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Research Article
Assessment of Threats Affecting Ginger Cultivation and its Management in Luke Kebele of Cheha Woreda, Gurage Zone, Ethiopia

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Abstract

Background and Objectives: Ginger is one of the most important spice crops. The quantity and quality of ginger products are becoming low due to the increment of both biotic and abiotic factors. The main objective of the study was to assess the threats that affect the ginger plant and its production. **Materials and Methods:** Hence, the research was done through systematic random selection and semi structured questionnaire by using the sample size of 95 selected farmers from February-June, 2019 in Luke Kebele, Cheha Woreda, Gurage zone, Southern Ethiopia. **Results:** The result of study indicated that bacterial disease, nematodes, shortage of rainfall, improper fertilizer usages and soil type were capable to reduce productivity of ginger which lead to disappear in the near future from the study area. **Conclusion:** Since the genetic diversity and productivity of ginger eroded from local grower's area, it needs to develop other environmental adaptable and productive varieties of ginger from Ethiopian agricultural institute. Therefore, every responsible body should strive to prevent threats that affect ginger crop and immediate conservation strategies should be applied in order to stop the disappearance of ginger in the near future.

Key words: Abiotic factors, adaptation, biotic factors, ginger, management, production, threats, varieties

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Ginger (*Zingiber officinale*) is monocotyledonous, herbaceous, tropical plant belonging to the family Zingiberaceae. It is a perennial plant, but is usually grown as an annual crop for harvesting as a spice. Ginger is native to South East Asia and now it is grown commercially in most tropical regions[1,2]. The top 5 ginger producer countries are India, China, Nepal, Nigeria and Thailand. India is the largest producer of ginger accounting for more than 34% of the world production in 2011 followed by China[3]. For the past five consecutive years, Ethiopia ranked 10th and 14th position in terms of area harvested and total production of ginger, respectively among the 36 countries engaged in ginger production globally[4].

The ginger had perhaps been known since then in Ethiopia and predominantly grown in the western parts of the Southern Nations, Nationalities and Peoples Regional State (SNNPRS) including Sheka, Kefa, Bench Maji, some parts of Gurage and also central zones of the region covering the areas of Wolaita, Kembata, Tembaro, Dawro and etc[5]. The statistical information from the Ministry of Agriculture and Rural Development of Ethiopia indicates that 99% of the crops production was in SNNPRS.

In Ethiopia, ginger has been used as a flavoring agent, carminative and stimulant and it has become the most important spice for the local as well as the export market. The underground rhizome of this crop is also valued throughout the world as a spice of flavoring agent for its two major classes of constituents, such as; essential oils and oleoresins. The more volatile essential oil consists of monoterpenes and sesquiterpenes, which contribute to the characteristics flavor of ginger and oleoresins which is responsible for the pungent flavor, which is also a source of antioxidants[6-9].

The principal compounds responsible for the pungency of ginger are ginger roots and shagols. Ginger is commercially available in various forms such as; green ginger, dry ginger, ginger powder, ginger oil, ginger oleoresin and preserved ginger[10,11]. Both biotic and abiotic factors affect yields and quality of ginger. Unfavorable environment, which can cause physiological disorders in ginger is a biotic factor. Therefore, abiotic factors are essentially non-living components that affect living organisms, while biotic factors that affect ginger are living organisms such as; diseases, insect pests and weeds that are present the ecosystem and their consequent action affects life cycle of a ginger plant[5].

Ginger plays a significant role in Ethiopian agriculture contributing 42% share in the gross domestic product. It is an important commercial crop, but the quality and specifications play a significant role in the supply and buying of spices. The quantity and quality of ginger is becoming low due to the increment of biotic and abiotic factors in the study area. Based on this, the following research questions were answered by the findings; What are the main threats that affect the ginger plant? Which threat is the most serious and common in the study area? At what stage do ginger is more affected by both abiotic and biotic threats? How was relationship between farmers and agricultural experts towards local pest control methods of ginger cultivation? The objective of the research was to assess the threats that affect ginger cultivation and its management in Luke Kebele of cheha Woreda, Gurage zone, Ethiopia.

