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Assessment of production practices of smallholder potato (*Solanum tuberosum* L.) farmers in Wolaita zone, southern Ethiopia

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Abstract

Background: Potato plays a great role for the achievement of food security program due to its plasticity to environmental conditions and yielding capacity. However, its productivity is far less than other countries due to constraints threatening subsistence farms in Ethiopia. Therefore, potato production practices by smallholder farmers were assessed in Wolaita zone of southern Ethiopia to identify major factors constraining production of the crop. Data were collected at two stages, *i.e.*, at a pilot survey and the time of basic data collection. Descriptive statistics, multiple linear regression, and index ranking were used to analyze the data.

Results: The descriptive statistical revealed that smallholder farmers have very small land (about 0.5 ha per household). Low access to and high prices of seed tubers of improved potato varieties (>0.25 USD kg^{-1} seed tubers) and scarcity of information on good fertilizer management practices for producing the crop with only a blanket rate of 147 and 135 kg ha^{-1} of urea and diammonium phosphate, respectively, limit potato production in the area. Furthermore, prevalence of diseases and low market prices of tubers at harvesting, but too expensive during planting period are the major constraints of potato production in the zone. In addition, results of the multiple regression analysis indicated that the occurrence of natural hazards, seeding rate and expensive price of improved seed tubers were important factors significantly influence potato productivity in Wolaita area. Likewise, disease problems, low market price of potato at harvesting time, storage problems, and lack of seed tubers were the four major constraints identified by index ranking.

Conclusions: Results of this study revealed that potato production is constrained by a number of factors among which diseases, storage problems, low market prices of tubers at harvest, and insufficient quality seed tubers for planting were the four major constraints challenging potato production in the study area according to the index ranking method.

Keywords: Constraint, Identification, Productivity, Survey

Background

Potato (*Solanum tuberosum* L.) contributes to world food security and has a critical role to play in developing nations facing hunger. It supplements or replaces grain-based diets where rice, wheat, or maize availability has lessened or price has become unaffordable [1]. Potato is also inexpensive to buy and easy to grow. It can give stable yield under conditions where other crops might fail, suitable to grow where land is limited and labor is plentiful [2]. Its plasticity to environmental conditions and yielding capacity also make it the best crop for food and nutrition security [3]. Potato ranked fourth in the world in terms of the volume of production after rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), and maize (*Zea mays* L.) [4]. It is also the most important tuber crop, ranking first in volume produced among root and tuber crops; it is followed by cassava (*Manihot*

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esculenta Crantz), sweet potato [*Ipomoea Batatas* (L.) Lam], and yam (*Dioscorea* spp.) [5].

The demand for potatoes continues to increase in conjunction with expanding diet diversity, requests for prepared food items, and a need for inexpensive foods. The ability to grow potatoes in a wide range of climates and their adoption by a broad range of cultures has increased potato consumption worldwide [6]. Therefore, potato is currently the predominant vegetable in terms of sales, production, and consumption [7]. It is the most important crop in developing countries, and its production is expanding more rapidly than other food crops [8]. As a result, it is becoming an increasingly important source of rural employment, income, and food for growing populations [9].

Potato is produced mostly for local consumption and local markets in Ethiopia and Cameroon. It might be a very important crop in this region and accounting for per capita production values as low as zero in some cases. Its production in Ethiopia, for example, is 0–45 kg per capita [10]. It is a crop that can be used to improve food security and cash income in Ethiopia. Because it is high yielding ability in a short season, presence of suitable agroecological zones within the country, the availability of labor for its production on large areas of land, and the accessibility of a potential market with considerable added value for its produce [11]. According to FAOSTAT [12], area under potato cultivation was about 51,698 ha in 2005/6 that produced 509,716 tonnes of tuber yields; currently, in 2014/2015, area under potato crop has increased to 67,362 ha and its productivity is about 921,832 tonnes in Ethiopia. Its national productivity is 13.7 t ha^{-1} in the production years of 2014/2015 [12] which is still far less than that of other countries such as New Zealand (50.2 t ha^{-1}) and North America (41.2 t ha^{-1}). Even yield potential of potato has been reported to reach about 100 t ha^{-1} [13].

Potato is produced twice a year. The bulk production is during *Belg* (a short rain season, March–June) season, whereas small production takes place during the *Meher* season (a long rain season, July–October) in southern Ethiopia. Rural households in the potato-growing areas of this region have less than 1 ha [14].

According to CSA [15], mean potato farm in Wolaita zone was as small as 0.025 ha HH^{-1}. During the 2014/2015 main production season, potato is the third important tuber crop in production volume next to taro [*Colocasia esculenta* (L.) Schott] and sweet potato [*Ipomoea Batatas* (L.) Lam] in the zone. Its productivity in the zone was 19 t ha^{-1} [15], which is a bit greater than its national productivity (13.7 t ha^{-1}).

