

A Review of Rain-Fed Wheat Production Constraints in Zambia

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Abstract

Wheat (*Triticum aestivum* L.) is an important food crop in Zambia. It is the second most widely grown cereal crop after maize. However, its production and productivity during summer rain season is limited by socio-economic, abiotic and biotic constraints. The socio-economic factors limiting high wheat yield are high cost of inputs, lack of improved rain-fed wheat seed, lack of affordable loans, lack of access to market information and poor mechanization. The abiotic constraints on the other hand include drought, high temperature and aluminium toxicity. Biotic constraints affecting rain-fed wheat production include various weeds, pests (aphids, grass hoppers, pink stalk borers and termites) and diseases (powdery mildew, loose smut, leaf rust, fusarium head blight and spot blotch). Termites being the most serious and destructive pest of rain-fed wheat. Spot blotch is the most devastating and widely distributed among the diseases causing high yield losses of between 7-100% followed by fusarium head blight. This review paper, looks at the factors that limit the production and productivity of rain-fed wheat among small holder farmers in Zambia.

Keywords: Biotic and abiotic factors; Limiting; *Triticum aestivum* L; Yield.



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1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important and widely grown food crops in the world. It is consumed in more than 175 countries with an average consumption of 67 kg per capita (kg yr^{-1}) [1-4]. It contributes 20% of the total calories consumed by the world population. In terms of world wheat production, Africa produces the least compared to other continents like Asia, Europe, and America [1, 5]. Africa produces about 28 million tonnes (MT) per year, against an annual consumption of 60 million [5] resulting in imports of more than 40%, to meet the demand [5]. In Zambia, wheat is the second most widely grown cereal crop after maize, with an average annual production of 201 504.13 t yr^{-1} compared to millet (30 534.46 t yr^{-1}), rice paddy (49 639.63 t yr^{-1}) and sorghum (11 557.42 t yr^{-1}) [6]. Further, it is grown by both commercial and small-scale farmers. Commercial farmers grow wheat as a cash crop in the cool, dry season (April to September), under irrigation mainly in the following provinces: Southern, Lusaka, Central, Copperbelt and some parts of the Eastern province [7]. Small-scale farmers on the other hand, grow wheat under the hot and humid summer rainy season (November to March) because of lower production costs when compared to growing the cool, dry season irrigated wheat [8]. These small-scale wheat farmers are located in all parts of the country, but mainly in the northern part. However, summer rain-fed wheat production in Zambia is still low with yields ranging between 1-2 t ha^{-1} [8]. Several factors contribute to low yield levels of rain-fed wheat. Some of which include high temperatures, drought, weeds, pests and a high prevalence of diseases. Once these problems are solved, summer rain-fed wheat production could expand and complement commercial production and could help Zambia reach self-sufficiency in wheat.

2. Rain-Fed Wheat Production Constraints

There are several factors limiting rain-fed wheat production in Zambia. These include socio-economic, abiotic and biotic factors.

3. Socio-Economic Constraints

Wheat farmers are faced with a fair share of socio-economic constraints which include; high cost of farm inputs such as pesticides, fertilizers, herbicides and fungicides, and lack of affordable loans from the lending institutions [9]. The cost of inputs coupled with high interest rates negatively affect wheat production. Most of the wheat cultivars grown require the use of expensive fertilizers, fungicides, and/or herbicides which most farmers cannot afford. These socio-economic constraints thus contribute to low rain-fed wheat production in Zambia as they discourage wheat farmers from expanding their production. Other constraints include lack of improved rain-fed wheat seed. Very few companies deal with rain-fed wheat research and production as compared to irrigated wheat. For this reason farmers depend on informal seed source such farm saved seed and from neighbours. Lack of proper market information also contribute to reduced rain-fed wheat production. Farmers often sell their produce at farm level among themselves or in small markets where the prices are not attractive. Poor mechanisation is another factor limiting rain-fed wheat production. Most farmers use hand hoes to plough their land and use sickles for harvesting. This limit the wheat production to about quarter a hectare due to drudgery that comes when using hand hoes and sickles. This implies that use of machines, therefore, can enable increased land productivity and increased production more efficiently with less labour.

4. Abiotic Constraints

Soil acidity, high temperature and drought are the major abiotic constraints affecting rain-fed wheat production in Zambia. Soil acidity is a common problem in most parts of the country especially in the north. It causes poor yields due to a high concentration of aluminium ions (Al^{3+}), which inhibits root growth resulting in decreased nutrient uptake by Ryan, *et al.* [10]. Lime is used as a control measure but it is scarce and expensive. There is, therefore, a need to improve wheat cultivars on their tolerance to aluminium as most of the currently grown cultivars are sensitive to aluminium toxicity.