MATERIALS AND METHODS

Study area description: The study was conducted in Luke Kebele of Cheha woreda, Gurage zone of Southern Ethiopia. Cheha woreda is one of the 13 woredas in Gurage zone, Ethiopia. Woreda is bordered on the south by Enemorina Eaner on the west by the Oromia region, on the north by the Wabe river which separates it from Abeshge woreda. The administrative center for Cheha is Endibir which is 180 km away from Addis Ababa. Luke Kebele is found 17 km away from the Endibir. The Luke Kebele is again bordered by Yeshere and Gurde Kebele (Reports of Luke Kebele, 2018). Luke kebele is geographically located at 8°C 17'N latitude and 38°C 47'E longitude and an elevation between 1923 and 2534 m above sea level and the annual rainfall is less than 1500 mm.

Population sample size and sampling technique: Sampling was carried out across the research area by using the random sampling technique. The sample size was determined by using Fisher equation[12]:

$$n = z^2 P (1-P)/D^2$$

Where:

- n : Number of the sample size
- z : Standard error at 95% confidence interval (Z = 1.96)
- D : Marginal error, which is equal to 0.05
- P : Proportion of the farmers who have practicing of ginger cultivation in the study area

Hence:

$n = z^2P (1-P)/D^2$, p = 50% = 0.5 so, p+q = 1, q = 1-p = 0.5

$n = (1.96)^2 0.5(0.5)/(0.05)^2$

n = 384

In order to reduce the sample size of the respondents, we applied the reduction formula of sample size when the numbers of households containing farmers in study area were less than 10, 000.

Thus:

$$n = n_o/1+n_o/N$$

where, "n" is the number of farmer households who practice production of ginger plant and those were interviewed, "n_o" implied the sample size obtained by Fisher equation which is equal to 384, "N" implies the total number of household of farmers who practice production of ginger plant in the study area which is equal to 342.

Then n = 384/1+384/342 =181 = 181/342×100 = 52%, which implied that the data collected from the study area were covered 52% the total number of households that contained ginger framers. But, due to the shortage of time and budget, only 95 household farmers who practiced the production ginger plant were interviewed. Which implied that the data collected from the study area was addressed 27% (95/342×100) = 27% of total households of farmers who practiced the production ginger plant in the study area. Random sampling technique was used to select the respondent in order to collect data from the study participants.

Study design and study period: A random selection study design was used to collect relevant data. The study was conducted from February-June, 2019.

Sources and study population: Both primary and secondary data were used. The current total population of Luke Kebele is 5140 (Statistical report of Luke Kebele, 2018). There are 886 householders of the Kebele and from those householders, 342 households contain farmers who practice production of ginger plant and 95 household farmers were selected for questionnaire due to shortage of time, budget and transport facilities in order to gather information about the threats of ginger plant in study area.

Methods of data collection and materials: For data collection, semi-structured questionnaire and interview were used to collect primary data. In addition to that, questionnaire was used by the researcher for the data collection from 95 the randomly selected farmers in the study area. The materials used to collect data were notebook, pen, pencil, cell phone and photo camera.

Procedures for data collection: Semi-structured questionnaire was used. The English language questionnaire was translated into the local language of the study area especially in to Amharic, Guragegna and then decoded back to English by researchers and other people who were skillful in both languages to keep the consistency of the questionnaires. Then, the researchers were controlled the data collection procedures. Observation involved revising all questionnaires on daily basis followed by meetings with the data collectors to confer on any problems faced during data collection. At last data cleaning and editing were occurred. In addition to that secondary data was used.

Methods of data analysis and interpretation: The collected data was analyzed by using Microsoft excel and word 2007, statistical tools like percentage and qualitative and quantitative methods. The results of analyzed data were presented in the form of descriptive statistics such as; frequency, table, chart, figures and percentage.

RESULTS AND DISCUSSION

After completing careful observation and data collection from different sources, the following different results with respective discussions were achieved. The major abiotic threats of ginger in the study area were shortage of rainfall, soil type and improper fertilizer usage. While, bacterial wilt, nematodes and weeds were the major biotic threats of ginger cultivation. All growth stage of ginger was highly affected by some pests and the relationship between farmers and agricultural experts on the pest management of ginger cultivation were very weak. Local pest management methods were commonly used by the farmers of the study area.

Demographic characteristics of the respondents: The general background information of 95 respondents was interpreted in Table 1.

As indicated in Table 1, the majorities of respondents were males and found within age group 25-40 and most of the respondents were Muslims. In addition, most of the respondents especially farmers were uneducated. According to respondents, majority of farmers have indigenous knowledge about the practice of ginger plant around their home for domestic consumption rather than marketing. Studying the background information of respondents provided the cultural and religious perception of farmers towards ginger cultivation.

