Journal of Environmental Science and Engineering B 2 (2013) 46-52
Formerly part of Journal of Environmental Science and Engineering, ISSN 1934-8932

Farmers' Coping Mechanisms for Common Bean Production under Water-Logged Soil Conditions in Uganda-Rwanda Boarder Region

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Received: December 28, 2012 / Accepted: January 12, 2013 / Published: January 20, 2013.

Abstract: Common bean (*Phaseolus vulgaris* L.) is a staple food and income crop in eastern Africa, especially within the Uganda-Rwanda boarder region where it constitutes a major component of food security. Unfortunately, bush beans are severely affected by frequent water-logging which persists over a considerable period of the year. In spite of this, farmers have continued to cultivate bush bean though with miserable yields. The study aimed to identify farmers' indigenous coping mechanisms to the climatic predicament, as a foundation for nurturing and subsequently designing appropriate management strategies for improved bean production in the region. A household survey was conducted in Kisoro district, in a location representative of the ecological conditions of Uganda-Rwanda region. 96 respondents were selected randomly at village level from a list of 500 households provided by the extension workers. Data were collected using semi-structured interviews. Findings showed that farmers possess vital coping mechanisms including construction of ridges, fertiliser application and chemical control of pests and diseases to expedite plant growth, and construction of drainage channels. It is clear that farmers' indigenous coping mechanisms need further nurturing and refining to improve their performance in dealing with water-logging crisis in the region.

Key words: Ridges, manure, drainage channels, bush bean.

1. Introduction

The common bean (*Phaseolus vulgaris* L.) constitutes approximately 50% of the grain legumes consumed worldwide [1, 2]. It is the main source of protein for low-income families in rural and urban areas, particularly in Sub-Saharan Africa [3] where high quality animal protein products are prohibitively costly. In eastern Africa, beans account for approximately 20% of the most important staple food for the vulnerable populations [4]. In Uganda, for instance, beans provide about 25% of the total calories and up to 45% of protein intake which are beyond the Sub-Saharan Africa average [5].

Common bean produced within the Uganda-Rwanda boarder region accounts for most of the beans produced and consumed in both countries [6]. This is attributed to the favourable conditions for its production and community preferences of the crop. Unfortunately, common bean yields have declined drastically over the years, despite attempts by farmers to expand areas under production [7]. The decrease in productivity is attributed to several factors, amongst which is water-logging due to more than usual heavy

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rains [8]. Moreover, it is evident that submergence of the soil with water for barely two reduces crop growth rate and drastically suppresses yield of some crops that prefer reasonable drainage within the root zones [9, 10]. Water-logging in the Uganda-Rwanda boarder region is largely due to sporadic and increasingly heavy rainfall perhaps attributable to climate change. Moreover, the soils of the region are characterised by poor drainage.

Many scholars have reported various cultural practices used elsewhere to obviate water-logging soil conditions [11-14]. In Uganda and Rwanda, farmers cope with the situation using indigenous practices which hitherto remain neither documented nor research-supported. Elsewhere, various agricultural practices used to deal with water-logging have been categorised as either preventative or palliative [15]. Examples of the preventative practices include establishment of drainage channels and raised beds, ridging, molding and application of gypsum. On the other hand, examples of the palliative measures include fertiliser and fungicide application as well as synthetic hormones for correcting hormonal imbalances. The palliative measures are essential in dealing with the aftermath of water - logging [15].

Other studies have been undertaken to determine the effect of flooding durations on different growth stages [10]. According to such studies, flooding of five or more days may lead to more than 50% reduction in photosynthesis, leaf area and dry weight after. Similar effects were reported in soybean (*Glycine max* L.), where flooding for by as short as three days in early vegetative growth stages killed the plants [16]. Wilting, chlorosis, senescence and abscission of lower leaves of pigeaon pea (*Cajanus cajan* L.) were also observed after few days of water-logging [17]. Water-logging is known to slow root growth of crops like soybean and increase the incidence of fungal diseases like *Gliocladium roseum*, especially at early stages of growth [14]. Water-logging significantly affects root system functions including ability to obtain soil nutrients and firm anchorage of the plants in the soil. This leading to leaf chlorosis and yield loss [18].

This study was conducted to identify indigenous coping mechanisms used for bean production under rain water-logging condition in the Uganda-Rwanda boarder region as a basis for nurturing and subsequently designing appropriate management strategies for the wider bean producing areas in both countries.