Many constraints threaten production of potatoes on subsistence farms. As both its edible and reproductive part of potato is the semi-perishable tuber, diseases can easily be accumulated with each planting season and can dramatically reduce its yielding potential. Formal seed potato production systems produce disease-free, laboratory-tested mini-tubers to provide quality planting materials. However, the formal system in Ethiopia only accounts for 3% of seed produced [4]. It is also easily susceptible to damage and cannot be stored longer conventionally. Several other constraints such as traditional potato production system, shortage of clean seed tubers of improved varieties, limited knowledge on postharvest handling of the produce, and poor technology transfer systems also hinder its productivity in the country [4]. As a result, actual potato yields have been far below its potential yields in Ethiopia.

There is a little area-specific information on the production practices of potato in the study area. Therefore, assessing potato production practices is important to identify the major constraints and tackle the problems in the future. The objective of this survey was, therefore, to assess production practices of potato by smallholder farmers in the zone to elucidate and document major constraints of producing the crop.

Methods

Description of the study area

The study was conducted in Wolaita zone (Fig. 1) during the 2014/2015 growing season. It is located between 037°35′–037°58′E and 06°57′–07°04′N [16]. The population of Wolaita zone is about 1,808,548, of which 49.1% are male and 50.9% are female. About 17.3% of the population of the zone live in towns and the rest accounting for about 82.7% live in rural areas. The annual population growth rate of the zone is 2.3%, and it is one of the most densely populated areas in the country with a mean of 385 people per km^2 [17]. The zone covers an altitude range of 700–2900 m above sea level, having a bimodal rainfall: small rains from March to May and heavy rains during the months of July and August. The last thirteen years' (2003–2015) mean annual rainfall and temperature were 1580.0 mm and 20.1 °C, respectively, while the mean relative humidity of the area was as high as 70.4% during the month May but lowered to 30.3% during the month of December (see Additional file 1) [18]. The area is divided into three ecological zones: *Kola* (lowland <1500 m above sea level), *Woina-Dega* (mid-highland 1500–2300 m above sea level), and *Dega* (highland >2300 m above sea level). Most of the area lies within the mid-highland agroecological zone. Soils of the zone are varying due to its diverse topography. The dominant soils of the zone are reported to be Nitosols [19], which are sesquioxidic and moderately to strongly acidic [20]. The predominant farming system of the study area is a mixed