Table 1: Background information of the respondents

		Respondents	
Items	Alternatives	Number	Percentage
Sex	Male	71	74.73
	Female	24	25.26
	Total	95	100.00
Age group	<25	10	10.53
	25-40	47	49.47
	41-65	36	37.89
	>65	2	2.10
	Total	95	100.00
Educational level	Uneducated	46	48.42
	Primary school	30	31.58
	Secondary school	17	17.89
	College	1	1.05
	University	1	1.05
	Total	95	100.00
Religion	Orthodox	29	30.53
	Muslim	51	53.68
	Protestant	8	8.42
	Others	7	7.37
	Total	95	100.00

Table 2: Major abiotic threats that affect ginger plant

	Respondents	
Abiotic threats of ginger plant	Frequency (Hz)	Percentage
Fertilizer usage	36	29.27
Soil type	20	16.27
Shortage of rainfall	52	42.27
Temperature	15	12.20
Total	123	100.00

Major threats of ginger production: The cultivation of ginger crop can be affected by different abiotic and biotic threats. Abiotic threats were environmental factors that affect the growth, development and productivity of ginger such as; shortage of rainfall, soil type and improper usage of manures. While, biotic threats were living things that cause any morphological or physiological damages on ginger plant. The major biotic threats that affect ginger cultivation in the study area were worms (nematodes), bacterial wilt and some local weeds in addition to the above abiotic ones (Fig. 1).

Abiotic factors that affect ginger cultivation: According to respondents and field survey, the shortage of rainfall (42.27%) was the major threat that affects ginger plant growth and productions as indicated in Table 2. A rainfall of well distributed in 8-10 months is ideal for ginger cultivation[1,2]. Even though ginger needs 8-10 regular rainfall, the annual rainfall of the study area was very low especially it stayed for only 3 months as the farmers stated. Hence, ginger became dormant and producing annually was very low in the gardens of the farmers. The fertilizer usage (29.27%) was the second major threat for ginger plant production next to shortage of

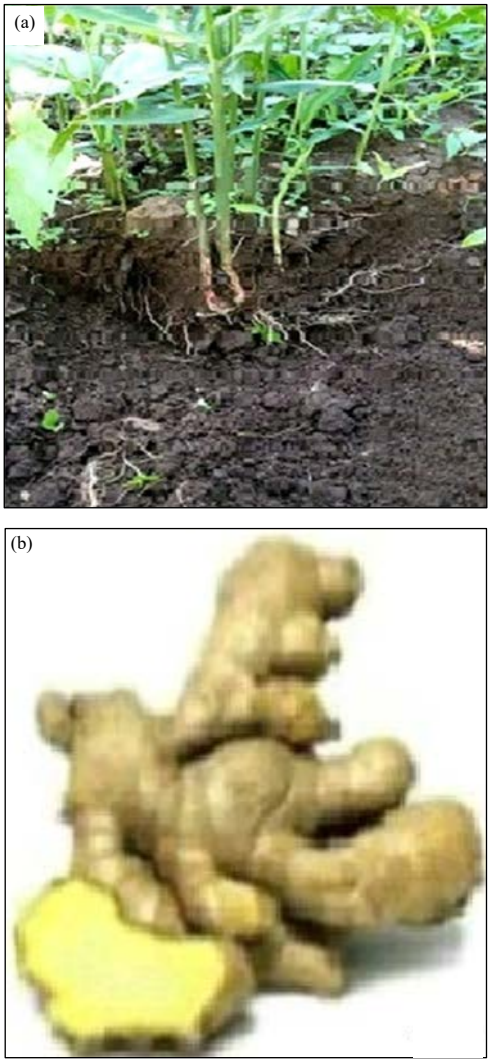

Fig. 1(a-b): Ginger plant, (a) Infected ginger and (b) Ginger root capture from Luke kebele (by Fekede Pella)

rain fall. The local fertilizers such as; dung of cows, composts prepared from the cuts of shrubs and decomposed leaves were the major sources of fertilizer used to enhance the fertility of the soil in order to practice ginger plant in the home garden. Compost sources such as; crop residues, kitchen wastes, garden cuts and manure are important for the production ginger. Even though, local fertilizers are less costly compared to artificial fertilizer such as; DAP and urea, it favors the growth of some worms like nematodes.

