characteristics most preferred by farmers in wheat such as grain colour (white type), high yield, resistant to disease, tolerant to termite attack, drought and bird damage. Farmers also desired to have a wide range of rain-fed wheat cultivars other than the current one.

Leaf spots (spot blotch), smut and ergot diseases are important biotic stresses for rain-fed wheat. However, spot blotch is the most important disease. Nevertheless, no sustainable control method was being used to control the spot blotch. Hence, it is essential to develop rain-fed wheat cultivars resistant to disease and incorporate farmers` preferred traits.

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Tables

Table-1. Total number of wheat farmers selected for PRA in Mpika District

	Village	Females	Males	Total number of wheat farmers
1	Mufubushi Centre	4	8	12
2	Changilo	2	2	4
3	Kafuko	1	1	2
4	Kambale	2	2	4
5	Kapoko	0	1	1
6	Kawama	1	1	2
7	Kwacha	3	1	4
8	Lubanga	1	1	2
9	Mpika main	4	4	8
10	Mubabe	1	3	4
11	Mumbulu	2	4	6
12	Mwaisen	5	2	7
13	Sotambe	1	2	3
	Total number of wheat farmers	27	32	59

Table-2. Mean values of farmers' ranking of the major crops

Crop	Mufubushi (n=51)	Mpika Main(n=8)
Maize	1	1
Groundnuts	4	2
Sunflower	5	3
Beans	2	6
Cassava	7	3
Finger millet	3	7
Soybeans	5	5

Table-3. Wheat production constraints as viewed by farmers in the study areas

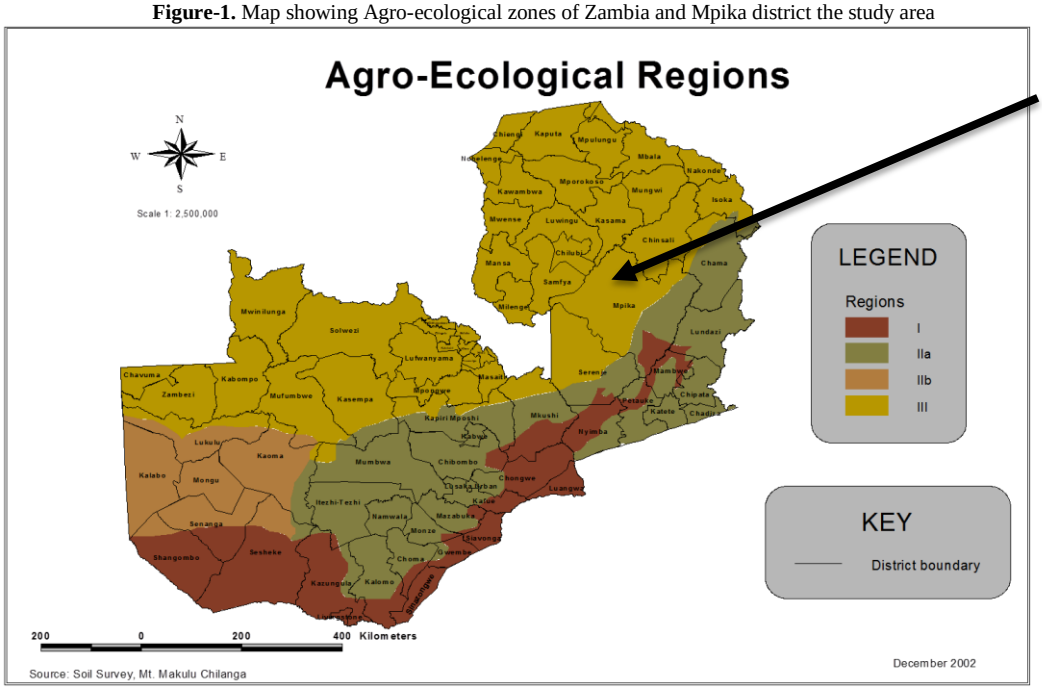
Constraints	% of respondents	rank values
Birds	72.0	1
Weeds	23.0	3
Lack of markets	16.4	4
Termites	32.3	2
Diseases	16.2	5
Drought	11.1	6
Labour	10.0	7

Table-4. Farmers proposed views on how wheat marketing could improve

	Proposed views on improving marketing of wheat.
1	Advertising wheat markets so that farmers are aware of them
2	Government commitment to rain-fed wheat production by buying their wheat as they do with crops such as maize
3	Government linking farmers to markets
4	Farmers forming agricultural co-operatives so that it is easier for buyers to buy their wheat

