Economic Feasibility of Small-scale Onion and Tomato Production in the Central Rift Valley in Ethiopia: Evidence from Adama and Doddota Districts

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Abstract

Vegetables contribute to food and nutritional security and provide employment opportunities for women and men. Onion and tomato, in Ethiopia, are major vegetables grown primarily for cash income under irrigated farming and high input agro-chemical use. The production of these crops has been expanding as more land and other agricultural inputs are allocated to them. Yet, the economic feasibility of the business in light of heavy agrochemical use, fluctuating prices, and gender participation, are points of discussion. Hence, the paper assesses the economic viability, the roles men and women play, and the benefits men and women farmers fetch from the onion and tomato production business. Primary data were collected from small-scale onion and tomato producers in the Arsi zone Doddota district and Adama district in the East Shewa zone. Results reveal that women constitute 24 percent of the household heads who participated in producing onion and tomato. Women contribute up to 36 percent of the labor participating in those crop production. Field data confirm that the business is economically feasible under varying inputs and produce prices. The profitability can be further boosted if the farmers reduce the excessively used agrochemicals by applying the recommended types and rates. The proportional variable costs of the over-used pesticides were estimated to be 32% for onion and 36% for tomato production. Hence, reducing the chemicals used is commendable to increase economic profit while reducing the environmental risks posed by the excessive use of agrochemicals. In this aspect, hands-on training on appropriate pesticides use and handling may help producers enhance their income while curbing risks to human and animal health and environmental damage.

Keywords: horticulture, benefit-cost ratio, pesticides, sensitivity analysis, Ethiopia.

Introduction

Production of horticulture is increasing in Ethiopia in terms of volume and the households that grow them. The production increased from 2.22 to 6.26 million metric tons between 2000 and 2018, while the number of growers increased from 13 to 17 million households between 2010 and 2019 (CSA, 2011 and CSA, 2019). Similarly, worldwide vegetables production increased by 65% while that of fruits grew by 54% between 2000 and 2009 (FAO, 2021). Likewise, population growth, increased incomes, and rising market demand for vegetables and fruits

create economic opportunities for smallholder farmers (Pepjin et al., 2018). According to Pepjin et al. (2018), profits per hectare from vegetables were 3–14 times higher as compared to food crop such as rice production. Horticulture, mainly vegetables, provides more employment opportunities by engaging about three times the number of labor days that cereal production requires (Weinberger and Lumpkin, 2007). Vegetable farming offers job opportunities as a business venture for youth and women. Female labor is essential in vegetable production for their careful handling, while its production in a small area and quick maturity provide opportunities for youth. Horticulture has a higher or comparable economic value than cereals. For instance, in 2019, the world dollar value of fruits and vegetables was 274 billion USD, making up 20% the value of world food exports, while that of cereals was 193 billion USD in 2019 (FAO, 2021). Among horticultural crops, onion and tomato are the primary ones, contributing 25% of the dollar value of the global production of fruit and vegetables (FAO, 2021).

Vegetables and fruits are essential sources of the micronutrients needed for healthier diets (Pepjin et al., 2018). According to the WHO recommendation, 400 g of vegetables and fruits per day are needed for the prevention of chronic diseases such as diabetes, heart disease, cancer, and obesity, as well as the prevention and alleviation of several micronutrient deficiencies, especially in less developed countries (Joosten et al., 2015).

Labor is an important cost item in onion and tomato production involving men and women in various activities. Since vegetable production is a small-scale and labor-intensive enterprise, the participation of men and women with distinct gender roles is inevitable. Th information, however, on the level and areas of their contribution or participation is scant. Shrestha et al. (2016) reported that women are more effective as vegetable farm managers, and the same authors proposed that women's participation can improve vegetable crop productivity. Similarly, a crop financial feasibility is essential for informing sustainable production and business investment by assessing the inputs used and the level of returns to the inputs. Though small-scale farming is a family-based enterprise, the intensity, and timeliness of certain activities such as hoeing, transplanting, weeding, and harvesting demand more labor than an average farm family can handle with the available technology at present in Ethiopia and such a trend is expected to continue for several years to come.
Observations in Ethiopia indicate that the most likely drivers of onion and tomato farming are speculated financial gains. Yet, the income obtained from those crops at times sustains heavy losses to producers,

disrupting the production of the crops from time to time due to unbalanced seasonal demand and supply. On the other hand, Ethiopia has been importing high values of onion and tomato products annually to fill the deficit in feeding the fast-growing population (https://trendeconomy.com/data/h2/Ethiopia/0703; https://ensp-seed.org/about-ensp.)