The main limitation of the artificial fertilizer was that it burns the germinating ginger when applied during sunny day. Besides burnage, it was costly. As the respondents described, the primary abiotic threat that affects ginger plant was shortage rainfall. Based on Table 2, soil type is the other abiotic factor to practice ginger. Ginger plant requires sandy loom

soil[1]. But in Luke Kebele, the type of the soil is heavy clay. Due to that fact, the soil is easily cracked during summer and exposes ginger to sun burn and then the root of ginger became dried. In addition to soil, temperature is other factor to grow ginger[13]. However, as respondents pointed out temperature condition in Luke Kebele are fluctuating from day to day in spring was unfavorable for ginger cultivation. The non-living things that can affect the growth and developments of ginger are called abiotic factors. In other words they are unfavorable environmental conditions, which can cause morphological and physiological disorders in ginger crop such as; rainfall, soil type, temperature and this was similar with research done by Abeysekera *et al.*[2] and Aragaw *et al.*[13].

Biotic factors of ginger cultivation: The biotic factors are the living entities that can cause any morphological and physiological damages on the growth and development of ginger plant. The major biotic threats that invaded the cultivation of ginger plant in the study area were bacterial wilt, nematodes (worms) and weeds. Compared to other biotic threats, bacterial wilt was the most serious one and worms were the second dangerous biotic threats of ginger cultivation.

In Ethiopia, there are different biotic factors which affect the production and growth of the ginger plants. The biotic factors mainly include different types of disease, pests and weeds. From these, biological diseases is the most serious limiting factor at current situation in our country which includes bacterial wilt disease, ginger soft rot and ginger leaf spot[2,14]. The same is true in the study area. According to respondents especially agricultural experts of Luke kebele, bacterial wilt (36.81%) was very dangerous disease of ginger plant. According to some farmers and agricultural experts, worms such as; nematodes (29.67%) were the second dangerous disease of ginger plant by causing wound around underground root (locally called, Zinjebil) (Fig. 2). Some of nematodes, which causes injury to ginger are root knot nematodes especially, *Meloidogyne* species[10,15]. The other biotic threats such as; ginger leaf spot and ginger shoot borers were rarely appeared. Based on respondents reasoning, cultivation of ginger in Luke Kebele is going to disappear because of these major biotic threats discussed above.

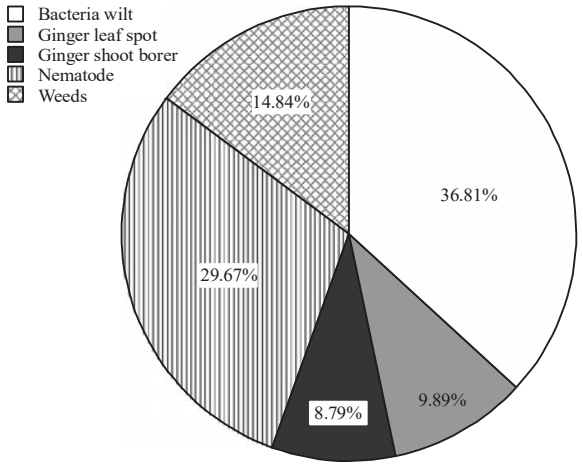

Fig. 2: Major biotic threats that affect the ginger plant

Infected growth stage of ginger: As other herbaceous plants, ginger has different growth stages such as; germination, maturation and flowering stages. When pests began to damage, all the growth stages of ginger became distorted in a short period of time as indicated in Fig. 3.

As it was indicated in Fig. 3, all growth stage (45.45%) of ginger plant was the most vulnerable to risks caused by pests. According to the respondents and field observation, the maturity stage (31.82%) was the second major stage affected by pests. The main pest that affects the growth of ginger at maturity stage was nematode (worm). At maturity stage of ginger, the worm bores the underground roots and the plants

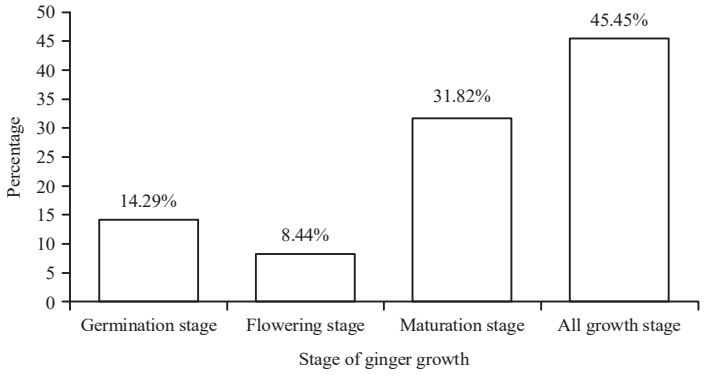

Fig. 3: Stage where pests affect the growth of ginger plant 1

Table 3: Relationship between farmers and agricultural experts on threats of ginger cultivation