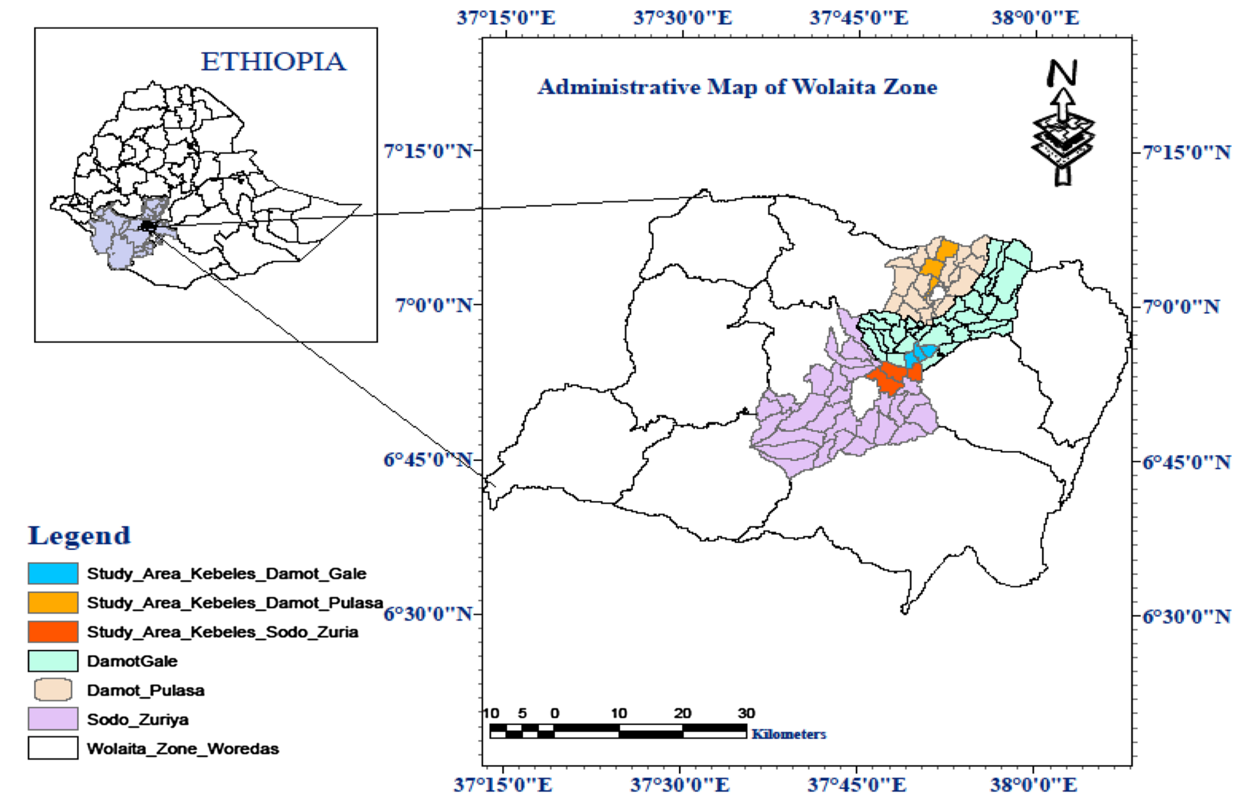

Fig. 1 Location of the study area

farming system with the main food crops of maize (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), sweet potatoes [*Ipomoea batatas* (L.) Lam.], and ensete [*Ensete ventricosum* (Welw.) Cheesman], while Irish potato (*Solanum tuberosum* L.), tef [*Eragrostis tef* (Zucc.) Trotter], coffee (*Coffea Arabica* L.), and ginger (*Zingiber officinale* Ros.) are among the cash crops cultivated in the zone. Cattle, sheep, poultry, and donkey are the main livestock types.

Sampling procedures and sample size

The study was conducted in nine *kebeles* (lowest administrative units) in Sodo-Zuria, Damot-Gale and Damot-Pulasa rural districts where potato is grown intensively. The population for the study consisted of the household heads, especially men and women.

A purposive sampling technique was adopted to select three *kebeles* in Sodo-Zuria rural district, namely Kokate, Dalbo-Wagane, and Dalbo-Atwaro; three *kebeles* in Damot-Gale rural district, namely Shasha, Fate, and Chocha; and three *kebeles* in Damot-Pulasa district, namely Golo-Shanto, Tontome-Menta, and Lera (see Fig. 2; Additional file 2). The number of farmers (n) to be selected from each *kebele* was calculated as sample size by using a simplified formula of Yemane [21]:

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

where $n =$ sample size, $N =$ population size, and $e =$ level of precision (0.05).

Head households were selected by systematic sampling technique, dividing N by n ($N/n = i$), and every ith head of the household was selected starting from the first name of the head household based on the list at their *kebele* level. The first household was obtained by a lottery method out of the i ranges accordingly. The percent of sampled population (C) was computed using the formula as stated by Boyd et al. [22]:

$$C = \frac{n}{N} \times 100 \quad (2)$$

where n = number of selected farmers and N = total number of farmers in a district.

I brought the permission letter from Wolaita Sodo University to the Agricultural Office of Wolaita zone; the zone also gave me a letter to give it to the study districts; the districts as well write letters to the respective study *kebeles*. Accordingly, the participants were volunteer and which is consent to participate by proxy.