Several authors (Mume, 2007; Adgo, 2008; Alemu et al., 2004; Asante et al., 2011) assessed the issue of onion and tomato production technologies—improved varieties and agronomic practices—and their adoption levels in different parts of Ethiopia. Considering the labor intensity of vegetable production, the benefit-cost ratio, including the value of land (a scarce resource), gender participation, and the financial feasibility of the crops, are all points of discussion that require evidence based on the high rate of producers turnover as they enter and leave the business. In the Ethiopian Growth and Transformation Program (GTP), irrigated crop production was identified as a key area for the country's economic transformation using improved water utilization techniques by assigning a development investment of 4.143 million hectares (FDRE, 2016). The transformation plan emphasized the empowerment of women by creating jobs and improving their ability to earn income, among which irrigated vegetable production was a target (FDRE, 2016).

Onion and tomato area, productivity and production trend in Ethiopia

According to FAO and UN 25-year data (1994 and 2018, the area of onion farming in Ethiopia was tripled while that of tomato increased by 77%. The onion area increase was accompanied by a proportional increase in the crop production. However, productivity and production declined compared to the positive increase in area. The production increase for onions is strongly associated with area expansion, which is highly significantly associated at 5% ($r=0.97$, $t(23)=20.09$, $p=.00$), showing a strong linear relationship between onion area and production increase. Similarly, from a regression analysis result, one can conclude that the area explains the principal variation in onion production, as evidenced by 94% R^2 (the adjusted R square). The correlation between area and production for tomatoes was 5% ($r=0.31$, $t(23)=1.51$, $p=.07$). On the other hand, the national level productivity of both onions and tomatoes has stagnated at about ten tons per hectare in Ethiopia, according to FAO and CSA long-term data (www.fao.org/faostat/en/#data/QC; CSA, 2011 and CSA, 2019).

Melkassa Agricultural Research Center of the Ethiopian Institute of Agricultural Research (EIAR) is a lead center for horticultural crop improvements. Over the past four decades, the center has released (or

recommended) large number of onion and tomato varieties. Open-pollinated varieties (OPV) have been predominant, while hybrids are fast entering the Ethiopian vegetable production system. Field works in the Central Rift Valley, however, show a higher productivity per hectare for onion (33 t/ha) and 40 t/ha for tomato (Bedru et al. 2009). Emana et al. (2017) reported 39.8 tons/ha from a survey in the Dugda and Bora districts in the East Shewa zone based on a field survey. Emana et al. (2017) further recounted that the tomato production was estimated to be 387,567 tons in 2016/7 in Dugda and Bora districts alone, while the CSA reported the entire country's tomato production to be 28,364.8 tons in 2016/7 (CSA, 2017) and 34,947.3 tons in 2019/20 (CSA, 2020). The CSA reported low tomato productivity (4.5 tons per hectare in 2016-17 and 5.9 tons per hectare in 2019-20), and such comparatively low figures were also reported for onion. These results are highly contrasting with those of both the FAO and the CSA country-level reports of ten tons per hectare or less for both crops based on the main season crop production data, though onion and tomato are predominantly produced under irrigation.

The production and productivity increase in vegetables is anticipated to bring a "green revolution" in developing countries given the demand for the crops, their labor intensity, financial benefits, and their suitability for rural, peri-urban, urban, and small-scale agriculture (Armanda et al., 2019). In Ethiopia, onion and tomato are high potential for agricultural transformation since their production is both knowledge and labor-intensive. Likewise, it can fit rural and peri-urban agriculture. The average country-level productivity for the two crops is still reported low at 10 t/ha for onion while the potential of the recommended varieties was four folds and that of on-farm demonstration is also high about 3–4 folds.

This work analyzes the economic feasibility as well as addresses gender participation in onion and tomato production to improve understanding of the vicious cycle of speculated onion-tomato production syndrome where farmers grow in some years tomatoes and other years onion many times facing financial losses from seasonal overproduction. The works look at the feasibility of more frequent and high-volume use of agrochemicals observed in the area, which would reduce the profitability of onion and tomato farmers, let alone the uncalculated environmental damage it may cause.

The paper is organized as follows: the first section introduces the work and sets the background and purpose. The second section highlights the study area and methods used in obtaining and analyzing data. The third section presents the result and discusses it in

light of the existing literature. The fourth section closes the paper, drawing conclusions and suggesting a way forward for increasing income and enhancing onion and tomato production and marketing.

