Bringing experts judgments and local knowledge into yield gap assessments: The Sub-Saharan Africa potato case

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Abstract

Potato farmers across Sub-Saharan Africa (SSA) produce on average 12 % of the potential yield and 24 Mg ha^{-1} less than yields obtained in experimental stations as evidenced by this study, that implemented an innovative consultation for assessing potato yield gaps (Y_g), based on modeling and the use of non-published experimental and farm data provided by experts organized in a community of practice (CoP). It also tested a participatory elicitation and analysis of yield gap drivers, conducted through an online survey involving experts in potato research and development in SSA. This describes a unique methodology tested most likely for the first time on potato, that combined modeling and a comprehensive online survey through a community of practice. This initiative intended to overcome the paucity of experimental information required for crop modeling in developing countries. Over twenty-five researchers from ten countries, who provided the data and contributed to the estimation of the crop parameters for modeling, participated in the Y_g analysis conducted. Knowledge and data contributed by the experts were systematized through a novel algorithm duly validated against experimental data by the CoP. Data from ten SSA countries were included in the analysis. The model, developed by CIP, simulates tuber dry mass assimilation and partitioning, based on the light interception and utilization framework. Yield gap drivers were assessed through a 6-month survey co-designed through the CoP and administered through a paid Web-based platform SurveyMonkey which submitted 15 closed-ended questions pertaining to the three major SSA potato agro-ecologies. Further analysis proved that SSA countries (excluding South Africa) could easily increase by 140% the current annual production of 10.8 million metric tons if high quality seed of CIP-derived varieties along with improved management practices were deployed to fill the yield gap.

Keywords: yield gap, yield gap drivers, potato, Sub-Saharan Africa, participatory modeling, community of practice, crop modeling

1 Introduction

Potato (*Solanum tuberosum* L.), the third most important food crop after rice and wheat, is consumed by over a billion people (Devaux et al. 2014; Haverkort et al. 2015). In 2007 global production reached 325 million metric tons and in developing countries it increased faster than any other major crop (FAO 2009). Potato production in Africa doubled from 1994 through 2011, largely due to the increase of cropping area (Devaux et al. 2014). However, food demand is increasing along with global population and average income (Monfreda et al. 2008; Lobell et al. 2009) and this trend will be accentuated in Sub-Saharan Africa (SSA) as this region is expected to account for one half of the world population increment by 2050 compared to one fifth in 1999 (Alexandratos 1999). As yields for cereals such as rice and wheat might level off or even decline in many regions over the next decades (Lobell et al. 2009; Licker et al. 2010; Svubure et al. 2015) potatoes are expected to play a major role in reducing food shortages although farmers' yields in many developing countries are still far from attainable productivity, showing huge yield gaps, particularly in SSA as limiting (water, nutrients and biotic) factors are not fully controlled and farmers do not grow the right varieties and/or seed at the right time.

Fig. 1 An example of potato yield gap in Sussundenga, Mozambique. The high yielding CIP variety Lulimile (CIP381381.13) produced up to 38 Mg ha^{-1} under sprinkler irrigation and fertilization. The control treatment - with the same variety and irrigation scheme but without fertilizers – produced 15 Mg ha^{-1}. The experiment was conducted during the Winter season of 2012.

Although yield gaps in most crops are known by researchers, what is lacking in all studies is how stakeholders perceive yield gap and its major causes, called drivers in this paper. This study tests a participatory methodology that involves key local actors in the elicitation and analysis of those drivers. This methodology is unique as it combines modeling and a comprehensive online survey through a community of practice for the analysis of yield gap and its perceived drivers. We are not aware of any other study of this kind on potato. There is only one global survey involving potato farmers in developing countries but only eight responses out of fifty-five collected pertained to SSA (Fuglie 2007) and its design could not allow a cross constraint analysis.

