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Yield gap analyses to inform policy on Sustainable Crop Intensification pathways in Uganda

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Abstract

Smallholder potato yields in Uganda are low (<4.7 tha^{-1}) compared to 25 tha^{-1} attainable on-station yields, attributed to: poor quality seed, low soil fertility, pests and diseases, limited knowledge and weak policy environment. Potatoes however represent about half of the total monetary value of crop production in Uganda's Southwestern highlands. Development and policy actors wish to intensify potato systems to sustain rural livelihoods and high population growing at 3.4% per annum. The agronomy study was undertaken to understand how genotype x environment x management interactions affect potato yields at plot, farm and community levels to generate evidence for stimulating policy action relevant to crop intensification. The objectives of the study were to; (1) analyze the magnitude of the yield gap by determining attainable and actual potato yields, (2) establish the resource utilization (land, seed quality and fertilizers) and management practices for potato production (3) develop policy recommendations to largest potato yield to support increase and improve potato production systems in Uganda.

The study was conducted in 2014- 2015 in the highlands of Southwestern Uganda using a total of 283 households in rainfed potato farms surveyed for: production and crop management, access to services and technologies. Households were selected using stratified cluster sampling. Yield data obtained were compared to on-station yields to establish the yield gap. Results show a large yield gaps (60-80%) exist between average farmer and best on-station yield. The results suggest that seed is the major limiting constraint in potato cropping systems. Households using good quality seed potato obtained an average 11.1 tha^{-1} versus 6.4 tha^{-1} for those using poor quality seed. On-station yields reach 25 tha^{-1}. It can be concluded that Uganda has the potential to more than double the yield if an enabling policy environment of increasing access to quality seed for potato is created. This can be through the National Seed Policy to guide production marketing, distribution and access to quality seed for smallholder potato farmers. Sustainable intensification would require easy access to key yield augmenting inputs used in a stepwise approach starting with quality seed and then other complementary inputs.

1 Introduction

It is estimated that Uganda's population will grow by 15.6 million people from 39.3 million between 2015 and 2025 given the current population growth rate of 3.4% per annum, hence creating land pressure (MLUHD, 2013). Production increase will increasingly depend on

improving the existing low yields from the existing croplands as opposed to area expansion. The course of increasing crop yield through sustainable intensification without ecologically destructive agricultural practices is a basis for achieving food demand (Struik and Kuyper, 2014).

Potato is the third most important food crop in the world after rice and wheat, consumed by more than a billion people globally. The average yield in Sub Saharan Africa only reaches 7.8 tha^{-1} while yields of 25 tons are being attained by progressive farmers using best production practices (Schulte-Geldermann, 2013). The demand for potato In SSA is projected to increase by 250% between 1993 and 2020 (Scott *et al*.2000), strengthened by an increasing demand from the rapidly growing urban centers. Potatoes represent about half of the total monetary value of crop production in Uganda's Southwestern highlands (Bonabana-Wabbi et al., 2013). However, smallholder potato yields in this region are low (<4.7tha^{-1}). The large yield gap is attributed to poor quality seed, low soil fertility, pests and diseases severity resulting from continuous recycling of seed, limited knowledge on potato management practices and limited use of potato intensification technologies. The weak adoption of intensification technologies is also attributed to a weak enabling /policy environment in terms of smallholder access to information, credit and quality input-output markets.

Sustainable intensification aims to close the yield gap (YG); the difference between the current actual yields and the attainable yield of the crop in the given agro-ecological environment (Van Ittersum *et al*., 2013). Attainable yield (Yh) is the highest yield achieved through skillful use of the best available technology in a given agro-ecological area (Evans, 1993; Van Ittersum and Rabbinge, 1997). Average actual yield, (Ya), is the crop yield actually achieved by farmers in a given agro-ecological region; the crop being grown under the general management practices commonly used in the region (Cassman *et al*., 2003). Yield gap analysis is useful in identifying regional yield differences and identifying the factors that cause low yields. This analysis will then help identify which key soil and management measures need to be taken to increase yields (Van Ittersum *et al*., 2013).

Yield gap analysis for potato in Uganda will help to identify the factors that limit yields, identify technologies that can help increase yields, and to discuss policy options and interventions that can sustainable intensification of Uganda cropping systems in general and potato systems in particular.

The study was undertaken in southwestern Uganda to understand the factors that affect potato yields at plot, farm and community levels. The objectives of the study were to; (1) analyze the magnitude of the yield gap by determining attainable and actual potato yields , (2) establish the resource utilization (land, seed quality and fertilizers) and management practices for potato production (3) develop policy recommendations to improve potato production systems in Uganda.

2 Materials and methods

2.1 Data types and sources used to determine yield gap factors

An agronomic study was undertaken in 2014- 2015 in the highlands of Southwestern Uganda, (Kabale, Kanungu and Kisoro districts) using a total of 283 households in rainfed potato farms. The 3 districts are the main potato growing areas accounting for 80% of total potato production in Uganda. This region experiences a highly variable climatic pattern, characterized by two rain seasons, with the first season covering the months of March to May. The second season covers September to January and dry season from June to August. Heavy precipitation (836mm) mostly

occurs in the second season compared to 572mm in the first season, thus considered as the main potato growing season in the region.

The households were selected by the government agency, Uganda National Bureau of Statistics (UBOS) for field data collection using random stratified cluster sampling based on the use and adoption crop intensification technologies. The households were surveyed for: production and crop management and access to technologies. Data collected included; potato planting area, variety used, crop density, weed pressure, fertilizer application, disease and insect pest incidence and severity, technology use levels, seed quality and average gross potato yield (Ya). Data collected were used to compute the resource use; land, agro inputs and nutrients based on the actual yields (Ya). Data were also used to determine the yield gap; the difference between attainable and actual yield.