Method

Description of the study area

This study was conducted in Adama and Doddota districts in Oromia National Regional State, Ethiopia (Figure 1). The location is within 75 to 145 km, respectively, southeast of Addis Ababa. Vegetable production is practiced using mainly flood irrigation from the Awash River, using largely diesel-fueled small motor pumps.

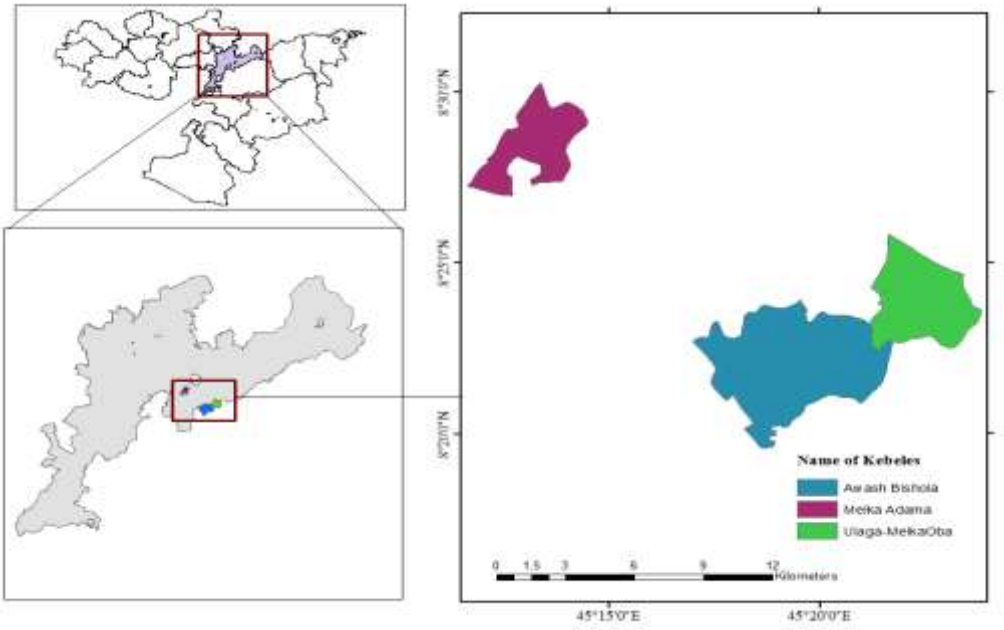

Figure 1 Map the study area

Farming system of the area

Mixed farming of crops and livestock constitutes the major production system in the area. Oxen are the main source of draft power, while cows are sources of milk beyond their service for husbandry. The major field crops produced under rainfed conditions are tef, maize, common bean, wheat, and barley. Onion, tomato, cabbage, pepper, papaya, and sugarcane are horticultural crops produced using irrigation. Among the crops grown, onion and tomato account for about 40% (0.51 ha) of the total average holdings (1.65 ha) of the smallholder

farmers annually allocated to crop production.

Data source and data acquisition method

Data were collected from smallholder farm households using a questionnaire survey conducted in 2018. The questionnaire comprises a diverse area of socio-economic, production activities, labor, gender, input type, costs, and income. Farmers were selected from Adama and Doddota districts in three major vegetable-producing kebeles–Melka-Adama, Awash-Bishola, and Melka-Oba (Fig. 1). Sixty-two farmers (37 grow both onion and tomato 51 grows onion and 48 grow tomato) were randomly selected and interviewed face-to-face using the structured and pre-tested questionnaires. The data analysis included gender participation, inputs used, and revenues gained from onion and tomato production. The land and family labor were valued using the principle of opportunity cost and it was assumed that as a substitute for rental value of land and hired labor. Care was taken to accurately estimate non-purchased inputs such as family labor, while for purchased inputs, the actual prices reported were used. In addition, statistical data from the Ethiopian Central Statistical Authority (CSA) and FAO for the past 25 years from online data sources were consulted to get the bigger picture of onion and tomato production and productivity trend and compare it with local yield.

Data analysis

The primary data collected using structured questionnaires were encoded and entered into Statistical Package for Social Science (SPSS) Software Version 23 and analyzed. Gender analysis documents the level of men's and women's participation in tomato and onion production and marketing, from nursery management through harvest and marketing. The percent labor participation of men and women in onion and tomato production operations weighed in percentage person days.