2. Materials and Methods

A household survey involving 96 farmers was conducted in Chahi sub-county, an area representative of the boarder region of Uganda-Rwanda. The area is hilly with an average altitude of 1,981 m above sea level. It is characterised by a bimodal rainfall pattern, though increasingly with erratic distribution. Typically, the shorter rains occur from February to May, while the longer rains are from September to December, with an annual average of 1,300-1,500 mm. The average annual temperature is 16.5 °C. The soils in these highlands are mostly volcanic ash based, and possess poor internal drainage systems [19, 20].

The study was carried out in all the three parishes of Muganza, Nyakabingo and Rutare. One village per parish was purposively selected based on the intensity of water-logging problems as well as level of bush bean production. Sample selection at village level was based on a list of 500 households provided by the extension workers. The respondents were randomly selected by skipping every two names on the list until 32 persons per village were obtained, making a total sample size of 96.

Data were collected using semi-structured questionnaire which was pre-tested using 10 respondents from a neighbouring Nyakabingo parish. Direct observations were also carried out to validate information provided by the interviewees. Data were analysed using the SPSS (Statistical Package for Social Scientists) Version 16.

3. Results and Discussion

3.1 Ranking of Beans among Major Crops

Common bean was rated as a priority food security and income earner among the mainstream crops grown in the region (Table 1). Therefore, this underscores the extent to which alleviation of water-logging can impact on the socioeconomic welfare of the communities in the region.

This concurs with earlier studies that common bean production in southwestern Uganda (which boarders Rwanda) accounts for 78% of common beans produced in the country.

3.2 Relative Advantages of Bush over Climbing Beans

Bush beans still command an admirable position within the preferences of crop production among the Uganda-Rwanda boarder region despite being constrained by natural stresses such as water-longing. This is attributable to a wealth of advantages particularly against its immediate contestant, the climbing bean (Table 2).

Additional justification for the high ranking of bush beans within the realm of legume crops was that the crop was consumed continuously over its growth stages in the order of: (1) foliage as vegetables at 1.5 months after planting, (2) young pods at about two months old, and (3) as fresh beans at about 2.5 months. In contrast, its closest sister, the climbing bean could only be consumed after at least four months. These findings are in line with those of Spence [11], who reported similar stages of bean consumption and contrasts between bean types. According to the respondents in the present study, early utilisation of bush beans is a necessary complement, while communities await the maturation of the climbing beans. Furthermore, apart from requiring short maturity periods, bush beans do not need stakes unlike their climbing counterparts, which are increasingly in short supply due to environmental degradation and other competing uses such as firewood for cooking.

3.3 Major Bush Bean Production Constraints

Water-logging emerged as the most outstanding constraint to bush bean production in the region (28.9%) followed by disease (19%) and drought (15.6%) (Table 3).

The effects of water-logging manifest variously as stunted crops, chlorotic and total loss of yields (Fig. 1). This loss of yield is caused by the lack of oxygen in the root zone, which reportedly induce serious damage

Table 1 Farmer ranking of major crops grown in the boarder region of Uganda-Rwanda (*n* = 96).

Crop	Percent
Beans	34.1
Irish potato	27.2
Maize	23.0
Sorghum	9.4
Sweet potatoes	4.2
Banana	0.7
Tomatoes	0.7
Cabbages	0.7
Total responses	100.0

Table 2 Advantages of bush bean production against climbing bean types in the Uganda-Rwanda boarder region (*n* = 96).

Reason	Percent
Early maturing	48.0
Do not need stakes	45.2
Good taste	2.7
More demanded on market	1.4
Others	2.7
Total	100

Table 3 Constraints to bush bean production in the boarder region of Uganda-Rwanda (*n* = 96).

Constraints	Ranking (%)
Water-logging	28.9
Diseases	19.0
Drought	15.6
Low soil fertility	14.0
Pests	13.7
Soil erosion	8.0
No coping mechanism	0.4
Others	0.4
Total responses	100

to crops [21].

Other consequences of water - logging are emergence of devastating diseases and pest damage as identified during the study (Fig. 2). *Rhizoctonia* sp. is among the disease-causing fungi that are known to proliferate in beans largely under such conditions [21]. It causes crop failure and colossal yield losses. The effect of the fungus is registered initially *via* the vesicular tissues, sometimes leading to death of lateral roots and the entire plant mass (Fig. 2).