2 Materials and Methods

2.1 Concepts and definitions

Yield gap (Y_g) is a rather simple concept: quantitative differences between a base-line yield (generally, average farmers' yield) and either attainable (generally, experiment-based yield) or potential yield (Y_p) over some specified spatial and temporal scale (FAO et al. 2015). However, the conceptual framework for its calculation is complex (Lobell et al. 2009; Licker et al. 2010; van Ittersum et al. 2013). The most difficult task is estimating potential yield, which is defined as the yield of a cultivar when grown in environments to which it is adapted; with water and nutrients non limiting; and all biotic stresses effectively controlled (van Ittersum et al. 1997; Licker et al. 2010; Haverkort et al. 2015). Potential yield is relevant to crops and environments where irrigation, the amount and distribution of rainfall, or a combination of irrigation and rainfall ensure that water deficits do not constrain yield (FAO et al. 2015). In case of rainfed systems, where non supplemented water deficits occur, the Y_p is substituted by water-limited potential yield (Y_w) (Lobell et al. 2009) (Lobell et al. 2009; van Ittersum et al. 2013). Since Y_p (or Y_w) determination depends on a number of biophysical variables that are not precisely measured and controlled in the field, they are more a construct based on a number of assumptions rather than a measurable property and its best assessment requires integrative methods such as remote sensing, geospatial analysis, simulation models, combined with field experiments and on-farm validation (Lobell et al. 2009). Three techniques are normally used to estimate potential yields (Lobell et al. 2009): (i) model simulations, (ii) field experiments, and (iii) yield contests and maximum farmer yields. Among these techniques, modeling is the most reliable (Hochman et al. 2013; Lobell 2013; van Ittersum et al. 2013) and thus the approach adopted in this study. In the literature, potential yield from simulations is defined as the 90th percentile yield achieved for a given climate/cropping season. Nevertheless, the task is not that easy in most developing countries where historical field data is limited or no experiments with sequential sampling to estimate model parameters exist. Thus, innovative approaches to overcome the problem of absent information are required.

Yield gap analysis measures untapped food production capacity (Lobell et al. 2009; van Wart et al. 2013; Grassini et al. 2015) but most Y_g analyses have been conducted on cereals (van Wart et al. 2013; Grassini et al. 2015) with limited information on other crops like potatoes. In this study we express Y_g in Mg ha^{-1} as the difference between a given base-line yield and potential yield (Lobell et al. 2009; van Ittersum et al. 2013; Haverkort et al. 2015), base-line yield being either experiment-based yield (Y_r) or average farmers' yield (Y_f) for both, rainfed (water limited) and irrigated conditions. Thus, several yield gaps could be discerned. The yield gap which is the difference between attainable yield (which in this study is the relevant experiment-based yield) to potential yield is hereafter named research yield gap whereas the yield gap derived from the difference of average farmer's yield (in a particular location) and potential yield is termed absolute yield gap. In important practical terms, the difference between average farmer's yield to attainable yield is named farmer's yield gap, which is the one generally addressed in most agronomic work. Thus, estimated yield gaps are function of the crop, geospatial and temporal dimensions, and the methods used for the assessment (Hochman et al. 2013) and the scale and the aims of the work intended to close them.

2.2 Framework for participatory yield gap assessment

This study developed an innovative consultation approach for yield gap assessment in the SSA region, based on synergies between modeling techniques and historical non-published data of potato experiments provided by potato experts organized in a community of practice (CoP). To overcome the paucity of experimental information required for crop modeling in developing countries (Grassini et al. 2015), a four stages protocol was established: (1) The development of a routine within the Solanum model (Condori et al. 2010; Condori et al. 2014) capable of translating expert knowledge on the crop into model parameters; (2) Participatory work and modeling with experts to estimate Y_r, Y_p, Y_w and Y_g; (3) Field experiments to confirm the Y_r and parameters estimated with experts for Africa; and (4) Online survey to identify perceived yield gap drivers for potato production in Africa. The details of stage 1 are out of the scope of the present paper and will only be succinctly described here. The method to estimate growth parameters from expert knowledge is based on allometric and heuristic procedures and uses the relationship between aerial and tuber partitioning crop growth functions. As can be seen in stage 3, the estimation made by experts was successfully validated with field trials indicating that model parameters can be reliably estimated with participatory modeling.