Farm budgeting: this method was adopted in a financial feasibility assessment for measuring farm enterprise performance. Farm budgeting analysis enables the estimation of the total expenses (costs) as well as various receipts (revenue or returns) within a production period (Smith et al., 2000). The tool is used to assess the costs and benefits associated with a specific change in a farm enterprise (Tigner, 2016). The estimate of the costs and returns associated with the production of products is considered an enterprise that can be defined and analyzed separately based on certain production input units and per unit land for most crop enterprise budgets (Smith et al., 2000). In this study, the enterprises chosen were onion and tomato, and the unit of land was a hectare. The procedure involved calculating costs, gross return, gross

margin, break-even, and sensitivity analyses. The gross return (GR) was calculated as the product of the total volume of output and the average price during the harvesting period using the following formula:

GR= QP……..…… (1)

Where, GR is gross return from onion or tomato production (ETB), Q is Quantity of onion or tomato produced (Kg) and P is the average unit price of onion or tomato (ETB/Kg).

Net farm income (NFI): is the difference between the gross receipts or the total cost of production of the crop under study. It is defined as the surplus resulting from farm operations, which could be withdrawn without reducing the future scale of the business. NFI is calculated as follows:

NFI=GR–TC (FC+VC) ……. (2)

NFI=Net farm income; GR=Gross return; FC=Fixed costs; VC=Variable costs

Total cost of production was estimated by using the following formula:

TC=TFC+TVC …… (3)

Where; TC=total costs of production; TFC= Total fixed cost; TVC= Total variable cost

The performance and financial viability of the farm was determined by using the profitability ratios:

Benefit-to-cost ratio (BCR) = GR/TC… (4)

The breakeven point was used to determine what minimum level of output (yield) was to be achieved to cover the production cost at a given average market price. The break-even formulas used in the analysis are:

$$\text{Break} - \text{even(Price)} = \frac{\text{Total Costs}}{\text{Total Production}} \ldots (5)$$

$$\text{Break} - \text{even (Yield)} = \frac{\text{Total Costs}}{\text{Sale Price}} \ldots\ldots (6)$$

Results and Discussion

Socio-economic and demographic characteristics of respondents

Most onion and tomato producing households were headed by males, while female-headed households also constituted a significant proportion (24%). Onion and tomato farmers were mature and active people with a mean age of 44-years (standard deviation of 12). The farmers have a long experience of 16 years of field and vegetable crop farming. This should enhance the farmer's productivity since experienced farmers can use inputs efficiently and use improved agronomic practices as well as pest and disease management in their fields. Concerning the size of their land holdings, the farmers own a mean of 0.76 ha (45% of the holding) of irrigable land and 1.65 ha of total average land. The per capital land holding here is less than that of field crop growers in the Central Rift Valley, with an average of 2.36 ha (Bedru and Nishikawa 2017). The average area allocated to onion was 0.28 ha and to tomato 0.23 ha per household (Table 1).

Table 1 Socio-economic and demographic characteristics of onion and tomato producer households

Characteristics/parameter	Mean	SD	Maximum
Gender (male percent)	76		
Age of household head (average year)	44	12	70
Formal education of household head (year)	4.63	3.75	14
Vegetable production experience (year)	15.81	9.23	35
Rainfed cultivated land (ha)	0.80	0.99	4.00
Irrigated land (ha)	0.67	0.66	3.50
Area of onion (ha)	0.28	0.30	1.75
Area of tomato (ha)	0.23	0.20	1.00

Source: Field survey
Note: SD= standard deviation

Gender participation in onion and tomato production and marketing

Labor is a crucial component in vegetable farming, which involves various tasks such as nursery management, transplanting, hoeing, weeding, harvesting, curing, loading and unloading. Men and women participate in all the processes from production to marketing.

The share of men and women is high though there are differences in the level of labor input share for different operations. Some of the activities are predominantly handled by women while others are dominated by men. For instance, irrigation water management and chemical application

are the specialties for men whereas transplanting and weeding are principally handled by women. The production process of onion and tomato recruits a large number of men and women per hectare (Table 3) as indicated by person days. Considering the average of the labor in demand, the land operated, both onion and tomato create job opportunities since they require more than what average household labor can handle for about four months taking an average of 5 hours daily work. In labor use, onion participates more labor than tomato, particularly in certain activities such as transplanting, hoeing, and harvesting are labor-intensive operations in onion production than in tomato production while cutting bulb tips is only done for onion. Women have a higher labor share (36.2%) in terms of person-days in onion production than they do in tomato (21.2%) (Table 3). In terms of crop productivity, there is no significant difference between households headed by men and women in onion and tomato production. In terms of marketing, women tend to sell at higher prices as some of them sell at retail markets though in general, the difference is not significant statistically (Table 2).