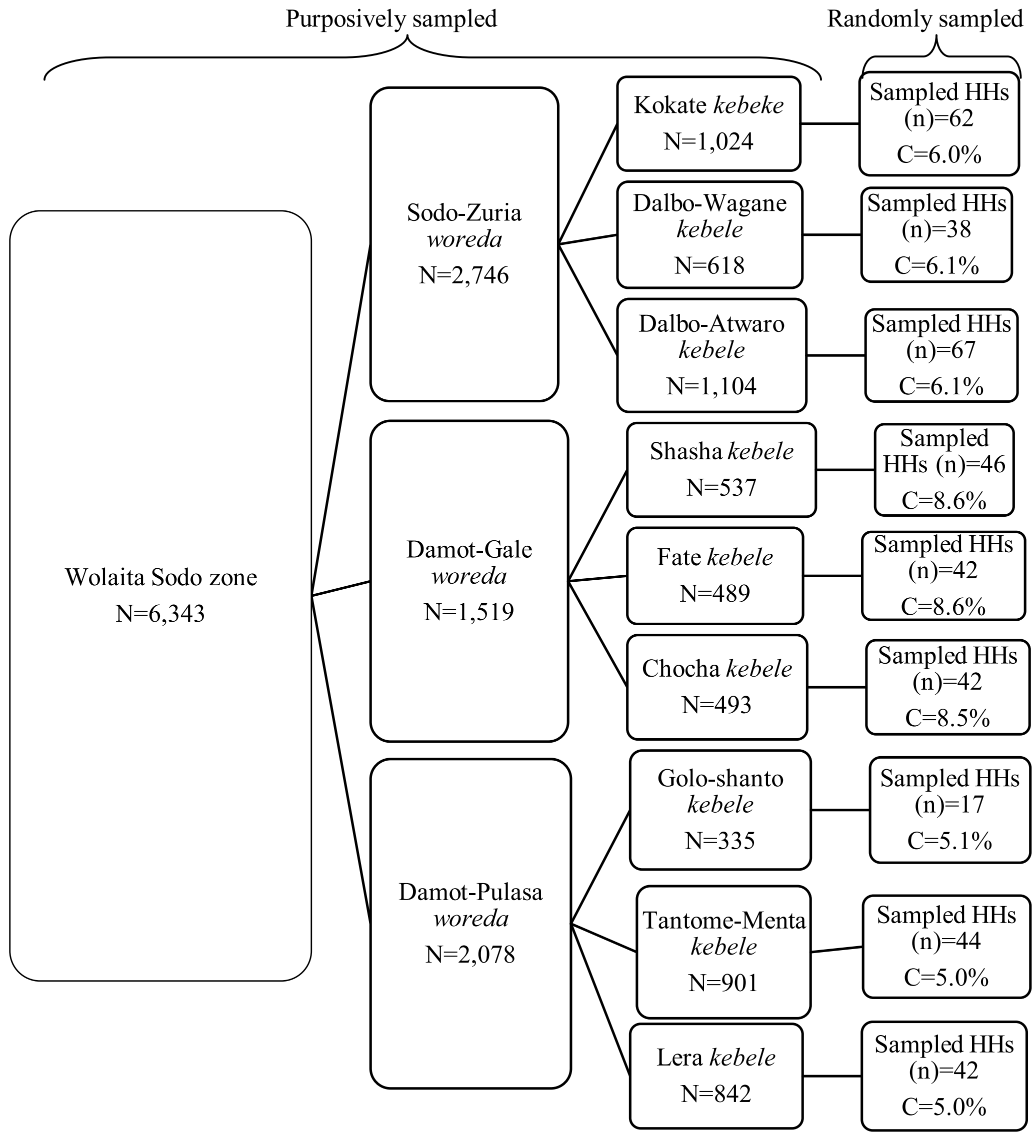

Fig. 2 Total *kebele* households, sampled households, and percentage of sampled households

The primary data were collected by using a structured questionnaire (see Additional file 3). This was conducted in two stages. The preliminary (pilot) survey was very important to obtain general information about the *kebeles* and for familiarization and introduction of the study objectives to the *kebele* administration. During the preliminary survey, a list of relevant guidelines and questions were used to guide the discussions with the focus groups and key informants. To ensure validity, ten to fifteen members from each *kebele* were interviewed. The main reason of pretesting was to identify any shortcomings and assist in making modifications in some questions before the actual data collection.

The second stage was the basic data collection. These data included information of households on demographic characteristics, production experience, production efficiency, use of appropriate production practices (source and selection of improved varieties, recommended spacing, soil fertility management, pest control methods, postharvest handling activities, and decision making by gender on production and utilization of potato). It also involved the observation method. The observed data on what was happening in the field and potato storage and general appearance of the area were noted in a notebook for additional information.

Open-ended questions were added to investigate deeply for additional insights into the information collected. Secondary data were obtained from reports and other documents from various offices of bureaus of agriculture at different levels.

Data analysis

Data were analyzed using the Statistical Package for the Social Science (SPSS, version 16) (see Additional file 4). The important descriptive statistical measures such as percentage, frequency, and mean were used to summarize and categorize the research data.

The multiple linear regression analysis was used between average yield (t ha^{-1}) as a dependent trait (Y) and other studied variables as independent variable (X) to study the effect of each variable on productivity of potato under smallholder farmers in the study area.

Furthermore, major constraints in production practices of potato were ranked by using index ranking that employed using the formula:

Index = sum of (8 × No of household head ranked 1st + 7 × No of household head ranked 2nd + 6 × No of household head ranked 3rd + 5 × No of household head ranked 4th + 4 × No of household head ranked 5th + 3 × No of household head ranked 6th + 2 × No of household head ranked 7th + 1 × No of household head ranked 8th) for each constraint divided by sum of (8 × total No of household head ranked 1st + 7 × total No of household head ranked 2nd + 6 × total No of household head ranked 3rd + 5 × total No of household head ranked 4th + 4 × total No of household head ranked 5th + 3 × total No of household head ranked 6th + 2 × total No of household head ranked 7th + 1 × total No of household head ranked 8th) for all constraints mentioned.

Results and discussion

Demographic characteristics of households

Most (88.8%) of the interviewed head of households were men while the rest (11.2%) were female household heads who are widows or divorced (Table 1). Household resource leaders are mostly males as the case in other African countries. For instance, Muthoni et al. [23] reported that over 60% of the farmers interviewed were men in their study in Kenya.

About 63.5% of respondent households were within the range of working age (15–65 years old), whereas 36.5% of them were elder (>65 years old) (Table 1). This might be related to the fact that effective and independent workers who are known to possess the physical strength required for crop production are found in this age category. Similarly, Negasi et al. [24] reported that onion production in the rift valley areas of Ethiopia is mainly carried out by the active age group (15–65 years old) of the society.