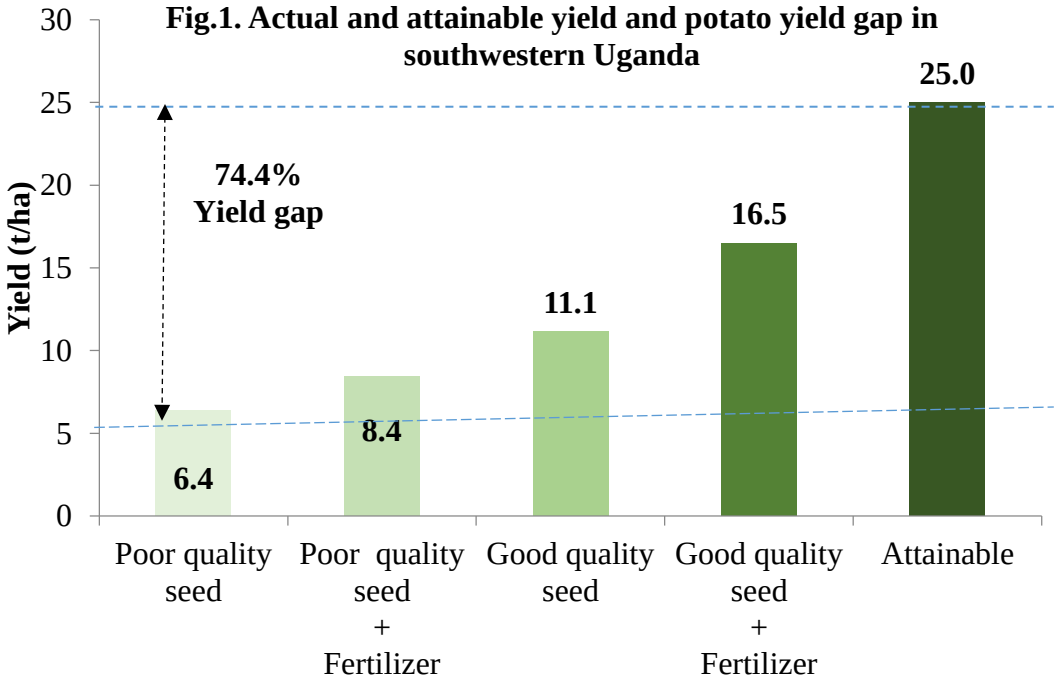
2.2. Data analysis

Data were subjected to analysis of variance (ANOVA) using SPSS version 20 edition statistical package. Mean values of source factors production system identified were tested for significant differences using the F-test at 5% and were separated using the least significance difference (LSD) test at 5% where the F-test showed significant effects.

3 Results and discussion

We observe significant differences ($p < 0.05$) in mean actual yields among the production systems (figure 1). Tuber yield ranged from 6.4 tha^{-1} to 16.5 tha^{-1} per season in the households using improved potato production technologies in the 3 locations. Households with the most technically inefficient system and the lowest level of input use for potato growing in the region obtained significantly lower yields (6.4 tha^{-1}). On the other hand, households with technically more efficient and high levels of inputs use in potato production achieved the highest yields in the region (Figure 1).

Fig.1. Actual and attainable yield and potato yield gap in southwestern Uganda



The study showed that the difference between average farm yield (6.4 tha^{-1}) and attainable yield (25.0 tha^{-1}) results in yield gap of 74% was observed. This reflects a huge potential to increase

potato production. The major underlying factor for the biggest yield gap identified as seed potato quality. Seed is the most elementary input in potato cropping system. Potato yields and response of other inputs in crop production largely depend on the seed materials used for planting. It is estimated that good quality seeds can contribute about 20-25% increase in yield (Gildemacher *et al* 2009). Our results showed that good quality seed potato contributed about 42% increase in potato yield. Use of complementary inputs on poor quality seed potato contributed to $2tha^{-1}$ increase in potato yield while use of good quality seed potato alone led to $4.7tha^{-1}$ increase in yield. A combination of complementary inputs and quality seed potato increases yield by 10.1 tha^{-1} (figure 1). The use of poor quality seed potato is caused by limited availability and access to affordable quality seed potato by smallholder potato farmers. This results into farmers using potatoes saved from previous harvest and recycling of seed potatoes for several cropping seasons without renewing the seed lot from reliable source. Continuous recycling of Seed potato causes seed degeneration due to accumulation of seed borne diseases (Gildemacher *et al*.2007). This practice is commonly referred to as 'negative selection bias', since farmers often retain the smaller potatoes for next seasons' seed, but these smaller potatoes often originate from infected and poorer performing plants. Households that adopted improved crop management practices sustained this over the years.

4 Conclusion

There is high potential to increase potato production in Uganda by narrowing the existing yield gap. While this opportunity is available in different households, it is greatest in households where the technical efficiency is least especially the use of poor seed quality and poor management practices. Hence there is opportunity to more than double potato yields in Uganda through narrowing this gap if an enabling policy environment of increasing access to quality seed for potato is created. Sustainable intensification would require easy access to key yield augmenting inputs such as external nutrients and good quality seed. This requires a stepwise approach starting with quality seed and then other complementary inputs. The National Seed Policy is required to guide production marketing, distribution and access to quality seed smallholder potato farmers, as well as encouraging farmers to improve and sustain their home-generated potato seeds. Enforcement of National Fertilizer policy to is necessary to guide and regulate fertilizer marketing and quality, and enhance fertilizer access and use through improved training and extension on its use and benefits. Last but not least, this improved access to knowledge will also be guided by the new Extension policy, that is building on multi-stakeholder assessment and action on overcoming productivity constraints of key crops in Uganda including the potato.

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