Table 2. Gross return income of onion and tomato production by gender

Farm Income components (ETB ha^{-1})	Onion (n=51)		t-test	Tomato (n=48)		t-test
	Women (n=11)	Men (n=40)		Women (n=10)	Men (n=38)	
Average yield (kg/ha)	22363.6	23610.7	0.99	16098	22148.7	5.27**
Mean price (ETB/kg)	7.5	7.0		5.3	5.1	
Gross income (ETB/ha)	167727	165274.9	0.46	85319.4	112958.4	2.45

Source: Field survey data

Table 3. Labor participation (person-day) and costs of onion and tomato production (ha^{-1}) by gender in the CRV

Operations	Onion (n=51)			Tomato (n=48)		
	Mean labor inputs (PD)		Labor cost	Mean labor inputs (PD)		Labor cost (ETB/ha)
	M	W	(ETB/ha)	M	W	
Nursery mgmt.	298.6	50	5731.9	81.9	8.4	2601
Land clearing	9.2	1.6	631.3	10.2	1.2	558.5
Plowing	46.5	1.3	1856.7	50.7	1.6	1710.6
Ridging	25.8	1.5	1051.7	21.6	1.4	937.8
Total	380.1	54.4	9271.6	164.4	12.6	5807.9
Field operations						
Transplanting	45.5	105.5	3279.3	19.3	36.2	1342.3
Irrigating	99.3	—	4892.5	129.3	—	5813.6
Hoeing	783.0	446.6	6793.3	236.2	29.6	3484.5
Weeding	91.6	93	2425.0	13.8	13.7	555.7
Pesticides application	57.5	0.6	693.5	68.2	-	3125.4
Harvesting	86.7	34	755.5	76.6	98.3	2974.2
Cutting bulb tips	58.6	175	847.5	—	—	—
Total	1222.2	854.7	19686.6	543.4	177.8	17295.7
Total person-days	1602.3	909.1		707.8	190.4	
Labor share (%)	63.8	36.2		78.8	21.2	

Note: mgmt-Management; W=women; M= men; PD=person-days
Source: Field survey data

Agrochemical use/abuse in onion and tomato production

Chemical fertilizers and pesticides are the major external inputs used in onion and tomato production. In sum, they constitute the number one cost of production. In the current study, di-ammonium phosphate (DAP) (18-46-0) and urea fertilizers were applied to the onion at an average rate of 428 kg/ha and 399 tons/ha. The tomato received an average of 372 kg/ha and 349 kg/ha (Table 5), which are higher than the recommended rates of 200 kg/ha DAP and 100 kg/ha urea. DAP was used at slightly more than twice the recommended rate, while urea was used at about four times the recommended rate. The excessive use (abuse) of urea may be because the crop responds quickly to it. Farmers appreciate the quick vegetative growth and tend to expect that the higher application of urea is an indicator of higher yield, leading to overuse.

A large number of chemicals were also used at a high rate compared to the recommended rates (Table 4). However, the overutilization of the chemicals incur additional costs with no marginal return on additional currency invested. Farmers also apply a bunch of pesticides mixed up together using their own intuitions to "trap" and control pests (insects and diseases) because identifying diseases

and insect pests is a challenging issue for the producers.

During our field study, we discovered that farmers use fourteen different types of pesticides when producing onions and tomatoes (Table 4). Out of these, two were found to be recommended for use on onions, five for tomatoes, and three for both crops. However, we were surprised to find nine unrecommended chemicals were sprayed on onions, while six unrecommended pesticides were applied on tomatoes. Additionally, we found that one unregistered chemical was used on tomatoes. Over-applying pesticides not only has a negative environmental impact but also results in additional costs for farmers. In terms of finance, the excessive use of pesticides resulted in additional costs of 24,335.6 ETB/ha for onions and 25,737.5 ETB/ha for tomatoes. Furthermore, the cost of overusing pesticides accounted for 32% and 36% of the total variable cost for onions and tomatoes, respectively. It is also worth noting that some of the recommended chemicals were being used excessively, up to five times more than the recommended average.

According to a field survey conducted in the CRV area in Ethiopia, small-scale vegetable farmers are mismanaging and misusing pesticides, as reported by Mengistie et al. (2017). Studies conducted in the East African Rift region have also shown that poor pesticide management practices have led to the pollution of rivers and lakes, as reported by Loha et al. (2018). The use of certain chemicals like endosulfan and malathion pose acute ecological risks, as was discovered in the samples of the Central Rift Valley waters in Ethiopia, including Lake Zway, according to Merga et al. (2021). Endosulfan is one of the highly hazardous pesticides as classified by the WHO.