Mean family size of households of Sodo-Zuria and Damot-Gale districts was similar (≈4) while that of Damot-Pulasa was about 5 (Table 1). In other study, majority of the rural residents had family size of more than five [25]. In fact, as the number of household size increases, agricultural activities of the households can

Table 1 Demographic characteristic of the sample households

Variables	Frequency	Percent
Gender of HH head		
Male	355	88.8
Female	45	11.2
Age of HH head		
15–65 years old	254	63.5
>65 years old	146	36.5
Education level of HH head		
No education	155	38.8
Primary education	217	54.2
Secondary education	23	5.8
Above secondary education	5	1.2

Family size of HHs	Frequency	Percent	Mean ± SD	Minimum	Maximum
Sodo-Zuria	167	41.7	3.8 ± 0.9	2.0	6.0
Damot-Gale	130	32.5	3.7 ± 1.3	2.0	7.0
Damot-Pulasa	103	25.7	4.9 ± 1.4	2.0	8.0
Total	400	100.0	4.1 ± 1.3	2.0	8.0

SD standard deviation, *HH* Households also be accomplished in time due to sharing of the duties among the household members. In the same way, Okoye et al. [26] and Udensi et al. [27] reported that a relatively large household size are more likely to provide more labor required for farm operations such as weed control, fertilizer application. However, Simonyan and Obiakor [25] justified that large household size may not guarantee for increased labor efficiency since family comprises mostly children of school age are always in school during working period.

Most (54.2%) of the interviewed households completed primary education (Table 1), which is above the mean national literacy level of adults (46.7%) [28]. This is an indication that most farmers had a fairly good education level to understand basic farming practices. Similarly, Doss [28] pointed out that the high literacy level of farmers is considered as one of the variables that positively affect adoption of agricultural technologies. Due to high literacy level, improved potato production practices can be reached to the farmers through reading materials such as pamphlets, leaflets, and other aids [29].

Production experience

Mean farm experience of households was above 20 years (Table 2). This has good relation with the improvement in potato production, because rich production experience can educate the farmers to improve the practices of their farm business. The mean total land size occupied by a household was only 0.5 ha, of which about 0.1 ha (20%) was used for potato production.

Use of appropriate practices

Of the improved varieties grown currently in the zone, *Gudene* (32.2%) and *Jalene* (31.0%) were cultivated more than the other by smallholder farmers (Table 3). However, the price of improved seed tubers was unaffordable by most of the farmers. Most of the respondents (53.3%) realized that the price spiked to more than 0.25 USD kg^{-1} (Table 3) and even attained 0.37–0.75 USD kg^{-1} for some improved varieties during planting time. Similar price situation was reported by Zerihun et al. [30] that the price of seed potato in the market raised to 0.25 USD kg^{-1} seed tubers during planting times. The vast number of the farmers (97.7%) used appropriate spacing for potato in accordance with the recommendation of EARO [31] (Table 3).

Most of the farmers (88.5%) used fertilizers for their potato farm (Table 4). About 97.7% of the respondents were well aware on methods and time of application of inorganic fertilizers. This study is in agreement with the findings by Nyamwamu [32] in Kenya who reported that farmers using recommended rates of fertilizers were 58% and farmers using recommended fertilizer types were 96% for potato production.

The most (52.0%) households were identified disease pests as their important potato pests in the study area.

Table 2 Production experience and efficiency

Variables	Frequency	Percent	Mean ± SD	Minimum	Maximum
Farm experience of HH head (year)					
Sodo-Zuria	167	41.7	23.7 ± 9.9	5.00	55.00
Damot-Gale	130	32.5	22.3 ± 9.1	10.00	51.00
Damot-Pulasa	103	25.7	17.7 ± 7.7	3.00	43.00
Total	400	100.0	21.7 ± 9.4	3.00	55.00
Total land size of HH (ha)					
Sodo-Zuria	167	41.7	0.6 ± 0.2	0.13	2.00
Damot-Gale	130	32.5	0.4 ± 0.2	0.13	0.75
Damot-Pulasa	103	25.7	0.5 ± 0.2	0.13	1.50
Total	400	100.0	0.5 ± 0.2	0.13	2.00

HH Household, *SD* standard deviation

Table 3 Potato production practices in the study area

Variable	Frequency	Percent
Commonly planted potato varieties		
Jalene	124	31.0
Gudene	129	32.2
Wachacha	75	18.8
Tolcha	42	10.5
Local	30	7.5
Seed price for improved varieties (US $/100 kg)		
15.0–20.0	3	0.8
20.0–25.0	184	46.0
>25.0	213	53.3
Use of recommended spacing		
Yes	388	97.0
No	12	3.0
Important potato pests in the area		
Diseases	208	52.0
Insects	84	21.0
Weeds	18	4.5
Other (porcupine)	90	22.5
Control methods they used for diseases		
Chemical	172	43.1
Cultural	50	12.5
Both	178	44.6