2.2.1 Participatory modeling

Over twenty-five experienced breeders and field researchers from ten countries, who provided the data and contributed to the estimation of the required crop parameters for modeling, participated in the second stage. Although the methodology, once validated can be implemented online through facilitated webinars, face-to-face workshops were implemented to discuss the framework and go through the process with model developers. Two workshops were conducted for stage 2 - Nairobi, Kenya on 24 - 26 June 2013 and Addis Ababa, Ethiopia on 14 - 18 October 2013 - combining both theory and hands-on exercises, and introducing the concepts and modeling tools to participants. They were acquainted with the following subjects: (i) Yield Gap and Systems Analyses, (ii) Weather data management, (iii) Parameter estimation, and (iv) Crop modeling. Participants produced their own yield gap results, subsequently validated against their own field data and expert knowledge. As an outcome, the community of practice (CoP) on potato yield gap in SSA was established.

Knowledge and data contributed by the convened experts were systematized through the Parameter Estimator, which was a response to the lack of data pervasive in developing countries (Hochman et al. 2013) where historical breeding data are seldom available. Data from ten countries from West Africa, Eastern and Central Africa and Southern Africa were included in the analysis of yield gap. Participating countries were taken from a targeting study based on the local importance of potato crop and a composite indicator of livelihoods, previously conducted by the International Potato Center (CIP) and partners, to identify the priority countries in Africa for investment in potato research and innovation to reduce poverty and hunger (Thiele et al. 2010; Devaux et al. 2014). These countries (and the locations within countries) were Burundi (Rwegura), Cameroon (Fongo-Tongo), Democratic Republic of Congo (Mulungu), Ethiopia (Adet), Kenya (Tigoni, Kabuku, and Kabete), Madagascar (Mimosa), Mozambique (Sussundenga), Nigeria (Kuru), Uganda (Kalengyere) and Malawi (Bembeke). Site geo-referencing was carried out using the coordinates given by participants who then validated the exact position in Google Earth, making adjustments when necessary. Simulations of potential yield included twelve potato genotypes evaluated by different scientists: Victoria (CIP381381.20, also called Asante or Victoria), Dosa, Guassa (CIP384321.9), Gudene (CIP386423.13), Kenya Mpya (CIP393371.58), Unica (CIP392797.22), Meva (CIP377957.5), Lulimile (CIP381381.13, also called Tigoni), Diamant, CIP395112.9, CIP396038.107 and CIP396036.201. All these materials belong to the CIP germplasm except two, Dosa grown in Cameroon and Diamant grown in Nigeria. Local farmers grow all the first nine genotypes listed here.

Planting and harvest dates, emergence day, days to reach 1% canopy cover, days at maximum canopy cover, maximum canopy cover index, days at maximum canopy cover, days at physiological maturity and, optionally, days at tuber initiation were the input data provided by experts to estimate sets of site-specific parameters of the model by variety and site. Participants also provided daily temperature and solar radiation data for modeling potential yield. NASA data were downloaded from their Website (here) when gauge data were unavailable. Working groups discussed the estimated parameters until they reached a consensus.

The Solanum model used to estimate Y_p and Y_w was developed by CIP (Condori et al. 2010; Condori et al. 2014; Fleisher et al. 2016). It simulates tuber dry mass assimilation and partitioning for different potato species (*Solanum* sp.), varieties and hybrids following principles of crop physiology. Based on the light interception and utilization (LINTUL) framework extensively described in the literature (Kooman et al. 1995; van Ittersum et al. 2003; Condori et al. 2010; Harahagazwe et al. 2012; Condori et al. 2014; Haverkort et al. 2015; Svubure et al. 2015) the model estimates tuber yield under non limited, water limited, and frost limited growing conditions. Site-specific sets of parameters were selected and used for potential yield simulations.