The pesticides used in tomato and onion production in Ethiopia have a hazardous chemical classification level according to WHO. Selecron (Profenofos 72%), Profit 72% EC/ profenofos 72%, Karate 5% EC/Lambda-Lambda, Cyhalothrin, Dimethoate/ Agro-Thoate 40% EC, Endosulfan/ Thionex 35% EC, Helerate 5% EC/ Lambda-Lambda, Mancolaxyl 72 % WP/Mancozeb + metalxyl (are Class II), while Tilt / Tilt 250 EC (Propiconazole), Metasol (Thiabendazole) (Class III) and Mancozeb/80 wp (Mancozeb), Coragen 200 SC (200 g/L Chlorantraniliprole), Agro-Laxyl MZ 63.5 WP (Mancozeb 64% + Metalaxyl 4%) (U).

Table 4 Pesticides and their uses in onion and tomato production in the CRV in Ethiopia

No	Trade/Common name	Pesticide type	Rx (Yes/No)		Rx (Rate/ha)		Unit	Amount used/ha by farmers		Difference from the Rx (+/-)		Cost (ETB) of excess use of Rx chemicals		Remarks on use*	
			Onion	Tomato	Onion	Tomato		Onion	Tomato	Onion	Tomato	Onion	Tomato	Onion	Tomato
1	Mancozeb/80 wp (Mancozeb)	Fungicide	Yes	Yes	10	12	Kg	36.2	40.6	+26.2	+28.6	3,240.0	3,720.0	OU	OU
2	Ridomil Gold MZ 68 WP/Metalxyl.M	Fungicide	Yes	Yes	12.5	15	Kg	29.6	40.5	+17.1	+25.5	3,063.0	4,515.0	OU	OU
3	Selecron (Profenofos 72%)	Insecticide	Yes	Yes	2.5	4.5	Liter	28	14	+25.5	+9.5	2,701.6	1,617.0	OU	OU
4	Profit 72% EC/ profenofos 72%	Insecticide	Yes	Yes	2.5	4.5	Liter	26	40	+23.5	+35.5	3,869.0	4,762.5	OU	OU
5	Karate 5% EC/Lambda-Lambda Cyhalothrin	Insecticide	Yes	Yes	1.6	1.92	Liter	23	36.5	+21.4	+34.6	1,557.0	3,110.0	OU	OU
6	Agro-Laxyl MZ 63.5 WP (mancozeb metalxyl	Fungicide	No	Yes	—	18	Liter	5	—	+5	—	1,250.0	—	UM	UBR
7	Malathion (Helmathion 50 EC)	Insecticide	No	No	—	—	Liter	20	—	+20	—	2,400.0	—	UBR	UM
8	Dimethoate/ Agro-Thoate 40% EC	Insecticide	No	Yes	—	9	Liter	19.3	19	+19.3	+17.5	2,053.0	1,750.0	UM	OU
9	Endosulfan/ Thionex 35% EC	Insecticide	No	No	—	—	Liter	15	20.3	+15	+20.3	2,250.0	3,654.0	UM	UM
10	Tilt / Tilt 250 EC	Fungicide	No	No	—	—	Liter	12	12.4	+12	+12.4	1,260.0	1,290.0	UM	UBR
11	Helerat 5% EC/ Lambda-Lambda	Insecticide	Yes	Yes	1.6	1.92	Liter	6.3	7	+4.7	+5.08	692.0	829.0	OU	OU
12	Coragen 200 SC	Insecticide	No	Yes	—	1.5	Liter	—	6.5	—	+3.5	—	490.0	—	OU
13	Metasol	Insecticide	NR	NR	—	—	Liter	—	8	—	−8	—	—	NR	NR
14	Mancolaxyl 72 % WP/Mancozeb + metalxyl	Fungicide	No	Yes	—	18	Kg	—	1.5	—	−3	—	—	—	UBR
	Total											24,335.60	25,737.50		

Note 1: Rx= Recommended; NR=Not registered; *OU= Over used; UM= Misused (i.e., not recommended); UBR= Used below the recommendation; + (excess), - (low)

Note 2: application frequency for onion insecticide or/and fungicide is five times per production season (in four months); for tomato the application frequency is six times per production season (in four months).