Table 4 Use, types, and application rates of fertilizers

Variable	Frequency	Percent
Use of fertilizers		
Yes	391	97.7
No	9	2.3

	Frequency	Percent	Mean ± SD	Minimum	Maximum
Application rate of urea (kg ha^{-1})					
Sodo-Zuria	167	41.7	141.1 ± 61.8	25.00	275.00
Damot-Gale	130	32.5	146.6 ± 64.6	25.00	325.00
Damot-Pulasa	103	25.7	143.1 ± 62.6	25.00	275.00
Total	400	100.0	145.6 ± 61.0	25.00	200.00
Application rate of DAP (kg ha^{-1})					
Sodo-Zuria	167	41.7	135.9 ± 52.1	50.00	300.00
Damot-Gale	130	32.5	132.5 ± 51.4	50.00	350.00
Damot-Pulasa	103	25.7	135.9 ± 52.1	50.00	300.00
Total	400	100.0	134.9 ± 51.2	50.00	350.00
Application rate of FYM (t ha^{-1})					
Sodo-Zuria	167	41.7	0.7 ± 0.6	0.00	2.00
Damot-Gale	130	32.5	1.2 ± 0.9	0.00	10.00
Damot-Pulasa	103	25.7	0.7 ± 0.6	0.00	2.00
Total	400	100.0	1.1 ± 0.8	0.00	10.00
Application rate of compost (t ha^{-1})					
Sodo-Zuria	167	41.7	1.8 ± 1.3	0.00	6.00
Damot-Gale	130	32.5	2.1 ± 1.1	0.00	6.50
Damot-Pulasa	103	25.7	1.8 ± 1.4	0.00	6.00
Total	400	100.0	2.1 ± 1.1	0.00	6.50

SD standard deviation, *FYM* farmyard manure, *DAP* diammonium phosphate

Of the diseases, the frequently occurring during cloudy and rainy times and highly destructive to potato plantation might be the symptoms of late blight (*Phytophthora infestans*). Late blight is common in all potato-growing areas of Ethiopia, and it is the most important and damaging potato disease worldwide [33]. Although price of chemicals against pests is expensive, about 43.05% respondents applied chemicals (Ridomil and Mancozeb) and others (44.5%) controlled by the integration of both chemicals and cultural (rug out, adjusting planting time, etc.) practices (Table 3).

Farmers of the three districts of the study area used almost similar rate of inorganic fertilizers. Application of urea and DAP for potato farm varied from 25–200 and 50–350 kg ha^{-1}, respectively (Table 4), which are about 20 and 60 kg ha^{-1} less than the regional blanket recommendation of urea (165 kg ha^{-1}) and DAP (195 kg ha^{-1}), respectively. Similar study revealed that farmers applied lower doses of fertilizers for potato due to higher cost of fertilizers in southern region of Ethiopia [33]. In addition to inorganic fertilizers, farmers of the study area also applied small amounts of organic fertilizers to their potato farm with the mean value of 1.1 t ha^{-1} farmyard manure (FYM) and 2.1 t ha^{-1} of compost (Table 4). In the same way, Negasi et al. [24] reported that farmers in the central rift valley of Ethiopia applied 1.71 and 1.56 t ha^{-1} of FYM and compost, respectively, to their onion farms.

Productivity and postharvest handling of potato in the study area

Productivity varied between 11.5 and 17.2 t ha^{-1} in which the majority (44.5%) of the respondents obtained 11.5–17.2 t ha^{-1} (Table 5). In agreement with this finding, lower mean yield of 9.3 t ha^{-1} and similar yield of 14.2 t ha^{-1} were reported by Bezabih and Mengistu [33] in Tigray and SNNP Regions of Ethiopia, respectively. In another study conducted in southern Ethiopia, Mitiku et al. [34] reported average tuber yields of 16.6 t ha^{-1} for improved varieties (*Bellete*, *Jalene*, and *Gudene*) and 2.5 t ha^{-1} for a local variety.

Data regarding postharvest handling indicated that about 65% of the respondents have awareness on potato storage (Table 5). The place of potato storage varied from defused light storage (DLS) (1.5%) to leaving the tubers in the soil of the farm (44.5%) after physiological maturity. This could expose the tubers to various disease and pest

Table 5 Productivity and postharvest handling of potato

Variable	Frequency	Percent
Productivity (t ha^{-1})		
<11.5	168	42.0
11.5–17.2	178	44.5
>17.2	54	13.5
Awareness on potato storage		
Yes	259	64.8
No	141	35.3
Place of storage		
In the soil	178	44.5
In BRS	22	5.5
In DRS	51	12.8
In DLS	6	1.5
Not store	140	35.0
Best storable variety		
Wachacha	21	5.3
Jalene	40	10.0
Gudene	212	53.0
Tolcha	69	17.3
Local	30	7.5
I don't know	28	7.0

BRA bright room storage, *DLS* defused light storage, *DRS* dark room storage

attacks. Thus, postharvest problem has remained a serious constraint for agricultural commodities in general and for horticultural industry in particular in the country.