Similar constraints were reported by Spence [11] in a study on beans in the Uganda-Rwanda boarder region which highlighted problems like flooding in valleys, and pests and the diseases.

In order to counteract the effects of water-logging on bush bean production, farmers in the Uganda-Rwanda boarder region used coping mechanisms such as ridging (33.8%), substituting the bush bean with climbing beans (13.5%), fertiliser application after water - logging (12.2%), chemical spraying (10.8%) and construction of channels (10.8%). Other mechanisms used included planting bush beans in upland areas, fallowing, terracing, and timely planting, weeding and mulching (Table 4).

Ridging elevated the soil level and kept the plants away from stagnant water. This practice has also been referred to as molding by Furubayashi et al.[14], raised bed by Bakker et al. [12] and mounding by Spence [11], as a land preparation practice traditionally used for controlling flooding in Kisoro district (Fig. 3).

Farmers' perceptions towards the tolerance levels of various bush bean varieties to water-logging were presented (Table 5). Despite the yield losses due to water-logging, the results of this study showed that farmers continued to plant a wide range of local varieties of bush bean that offer a certain level of tolerance in comparison to other varieties.

Fig. 1 Waterlogged bush and climbing bean fields in Uganda-Rwanda boarder region.

Fig. 2 Incidence of pest and disease in bean fields affected by waterlogging in Uganda-Rwanda boarder region.

Table 4 Coping mechanisms for bush bean production under water-logged soil conditions in the Uganda-Rwanda boarder region.

Coping Mechanisms	Percent (*n* = 96)
Use of ridges	33.8
Replacing with climbing beans	13.5
Fertiliser application	12.2
Spraying	10.8
Construction of water ways	10.8
Planting bush beans in upland areas	5.4
Fallowing	4.1
Terracing	2.7
Recommended plant density	1.4
Timely planting	1.4
Weeding	1.4
Mulching	1.4
No mechanism at all	1.4
Total	100

Fig. 3 Ridging as a coping strategy against water-logging in the Uganda-Rwanda boarder region.

Table 5 Farmers' perception of tolerance level of various bush bean varieties to water-logging in the Uganda-Rwanda boarder region.

Bush bean variety	Percent (*n* = 96)
Nyagakecuru	41.7
Imvange (mixture of many varieties)	23.6
Nyirakabonobono	9.7
Biganza	8.3
Bwanarensi	2.8
Nyirakamuga	1.4
Nyirasarayi	1.4
Kigome	1.4
No answer	9.7
Total	100

There are many types of bush bean in Chahi sub-county which present a certain level of tolerance to water-logging. Though names of many varieties are given by farmers, most of them are found mixed as shown in the above. It was shown that the most resistant varieties to water-logging were Nyagakecuru (41.7%), followed by Imvange (23.6%) and Nyirakabonobono (9.7%). Other varieties although low ranked were Bwanarensi, Nyirakamuga, Nyiramwirasi and Kigome.

Although Nyagakecuru ranked the first in terms of tolerance to water-logging, most of farmers fields were dominated by the mixture of many bean varieties, namely Invange (Personal observation). This can be justified by the fact that the mixed varieties increased the chance of getting good harvest in case of biotic or abiotic stress. This was also observed by Spence [11] who reported that in Kisoro, traditional varieties are grown in mixtures of varieties and farmers have their indigenous criteria to mix the varieties: Beans must be of similar growth habits, simultaneous maturity periods and resistance to abiotic stresses such as excessive rains. Identification of indigenous varieties with different levels of tolerance to water-logging is an important initial finding which could be pursued further by breeders in an effort to enhance the capacity of such materials as well as widen opportunities for improvement of existing high market potential varieties.

4. Conclusions

The main coping strategies for producing bush bean under water-logging conditions in the Uganda-Rwanda boarder area include planting the crop on ridges, construction of waterways (channels), application of fertilizer, and chemicals to control pests and diseases. Additionally, a wide range of bean varieties with a diversity of tolerance to water-logging is grown by farmers most likely as an insurance against possible total crop failure. It is recommended that such tolerance capacities be harnessed by breeders as a strategy for furthering efforts aimed at bolstering productivity of bean materials in the region.

Acknowledgments

The authors are grateful to the Regional Universities Forum for Capacity Building in Africa (RUFORUM) for financial support during this research and the farmers of Kisoro District for their participation.

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