Yield gap estimations involved average attainable yields obtained in previous field trials by participating researchers, average farmers' yields and potential yields generated by simulations. FAOSTAT datasets for Africa since 1961 through 2014 comprising area harvested, total production and average yield (FAO 2016) were downloaded and used for comparison. Participants provided average farmers' yields from the neighborhood of their experimental sites/research stations. Sources for average farmers' yields varied but the major sources cited were the Ministries of Agriculture, FAO, own surveys, scientific papers and other reports. Scientists recognized the challenge of obtaining accurate information on farmers' yields.

2.2.2 Parameter validation

Five scientists conducted field experiments in their respective countries, under the same design and data collection protocol. Yield simulations based on parameters calculated using the tool was also evaluated in a workshop held at Entebbe, Uganda on 15 - 19 December 2014 against measured data, to confirm the accuracy of the tool in SSA. Experimental data from 4 countries and 11 varieties in Cameroon, Democratic Republic of Congo, Kenya and Uganda were used. Simulated and observed yield comparison showed an RMSE=5.99 using parameters estimated with standard procedures and an RMSE= 7.64 using the parameter calculator tool. The workshop was also used to develop a preliminary list of major drivers of the difference between researchers and farmers' yields. The list was thereafter shared for enrichment through the CoP to form the basis for the identification of yield gap drivers in stage 4.

2.2.3 Determination of potato yield gap drivers

Yield gap drivers in SSA were assessed through a 6-month paid Web-based platform survey called SurveyMonkey (Stage 4). This tool allows reaching out a wider audience and getting real-time results (Parsa et al. 2014). The survey comprised 15 closed-ended questions aimed at knowing the general opinion on current potato yields and rate the importance of thirty yield gap drivers previously identified through a CoP. Three dominant agro-ecologies where potato is grown were considered: tropical and sub-tropical highlands (over 1800 masl), tropical and sub-tropical mid elevation (less than 1800 m) and sub-tropical lowlands (winter potato found in Southern Africa).

Participants rated each of the thirty yield gap drivers using a Likert scale of 1 to 5 where 1 indicated *Not important* and 5 *Very important* (Parsa et al. 2014). Question Skip Logic feature of SurveyMonkey was enabled in order to customize respondents experience over specific agro-ecologies. The questionnaire comprised technical questions and non-identifying personal information, including current country base, sex, education degree, experience on the crop in SSA and area of expertise. The survey was uploaded in English, French and Portuguese, languages spoken in the target countries.

The survey went live on 8 April 2015 after a test period of several weeks and remained online for almost 6 months. It was administered through focal points in each target country as suggested by similar studies (Fuglie 2007; Parsa et al. 2014). Access to the survey required a password provided to invited potential respondents since the study was based on expert's judgement. The invitations were extended to 13 SSA countries (Angola, Burundi, Cameroon, Democratic Republic of Congo, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania and Uganda). In addition, people with long experience in potato research in SSA were invited even though they were no longer living in the region.

Prior to the analysis, data accuracy and quality check were conducted and non-complying responses were disregarded. The consistency of the ordinal responses to the questions in the survey was assessed through Cronbach´s Alpha (Cronbach 1951). This index establishes the relationship between the variability of responses to each question and variability of the surveys. In the case all the answers to a particular question were the same, they are deemed uniform and the variance equal to zero. In that case the index would approach the unit, weighted by $k/(k-1)$, where k would be the number of questions. On the contrary (i.e. total lack of uniformity), the index would approach zero or less than zero in special cases.

Likert scores were then analyzed using ordinal regression (McCullagh 1980; Anderson 1984) to link the categorical responses to a list of pre-defined factors known to limit potato productivity and determined those perceived as of high or low importance for each agro-ecology. Conditional probabilities for the categorical variable (scores) were estimated for each driver within agro-ecologies. To do that an ordinal regression model of the logit – i.e. the natural log of the ratio of the probability that the event occurs to the probability that the event does not occur a.k.a odd - as a function of the explanatory factors (scores) was run to estimate the regression coefficients. These coefficients were used to estimate the conditional probabilities as per McCullagh (1980). Five probabilities for each driver in each agro-ecology were computed. The probability associated to score=3 or P(3) was considered neutral. The probability that a driver was perceived as not important P(1) or somewhat important P(2) were added to build an overall low importance probability (P_{low}). By the same logic P(4) and P(5) conformed the high importance probability (P_{high}). Note that a probability equals to 0.34 will show the dominance of one of the three possibilities: P_{high}, $P_{neutral}$ and P_{low}. To define whether a driver was perceived as of low, neutral or high probability a very high cut off point of P=0.60 was assigned to minimize the chance of misinterpreting perceptions.