High temperature is another abiotic constraint limiting high rain-fed wheat yields in Zambia. It affects photosynthesis and physiological processes in the plant, thereby affecting plant growth and development [11-13]. Mohammadi, *et al.* [11] and Rehman, *et al.* [14] indicated the optimal temperature for wheat growth to be 25°C, above which yields start to decrease. Wahid, *et al.* [12], reported that high temperatures (above 35°C) before anthesis induced sterility in plants causing huge yield losses through non production of wheat spikes. Other studies have reported a reduction of 4% in grain weight for each degree increase in temperature [11, 15]. Temperatures above 25°C during wheat production cycle are not unusual in Zambia during the rainy season. High temperature has also been reported in many wheat growing areas to be the primary cause of poor yields and grain quality [14]. In view of the above, there is need to breed for heat tolerance to improve wheat production and productivity in Zambia as most of the varieties under cultivation are not heat tolerant. Drought is also another factor affecting rain-fed wheat production in Zambia. Ahmad, *et al.* [16], revealed that drought is a major factor affecting crop production and food supply worldwide. According to Mahpara, *et al.* [17] drought has devastating effects on wheat development, growth and consequently yield. Yield losses due to drought has been reported to range between 17 – 70% [18]. Nonetheless, to encourage rain-fed wheat production among the small scale farmers breeding for drought tolerant crops is essential.

4.1. Biotic Constraints

Weeds, pests (termites, aphids, grasshoppers and pink stalk borers) and diseases (powdery mildew, leaf rust, loose smut, head blight and spot blotch) are the major biotic constraints that affect rain-fed wheat production in Zambia. Weeds compete with plants for nutrients, water and sunlight affecting yield and quality of the grain. Yield reduction due to weeds has been reported to be between 10 - 65% [19]. Aphids, on the other hand, are among the important pests responsible for low rain-fed wheat yield in the country. They affect the crop either directly by sucking the sap out of the plants or indirectly by transmitting disease [20]. The sucking of sap from leaves cause leaf distortion which affect photosynthesis required for grain production. Compared to other pests, termites are the most common and destructive causing huge yield losses. The termites affect the plant from germination through to maturity. However, termite attack on wheat at maturing causes high yield losses that cannot be compensated [21]. The attack on the crop is so severe during a dry spell. Other pests of importance and need attention are grasshoppers and pink stalk borers. Plants infested with stalk borer produce ears that look white but without grains hence, affecting yields.

Fusarium head blight (Scab) is among the economically important diseases in Zambia during the summer rain season. Globally, *Fusarium graminearum* is common and devastating in warm and humid environments [22]. Wheat is most susceptible to infection during flowering through to soft dough stage [23]. Yield loss of up to 44% has been reported in Tunisia [24]. In China yield losses of over one million tonnes due to FHB has been reported [25]. In Zambia, yield loss of between 1-50% in wheat trials have been observed in severely infected lines. Breeding for resistance to Fusarium head blight is important to improve rain-fed production.

Among the diseases, spot blotch is the most wide spread, serious and devastating disease of wheat in summer rain season in Zambia [26]. Khan and Chowdhury [27] and Srivastava and Tewari [28] showed that spot blotch was a major disease causing huge yield losses in the tropics and subtropics. Severe yield losses (about 7 to 100%) due to the fungus have been reported to occur in Zambia, Bangladesh, Brazil and Bolivia [29, 30]. In Bangladesh, for example, yield losses of about 80% have been reported in warmer areas [31]. The outbreak of spot blotch disease is favoured by wet, humid and warm temperatures [6, 27]. These conditions are common in Zambia during the summer rainy season. As a result, spot blotch can be a devastating disease causing complete crop loss. The development of cultivars tolerant to spot blotch will boost sustainable summer rain-fed wheat production in Zambia as the crop is in high demand. Powdery mildew caused by *Erisiphe graminis* sp. *tritici*, loose smut caused by *Ustilago nuda* and leaf rust caused by *Puccinia recondita* sp. *tritici* occur late during rainy season hence are not a major threat to rain-fed production. However, powdery mildew, loose smut and leaf rust require attention in terms of developing resistant germplasm because the resistance of most of the varieties is unsatisfactory. At present, most small-scale farmers do not use chemicals to control the disease. This implies that disease levels will always be high in the small-scale farmers' fields resulting in poor quality grain and low yields. Hence, it is important to develop varieties resistant to the common diseases found during rainy season in Zambia.

5. Conclusion

The study revealed that wheat is an important food crop worldwide and that in Zambia it is the second most widely grow cereal crop after maize. The review also revealed that wheat in Zambia was grown in winter (dry season) and summer rainy season. However, summer rain-fed production was dominated by small-scale farmers whose production was low (1-2 tha^{-1}). The low productivity is attributed to high cost of inputs such as fertilizers and herbicides, weeds, poor mechanization, lack of market information and lack of improved wheat seed. Diseases such

as head blight and spot blotch are a major factors limiting high yields in summer season. Compared to other diseases, spot blotch being the most important disease affecting wheat production. Furthermore, drought, high temperature, soil acidity and aluminium toxicity aphids and termites are other factors aggravating low rain-fed wheat productivity.

In order to encourage rain-fed production, there is need for the government to come up with deliberate policies to encourage banks to let small-scale farmers' access loans to enable them buy machinery. There is also need for extension officers to assist farmers to create farmer groups as this will help farmers' access important market information timely. Additionally, it will help farmers to identify potential buyers for their crop and sell their crop together as bulk sales as small volume of products are difficult to sell individually. Access to mechanization is also advocated to further increase summer rain-fed wheat production. Furthermore, there is need to develop varieties resistant to major biotic and abiotic stresses found in this study. Resistance varieties coupled with good agronomic practice will help to improve rain-fed wheat production and productivity. All in all, capacity building for farmers is also important.

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