The gap has been already identified and brought forth several times by researchers [33, 34]. Some of them are referred to as follows: One of the major problems in potato production and marketing in Ethiopia is high postharvest loss [33]. A postharvest loss of 30–50% of the produce was reported by Endale et al. [35], and lack of adequate storage is the major reason for the postharvest loss. Bezabih and Mengistu [33] further specified that 62–63% of the producers in Ethiopia stated shortage of warehouse as the major problem resulting in postharvest losses of potato.

Potato tubers belong to the semi-perishable goods, *i.e.*, produce with high natural moisture content. The produce is more sensitive to quality loss than cereals because to use drying techniques for preservation cannot be applied. Loss of moisture leads to quality failure and finally to nonmarketable produces [36].

In accordance to the statements of the sample respondents, *Gudene* (53.0%) was the most storable variety while *Wachacha* (5.3%) was the least one out of the varieties commonly cultivated in the study area (Table 5). This might have occurred due to the genetic differences in the varieties.

Major factors and constraints affecting production practices of potato

The multiple linear regression was used in order to identify some independent factors that affect potato production by smallholder farmers in the study area. The results showed significant F-values (31.02) with R^2 values of 19% in which independent variables used in the model explained variation in potato productivity (Table 6) as their coefficients are significantly different from zero. This indicates the goodness of fit of the model. The variables with significant effect remained in equation were the prevalence of natural hazard (%), seeding rate (kg ha^{-1}), and the expensive price of improved seed tubers (USD kg^{-1}). The regression equation for the determination of the response of average yield to selection using the three identified variable is given as: $Y = 1.428 - 0.245 (X_1) + 0.234 (X_2) + 0.180 (X_3)$, where X_1 = prevalence of natural hazards (%); X_2 = seeding rate (t ha^{-1}); X_3 = expensive value of improved seed tubers (USD kg^{-1}).

Out of the three independent variables submitted into the model to assess their quantitative effect on the production practices of potato by smallholders, one of them (the prevalence of natural hazards) was found to has a negative and statistically significant impact, while the other two factors (seeding rate and the expensive price of improved seed tubers) were found to have a positive

Table 6 Multiple regression results for factors affecting productivity of potato

Independent variables	Regression coefficients	SE	*t*-value	*p* value
Occurrence of natural hazards	−0.245	0.067	−3.650***	0.000
Seeding rate (t ha^{-1})	0.234	0.067	3.518***	0.000
Major problem in using improved seeds	0.180	0.027	6.681***	0.000
Constant	1.428	0.155	9.200***	0.000
Number of observations	400.000			
R^2	0.190			
F-value	31.023***			

*** Significant at 99% level of significance

Table 7 Major potato production constraint in the area

Constraints	Priority ranking									
	1st	2nd	3rd	4th	5th	6th	7th	8th	Index	Rank
Lack of access to credit	27	2	2	0	0	0	0	0	0.0914	6
Lack of yielding cultivars	14	7	5	3	1	0	0	0	0.0793	7
Insufficient seed tubers	18	11	4	2	2	1	1	0	0.1012	4
Diseases	29	23	20	19	14	13	7	0	0.2708	1
Storage problem	23	17	14	10	7	6	2	1	0.1843	2
Low market price	42	11	6	0	0	0	0	0	0.1696	3
Soil degradation	3	1	0	0	0	0	0	0	0.0117	8
Lack of agrochemicals	20	11	1	0	0	0	0	0	0.0918	5
Total	176	83	52	34	24	20	10	1		

and statistically significant effect on the productivity of potato at the study area (Table 6).

Consequently, as the prevalence of natural hazards such as drought, diseases, and other pests increased by 1% in a growing season or year of production, productivity of potato would found to decrease by 0.245 t ha^{-1} (Table 6). This can be related to the fact that as natural hazards occur repeatedly, potato production will decrease due to the negative impact of the natural hazards on its growth and productivity. In support of this idea, the immediate impacts of climate change on agriculture occur during or immediately after a natural hazard or extreme event, such as damage to crops, farmlands, and agriculture infrastructure from cyclones and flooding [37].