3 Results and discussion

3.1 Magnitude of potato yield gaps in SSA

Figure 2 summarizes simulated potential yields, the best historical yields obtained at on-station experiments and the average farmers' yields. Regardless of the genotypes, seasons and sites, average yields turned to be 66.35 (+/- 2.52) Mg ha^{-1} for potential yield, 31.15 (+/- 1.87) Mg ha^{-1} researcher yield, 8.02 (+/- 0.71) Mg ha^{-1} as average farmers' yield, figures from which the absolute yield gap was estimated to be 58.33 Mg ha^{-1}. These results are consistent with relative yields that ranged from 8 to 35% found in Zimbabwe using LINTUL-POTATO Model (Svubure et al. 2015). Large yield gaps in the context of African smallholder farmers were already reported in the literature but with focus on cereals (Tittonell et al. 2013). For example, global actual yields for maize are reported to be around 50 % of the potential yield (Neumann et al. 2010) against 20% in Africa, which is due to biophysical and management conditions (Lobell et al. 2009). The analysis of yield gap is furthered if we made a difference between the farmers' yield and the researcher yield (attainable yield) previously defined as farmer's yield gap. In our study, the farmers' average yield gap was 23.54 Mg ha^{-1} and this is the gap that the extension and advisory systems try to close. On the other hand, the average researcher gap – the difference between potential yield and yields obtained by researchers – was 35.20 Mg ha^{-1} (Fig. 2b) This is the yield gap that researchers try to reduce through introduction of genotypes, better control of all factors impinging on productivity, and higher performance in terms of resource use efficiency.

With an average farmers' yield (5-year period, 2010-2014) of 10.3 Mg ha^{-1} provided by FAO (2016) and assuming an average reduction of 30% when extrapolating experimental plot yield to farm yield (Jean-Francois Ledent, Personal communication), SSA countries could easily increase by 140% the current annual production of 10.8 million metric tons if improved varieties and management practices were deployed to address yield gap drivers outlined in the next section. In the most optimistic scenario of closing yield gaps by rising the farmers' yields to 60% of the potential yield – meaning a Y_f/ Y_p ratio of 0.6 as achieved so far in the Netherlands and Unites States of America (Haverkort et al. 2015) - the current annual total production in SSA could be 37 million metric tons, i.e. over threefold, without expanding the production areas. Closing yield gaps with climate resilient strategies is one of the successful pathways that would allow to meet the twin challenges of food security and environmental sustainability (Foley et al. 2011) in SSA.