		Respondents	
Items	Alternatives	Number	Percentage
The relationship between	Strong	0	-
farmers and agricultural	Medium	7	7.37
experts regarding	Weak	65	68.42
to ginger cultivation	No	23	24.21
	Total	95	100.00

Table 4: Minimization of yield loss due o use of local and chemical pest control methods

		Respondents	
Items	Alternative	Number	Percentage
Local pests control methods	<25	21	21.10
	25-50	6	6.32
	51-75	-	-
	>75	-	-
	No	68	71.58
	Total	95	100.00
Chemical pest control methods	<25	-	-
	25-50	-	-
	51-75	-	-
	>75	-	-
	No	95	-
	Total	95	-

gradually became wounded and then after leaves were chlorised and finally became dried. The study has similar result with major symptoms of ginger plant affected by nematodes were stunting, chlorosis and unperiodic tissue death called necrosis[15].

Relationship between farmers and agricultural experts: The study of relationship between farmers and agricultural experts helps to know the knowledge of farmers to ward ginger cultivation and its threats.

According to respondents and indicated in Table 3, there was very weak (68.42%) relationship between farmers and agricultural expert. Thus, there was no strong agricultural advice given to farmers about modern farming practice of ginger cultivation, some threats that affect ginger plant and strong pest managements in Luke Kebele. Based on this fact, it was concluded that the weak relationship between farmers and agricultural experts about threats of ginger plant leads prediction that ginger is going to disappear in the near future.

As indicated in the Table 4, 71.58% of yield loss was occurred even if some farmers were used local pest control mechanisms such as; site selection and planting unwounded ginger seeds. According to respondents, there was no progress of yield loss minimization and the practice of chemical pest control mechanisms to prevent the yield loss of ginger cultivation by pests in the study area. The main reasons that caused the losing of ginger yield were the weak interaction between farmers and agricultural experts about the pest control mechanisms of ginger and shortage of rainfall.

Local pest management practices: As respondents stated there was no any chemical (modern) pest management practices were taken to control pest attacks on ginger cultivation. Even though chemical method was not applied, some local pest control methods still used by the farmers of study area were the dip plowing and exposing the nematodes and other pests to their natural enemies such as; ants and termites. The other method was mixing local composts such as; cow dung and kitchen wastes with domestic ash. This creates unfavorable condition for ginger worms and some weeds. Using rhizome from pest free as planting material was main means of local pest control ways. Although, these ways were used some pests such as, nematodes were still hurting. Therefore, integrated pest control methods should be needed to prevent ginger plant from pest damages.

CONCLUSION

This research showed that cultivation of ginger in the study area was very low due to both abiotic and biotic threats. The finding identified shortage of rainfall, improper usage of fertilizers and soil type were major abiotic threats of ginger. The main biotic factors that influence the cultivation of ginger were bacterial wilt nematode and local weeds. Bacterial wilt is the most serious disease and it affects all growth stage of ginger. Due to both abiotic and biotic threats, currently ginger is going to disappear in the study area. Therefore, every responsible body should strive for conservation of this expensive spice plant.

SIGNIFICANCE STATEMENT

This study is focused on the ginger production challenges and its traditional management. It is beneficial for surviving the critical problems on the production of ginger in the study area using scientific methods in the near future. To do this, traditional management is a baseline and it can be improved by applying different biotic and abiotic threat control methods. This can be done by all stakeholders of the district and zonal agricultural and development office and food and sustainability program of Ethiopia at large. Therefore, the findings will be remaining uncover for addressing each

farmland of the districts, the researchers allow to search the critical areas of ginger production factors that were not able to explore yet or under discovering the issue as country level. Thus, a new investigation on the ginger varieties which is genetically modified and management may be arrived at with help of biotechnology.

RECOMMENDATIONS

Based on the study results, the following recommendations are forwarded:

- Further research is very essential to get better solution especially to use genetically modified varieties of ginger that can resist both biotic and abiotic threats
- It is better to use modern ways of producing ginger than cultural method so as to increase the quality and quantity of the ginger plant product and keep it conserved in order to protect its disappearance in the near future
- To alleviate the threats of ginger, all concerned organizations and responsible bodies should get involved
- Integrated pest management mechanisms should be applied because local methods were not such applicable
- Finally, educating farmers how to control threats of ginger plant should be given by responsible stake holders

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