Source: Field survey data

Input uses and revenues from onion and tomato production

Agrochemicals are found to be the major input used in onion and tomato production as per the data presented in Tables 5 and 6. Fertilizers and pesticides account for about 40% and 52% of the production costs for onion and tomato, respectively. The second high cost item is labor, with an average total of 2511.4 and 898.2 person-days in onion and tomato production, respectively. Additionally, onion and tomato growers use an average of 828 kg/ha of both DAP and Urea, whereas tomato uses 721 kg/ha (Table 5), which is higher than the recommended rate. The excessive use of pesticides also increases the production cost of these crops. Apart from the chemicals, the farmers' use of seed for the two crops was well above the recommended rate. This suggests that the research recommendation needs to be revised, perhaps through participatory research, for a quick and applicable result. This implies that there is a need for research in irrigation agronomy. The average onion and tomato seed rates used per hectare were 13.7 and 0.6 kgs, respectively, while the recommended seed rates per hectare are 7.0 kg/ha for onion and 0.2-0.3 kg/ha for tomato (Shimelis et al., 2019).

Table 5. Inputs and their average rates used (ha^{-1}) in onion and tomato production in CRV.

Inputs	Onion (n=51)		Tomato (n=44)	
	Mean	SD	Mean	SD
Labor (person-days)	2511.4	362.8	898.2	102.3
Fertilizers (kg)				
DAP (kg)	428.4	57.3	372.5	52.7
UREA (kg)	399.5	61.2	348.8	80.5
Agrochemicals (liter/kg)	220.4	102.3	246.3	128.5
Seed (kg)	13.7	7	0.6	0.45
Fuel (liter)	489.3	88.3	508.3	133.6
Oxen (oxen-day)	152.2	88.2	150.8	99

SD= standard deviation
Source: Field survey data

Table 6 presents the total revenues from onion bulb and tomato fruit sales. The mean value of 167155.4 ETB per hectare (1 USD=22.66 ETB March 2018; www.gocurrency.com) was gained from onion bulb sales. Since the average holding was about one-quarter of a hectare, in real terms 41,789 ETB was obtained from a quarter of a hectare. Onion and tomato yields averaged 22.9 and 18.2 tons per hectare in the Central Rift Valley in Ethiopia, respectively. This result was above the average yield per hectare at the farmer level of 17 to 20 tons/ha Alemu et al. (2004), reported that labor inputs were employed for all operations in onion and tomato production. From the production cost analysis, the major input cost share of 38.8% and 32.2% of the cost of onion and tomato, respectively, goes to labor

(Table 6). Fertilizer was the second most important input in tomato production, accounting for about 16% of the input costs for both crops. When the costs of agrochemicals (fertilizer and pesticides combined), constitute 52 % in tomato and 40% of the variable costs in onion production (Table 6). Farmers use large bunches of chemicals at high rates (up to five times higher) than recommended (Table 5). In sum, however, onion and tomato growers still make significant profit margins. The benefit-cost ratios for onion and tomato were 2.0 and 1.8 respectively, which indicates the overall profitability of onion and tomato production (Table 6).

Sensitivity analysis

From the break-even yield and price analysis of onion and tomato production using household survey data, one can safely conclude that onion and tomato farming is a profitable venture even if there is a drop in yield of up to half the of existing production per hectare while keeping the price constant. On the other hand, the crop can be profitable at the existing production level even if the price drops by 50% for both onion and tomato (Table 7).

Table 7 presents the sensitivity analysis results for onion and tomato based on major inputs, output prices, and production changes. Scenario 1 assumes a 20% increase in production costs without a change in output price, resulting in a 9% onion profit margin and a 13.7% tomato profit margin. A 10% increase in the expected yield and a 20% increase in input costs may cause a 4.2 and 6.1% decrease in the profit margin from the base case scenario for onion and tomato, respectively. Regarding the changes in market prices of each commodity, other things being equal, reductions in onion and tomato prices have a high negative effect on net farm income, gross return, and profit margin.

Table 6. Revenues, expenses, and net farm income from onion and tomato production (ha^{-1}).