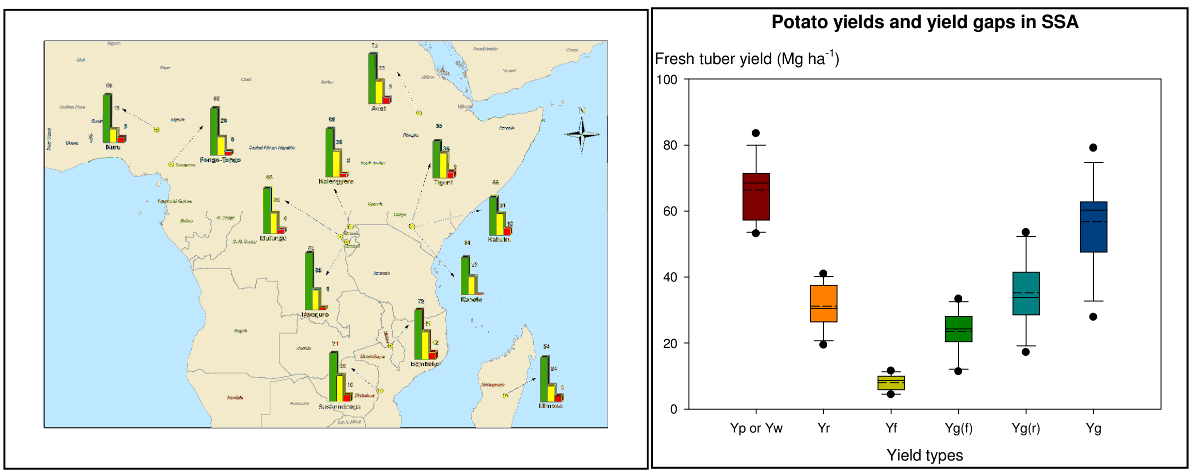

Fig. 2 Levels of potato yields and yield gaps in selected sites of Sub-Saharan Africa. (**a**) georeferenced graphs showing Y_p , Y_r and Y_f ; (**b**) boxplots. The X-Axis presents the following yields: Y_p=potential yield, Y_w=water-limited potential yield used for Winter potato (Bembeke and Sussundenga), Y_r=maximum yield attained by researchers, Y_f=actual yield obtained by farmers, $Y_{g(r)}$=research yield gap, $Y_{g(f)}$ =farmers' yield gap, Y_g=absolute yield gap where $Y_g=Y_{g(r)}+Y_{g(f)}$. Lines within boxes show the medians (solid line) and means (dashed line), and the boxes and whiskers represent 25th to 75th and 10 to 90th percentiles, respectively. Green, yellow and red graphs on Fig. 2a represent Y_p or Y_w, Y_r and Y_f, respectively.

3.2 Perceived potato yield gap drivers in SSA

During the 5 months and 20 days that lasted the survey, 119 responses were collected from 19 countries (13 from Africa and 6 from other continents) and only 10 responses were not useful for analysis. Out of the 109 valid respondents, only 12% were females, showing a gender imbalance in potato research and development in Africa. Respondents reported to work in research (71.4%), rural development/government (29.4%), NGOs (17.6%), private sector (10.8%) and others (5.9%). Scientists experience were in Agronomy (52.9%), Seed production (69.0%), Extension (37.9%), Breeding (37.9%), Phytopathology (34.5%), Storage and processing (16.1%), Crop modeling (10.3%) and Socio-economics (10.3%). Since the study was based on expert's judgement, 73.3% of respondents had the minimum of MSc level and 48.6% of respondents had a minimum work experience of six years on potato.

A high consistency of all the Likert-based responses was evidenced by a Cronbach´s alpha value of 0.94. On their opinion regarding potato yields in SSA, 65.2% of respondents replied that they were not satisfied. Out of the thirty drivers assessed, thirteen turned to be the most explanatory ones for farmers' yield gaps (Table 1). With regard to the top yield gap driver, poor quality seed was ranked first with a very high probability. The expected probability of experts rating poor quality seed as an important or very important problem is at least 95 out of a 100 times, with small changes over agro-ecologies. It is worth mentioning that seed borne diseases such as Bacterial wilt and viruses were deliberately separated from the seed driver for mainly two reasons. First of all, they are not the only determinants of a seed tuber quality. Also, perceptions from respondents on diseases-related drivers are based on visible observations in the field and not on laboratory tests. Seed quality as a potato yield-limiting factor has been extensively reported (Thiele 1999; Fuglie 2007; Schulte-Geldermann et al. 2012; Kaguongo et al. 2013; Haverkort et al. 2015; Thomas-Sharma et al. 2016). What was not documented so far was the quantified perception that practitioners had about its importance in SSA in a cross-analysis of drivers with data from a large number of respondents. Haverkort et al. (2015) defined quality seed as being seed tubers of good physical characteristics, the right physiological age and the best possible health. In a study conducted in Argentina, tuber yield was found to be correlated with the physiological age of seed potato which is a combination of several factors, including types of cultivars, seed origin, haulm killing date, storage conditions and pre-planting treatments if any (Caldiz 2000). These results are consistent with CIP's decision to include quality seed potato in SSA as one of the six strategic objectives of its new Strategy and Corporate Plan (Devaux et al. 2014).