The regression analysis also showed that for an increment of seeding rate from 1.59 t ha^{-1} (mean seeding rate in the area) up to the recommended rate (2 t ha^{-1}), it could result in rising of productivity of potatoes by 0.23 t ha^{-1}. This also implies that farmers have not using the recommended amount of seeding rate due to inaccessibility of improved seed tubers. In agreement to this study, Belay [38] reported that expensive price of improved seeds resulted in decreased productivity of crops in Ethiopia. Likewise, Tadesse [39] reported that the mean seeding rate used by farmers in northern parts of Ethiopia is below the recommended rate. Similar result was also reported the lower seeding rate in some parts of Eritrea might be attributed to the fact that most farmers in such area used the local landrace varieties which are known for having small sized tubers as compared to the imported ones, thus making the total weight of seeds relatively lower [40].

On the other hand, the high price of seed tubers of improved varieties also significantly affects productivity of potato (Table 6). Accordingly, as the price of seed tubers of improved varieties decreased by 0.01 USD kg^{-1}, productivity of potato could be increased by 0.18 t ha^{-1}.

Lastly, different problems constrain the farmers in producing and utilizing potato in the study area. According to the index ranking, diseases, storage problems, low market price at harvesting time, and insufficient seed tubers during planting were the most important (1st–4th rank) constraints associated with the production of potato in the study area (Table 7). Similarly, many authors worked on production constraints of horticultural crops in general and potato in particular. In Ethiopia, the major horticulture production constraints include pests, drought, lack of desired seed variety, price of fuel for pumping water for irrigation, and limitation of fertilizer [41]. Of the major problems constraining onion production, unavailability of storage facilities was reported by Negasi et al. [24]. The low national mean yield observed for potato could be attributed to various constraints related to low adoption of improved agricultural technologies, drought, and lack of improved varieties, poor cultural practices, disease, and environmental degradation [42]. In Rwanda, Muhinyuza et al. [43] reported that lack of access to credit and high yielding cultivars, insufficient clean planting materials, and potato late blight identified as major constraints in producing potato.

Conclusions and recommendations

Lack of farm land, diseases, lack of storage facilities for ware and seed tubers, low price of the crop at harvesting but high price of seed tubers at planting, shortage of money to purchase agrochemicals were among the major constraints identified in this study. Intensive farming system (*e.g.*, multiple cropping), use of area-specific recommendation of fertilizers, use of cost-effective pest control methods, introducing low-cost storage facilities, and cooperation of farmers to manage market problems should be adequately addressed to improve potato production and utilization in the study area. Furthermore, the extension service should take up potato as essential and specialty commodity giving priority to enhance its productivity. Input provision such as intensification of farm land, irrigation access, improved seeds, fertilizers, and pesticides should also be adequately scheduled to meet the cropping calendar. The agricultural bureau of the zone and respective districts of the zone should also start farmer-based seed production, multiplication and storage. Area-specific fertilizer use programs, appropriate land-use systems by cooperating with the nearby stakeholders such as higher education institutions and research centers are necessary to ensure that soil fertility will be maintained, and clean seed will be readily available. As a result, production and utilization of potato will be improved. By doing so, food security plan will also gradually meet its goal together with the strict accompany of similar food security programs.

Additional files

Additional file 1: Table S1. Meteorological data.

Additional file 2: Table S2. Total, sampled, and percentage of sampled households.

Additional file 3: Questionnaires S1. The structured questionnaire.

Additional file 4: SPSS Data document S1. Datasets.

Abbreviations
BRS: bright room storage; CGIAR: Consultative Group on International Agricultural Research; CIMMYT: International Maize and Wheat Improvement Center; CIP: International Potato Centre; CSA: Central Statistics Agency; DAP: diammonium phosphate; DAs: development agents; DCG: Dry-land Coordination Group; DLS: defused light storage; DRS: dark room storage; EARO: Ethiopian Agricultural Research Organization; FAO: Food and Agriculture Organization; FYM: farmyard manure; HH: household; ILRI: International Livestock Research Institute; JUCAVM: Jimma University College of Agriculture and Veterinary Medicine; MoFED: Ministry of Finance and Economic Development; NMA: National Metrological Agency; RAP: rapid assessment procedures; SPIA: Standing Panel on Impact Assessment; SPSS: Statistical Package for the Social Science; TAC: time activity curve; USAID: United States Agency for International Development.

Authors' contributions
HG and AM conceived and designed the research. HG collected and analyzed the data and wrote the manuscript which was part of his Doctorial Dissertation of Horticultural Science at Jimma University, Ethiopia. ND and DB participated in the design and coordination, reviewed and made editorial comments on the draft of the manuscript. All the authors read and approved the final manuscript.

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Availability of data and materials
The datasets supporting the conclusions of this article are included within the article ("Additional file 4 Datasets").

Competing interests
The authors declare that they have no competing interests.

Ethical approval and consent to participate
Ethical approval was obtained from the Research Ethics Committee at the College of Agriculture and Veterinary Medicine, Jimma University, while letter of consent was obtained from the Agricultural Office of the respective study districts to the respective study *Kebeles* (peasant associations). The participants were, therefore, volunteers to share the info.

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