Figures

Figure-1. Map showing Agro-ecological zones of Zambia and Mpika district the study area



Source: [14]

Figure-2. Major crops in the study areas

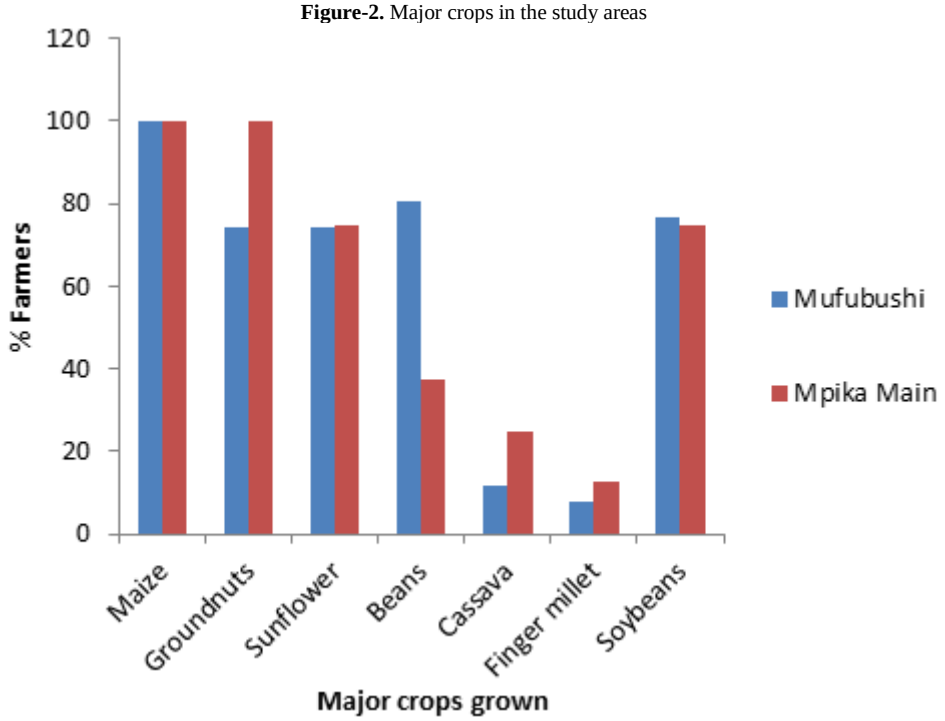


Figure-3. Wheat yield estimates in 50 kg bags in the presence and absence of spot blotch disease

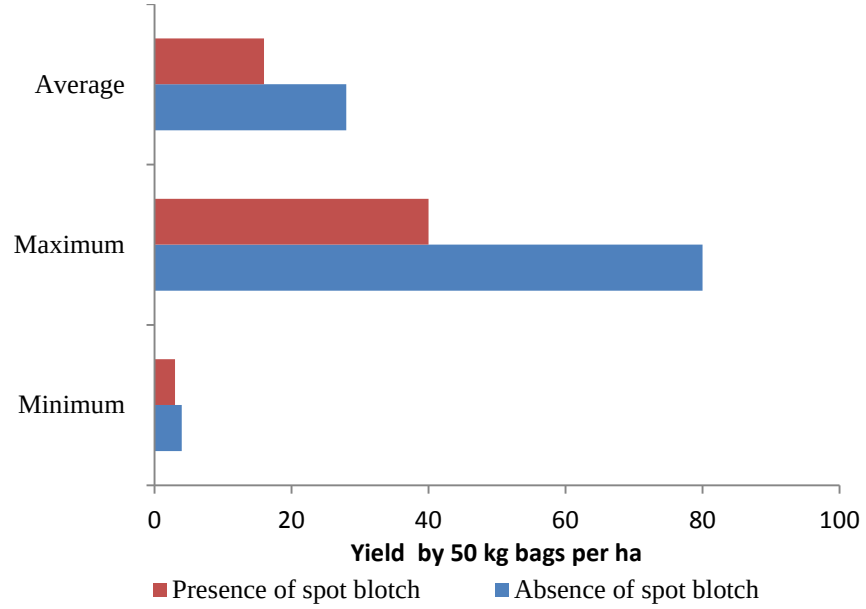


Figure-4. Farmers' preferred traits for wheat