Bacterial Wilt - caused by *Ralstonia Solanacearum* (Smith 1896; Yabuuchi *et al*. 1996) - is the second most important driver with also a high probability, which corroborates earlier findings that this disease is the most disturbing biotic constraint in SSA (Lemaga et al. 2001; Fuglie 2007). However, strategies for its control exist and are especially effective when they are part of an integrated approach. These strategies include clean seed potato, pathogen free soil, removal of wilting and volunteer plants, appropriate crop rotation systems with non-host plant species, negative/positive selection techniques and other agronomic practices. For example a severe Bacterial Wilt incidence in Burundi was almost eradicated from 60% to 0.7% as a result of integrated approach (Berrios et al. 1993). Other perceived drivers were listed but with much less probability. On the other hand, presence of clouds that reduce incident solar radiation, frost, hailstorms or salinity were consistently perceived as not important. The expected probability of rating these drivers as not important or somewhat important was less than 76 %. Not listed drivers did not exceed the cut off point for high or low importance in any of the agro-ecologies.

Table 1 Probabilities of highly important and less important potato yield gap drivers in SSA

Drivers	**Highlands (Tropical and sub-tropical, n=66)**	**Mid-elevations (Tropical and sub-tropical, n=46)**	**Lowlands (Sub-tropical, n=27)**
	High importance		
Poor quality seed	0.9598	0.9611	0.9639
Bacterial wilt	0.9001	0.9032	0.9097
Poor soil health	0.7545	0.7608	0.7745
Late blight	0.7455	0.7519	0.7661
Lack / inappropriate use of fertilizers	0.7352	0.7418	0.7564
Viruses	0.7083	0.7154	0.7308
Soil amendments (sub-optimum use)	0.7007	0.7079	0.7236
Varieties with low yielding ability	0.6910	0.6983	0.7143
Pests (Aphids, Leaf miners, Potato Tuber Moth)	0.6725	0.6800	0.6965
Farmers knowledge	0.6292	0.6371	0.6548
Poor timeliness of operation	0.6143	0.6223	0.6403
Lack of access to market			0.6083
	Low importance		
Too much and persistent clouds	0.7649	0.7588	0.7443
Frost	0.7536	0.7472	0.7323
Hailstorm	0.7204	0.7135	0.6974
Salinity	0.6445	0.6367	0.6185

n=number of respondents

4 Conclusion

The use of modeling tools was crucial for achieving the study goals. The workshops facilitated the creation of a CoP and the integration of knowledge as the methodology was streamlined and validated. The first two workshops built modeling capacities, evaluated the modeling tools, promoted feedback on the tools, allowed their improvement and provided an opportunity to discuss preliminary results of the yield gap analysis. Field trials demonstrated that participatory modeling with potato experts can generate model parameters comparable to those estimated through experiments with sequential harvests. The validated methodology can be implemented with online tools to substitute costly face-to-face workshops. The participatory approach through a CoP proved to be effective for accessing a wealth of knowledge and data possessed by potato scientists in SSA without which this study was not possible but it requires patience, perseverance and soft facilitation skills. Potato production in Africa is steadily growing, including its contribution to global production. This trend is expected to continue due to increased demand induced by fast population growth and urbanization, land availability and extremely high potential to increase yields as was demonstrated by this participatory methodology. This methodology was unique in the sense that it combines modeling and a comprehensive online survey through a CoP for the analysis of yield gap and its perceived drivers, and this is probably the first study of this kind on potato. With a farmer's productivity of 12% of the potential yield in SSA, there are no doubts these gaps could be reduced with sound technological, service delivery, policy, infrastructure and capacity building interventions. This study has contributed to shedding light to top thirteen yield gap drivers that need attention in a bid to increase productivity. Farmers' yield gaps can be significantly filled through an integration of three leverage interventions: clean seed, optimum fertilization and smart use of pesticides.

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