Revenue/cost item ($ETB\ ha^{-1}$)	Onion (n=51)			Tomato (n=48)		
	Mean	SD*	% Share	Mean	SD	% Share
Yield (kg/ha)	22,898.0	9,066.5		29,198.0	9,152.2	
Price (ETB/kg)	7.3	5.7		5.1	2.5	
Gross Return (ETB)	167,155.4	51,679.5		148,909.8	22,880.5	
Labor cost	29,393.5	1,204.2	38.8	23,103.6	1,638.7	32.2
Fertilizer cost	10,270.0	217.0	13.5	9,079.6	1,553.4	12.6
Pesticide cost	20,283.4	3,289.8	26.8	28,097.9	9,287.0	39.1
Cost of seed/seedlings	7,755.3	929.2	10.2	3,332.7	562.5	4.6
Fuel cost	5,347.6	488.3	7.1	5,837.8	1,255.7	8.1
Ploughing cost by oxen	2,765.8	699.4	3.6	2,371.3	465.4	3.3
Total variable cost (TVC)	75,815.6	6,827.9	100.0	71,822.9	14,762.7	100.0
Land rental value (fixed cost)	11,500.0	3,542.0		11,500.0	3,542.0	
Total cost (TVC+FC)	87,315.6	10,369.9		83,322.9	18,304.7	
Net Farm Income (NFI)	79,839.8	41,309.6		65,586.9	4,575.8	
Benefit-cost ratio (BCR)	2.0			1.8		
Input-output ratio	1.0			0.8		
Break-even (yield)	11,961.0			16,337.8		
Break-even (price)	3.8			2.9		

Note: 1 Ethiopian birr (ETB) = 0.04 US$ in 2018; *SD= standard deviation
Source: Field survey data.

Table 7. Sensitivity analysis of onion and tomato production in the CRV (ETB/ ha)

Scenario	Onion		Profit margin		Tomato		Profit margin (%)	
	Gross revenue (EBT)	Total cost (ETB)	Net farm income (ETB)	% Profit margin	Gross revenue (EBT)	Total cost (ETB)	Net farm income (ETB)	% Profit margin
Base case scenario	167,155.4	78,789.0	88,366.4	52.8	92,445.8	63,466.8	28,979.0	31.3
Production cost increase by 20% without a change in produce price	167,155.4	94,546.8	72,608.6	43.4	92,445.8	76,160.6	16,285.6	17.6
Yield increased by 10% & input cost increased by 20%	183,870.9	94,546.8	89,324.4	48.6	101,690.4	76,160.6	25,530.2	25.2
Produce prices decreased by 50% & others remain constant	83,577.7	78,789.0	4,788.7	5.7	46,222.9	63,466.8	-17,243.9	-37.3
Labor & pesticides increase by 50% & others remain constant	167,155.4	114,060.9	53,094.5	31.7	92,445.8	90,691.3	1,754.5	1.9

Note: GR=Gross revenue; TC= total cost; NFI= Net farm income.
Source: Field survey data.

Conclusion and Recommendations

The cultivation, promotion, and utilization of horticultural crops are on the rise globally, including in Ethiopia. These crops have higher values per unit area and require more labor and knowledge, creating more job opportunities for both men and women. Furthermore, they contribute to food and nutritional security while aiding in the prevention of chronic diseases.

In the Central Rift Valley of Ethiopia, onion and tomato are major warm-season vegetables. Onion farming provides employment to a significant number of young men, young women, and adults, with women contributing 20 to 36 percent of the labor force. Women are also a significant portion of onion-growing household heads as farm owners and managers.

The financial feasibility of growing onion and tomato is positive for households headed by both men and women. The major costs of producing these crops are agrochemical inputs and labor inputs. However, the cost of agrochemicals is high due to the excessive use of pesticides and fertilizers. This excessive use may pose a risk to human health, as most of the pesticides used are classified as moderately hazardous by WHO. Despite these challenges, the feasibility of growing these crops is acceptable even in scenarios where there is a high price reduction and modest increase in input costs unless the market is temporarily flooded by harvests.

Onion and tomato production can be profitable businesses, and there are opportunities to increase profits by reducing the use of agrochemicals. It is important to reduce the risks to human health and the environment that come from overusing these chemicals. To achieve sustainable crop production, research and development partners should focus on communicating the proper use of agrochemicals (including the correct rate and timing) and their packages disposable. Hands-on training should be provided to farmers and those who work closely with farmers help them improve production and ensure that chemicals are used appropriately by both women and men farmers.

This report provides an overview of the results obtained and is expected to encourage discussions and actions towards sustainable vegetable production, especially in areas where intensive vegetable farming is taking pace. In the case of irrigated onion and tomato farming, policy recommendations should aim to encourage both male and female farmers to reduce the application of agrochemicals in line with research recommendations. This will not only boost profits, but also promote the safe use of agrochemical (fertilizer and pesticides) to minimize any potential

negative effects on human health and the environment.

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