academicresearchJournals

Vol. 6(5), pp. 276-290, June 2018
DOI: 10.14662/ARJASR2018.027

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

Status of ginger (*Zingeber officinale*) research and production challenges and future prospects in Ethiopia; a review

[1]Mohammedsani Zakir, [2]Girma Hailemichael*, [3]Mesfin Seyoum and [4]Melaku Addisu

[1,2,3,4]Jimma Agricultural Research Center, P.O. Box: 192; Jimma, Ethiopia
* Corresponding Authors; E-mail address: mohammedsani641@gmail.com girmah2003@gmail.com
mesfinseyoum77@yahoo.com, hawitim@yahoo.com

Accepted 7 June 2018

Ginger (*Z. officinale* Rosc.) is one of the important spices crop in the world. It grows in more of the countries in the world including Ethiopia. This spice has wider adaptation and it grows in most parts of the country. The major ginger production is in SNNPRS, Oromia, Amhara, Gambella and Benishangul regions. The rhizome from this herbaceous plant is very valuable for different uses; food seasoning for home based or industrial level application, for pharmaceutical uses. The spices research in Ethiopia with various limitations did lots on ginger technology development and achieved significant results. Acquiring significant number of ginger accessions from domestic and foreign source, variety development, crop management, protection and postharvest handling recommendations could be mentioned as some of the research achievements. The country, in addition to huge domestic consumption generated 22.6 million USD hard currency in 2008 from export of products of ginger technologies (Yali and Boziab) and local materials. However, with all such huge potential (production and export), the production and productivity of ginger remained very low due to a number of challenges; shortage of variety, traditional crop production and processing and the recently emerged ginger bacterial wilt disease. The current status of ginger needs to be reviewed to give updated image for producers and policy makers and to give possible direction of the ginger revitalization. This paper reviews the research activities conducted and achievements in different disciplines so far, the status of current production and the challenges and future prospects in the country. This can help devise up to date research strategy on ginger, intervene the production and processing improvement.

Key words: Ginger, production, challenges, *R. solanacearum*, processing, quality, and Ethiopia

Cite this article as: Zakir et al.,2018. Status of ginger (Zingeber officinale) research and production challenges and future prospects in Ethiopia; a review. Acad. Res. J. Agri. Sci. Res. 6(5): 276-290

INTRODUCTION

There are about 70 plant species that have been grown as spices, the majority of which are in Asia (Purseglove *et al*., 1981); Girma *et al*. (2008) and Momina *et al*. (2011) also supported this finding. Ginger (*Zingiber officinale* Rosc.), in the family Zingeberaceae is an important tropical herbaceous perennial plant; grown as annual. It is indigenous to tropical India, South East Asia, Australia and Japan with the main center of diversity in Indo-Malaysia (Purseglove, 1972). Other important producers are Jamaica, Nigeria, Sierra Leone, Thailand, and Australia (Purseglove, 1972; Jansen, 1981; Weiss, 2002; and Abraham *et al*., 2014). Ginger has diverse uses for human; for food flavoring at home level (Purseglove *et al*., 1981; Edossa, 1998; Girma *et al*., 2008). Ginger is consumed worldwide as a spice and flavoring agent and is attributed to have many medicinal properties. The British Herbal Compendium reported its medicinal use as carminative, anti-emetic, spasmolytic, peripheral circulatory stimulant and anti-inflammatory (Bradely, 1992). It has also been used throughout history as an aid for gastrointestinal disturbances, to relieve inflamed joints (Katzer, 2007; Momina *et al*., 2011). From the current status, it is not possible to say that Ethiopia is benefited enough from ginger as the research has not been in a position to deliver sufficient technologies and because of that the production remained partly traditional, ginger bacterial wilt being additional challenge.

In Ethiopia the cultivation of ginger started during 13th C when Arabs introduced it from India to East Africa (Jansen, 1981; Girma *et al*., 2008; Endrias and Asfaw, 2011). Its production was mostly limited in the wetter regions of Southern Nations Nationalities and Peoples Regional State (SNNPRS). In Ethiopia ginger research and production has been going on as part of coffee diversification, since the inception of coffee research in 1969 (Girma *et al*., 2008).

Some reports indicated that, ginger was cultivated in an area of 45,164 ha with production of 716,550 t (Ministry of Agriculture and Rural Development, MOARD, 2007). According to the Ethiopian external trade statistics (2008) 22.6 million USD had been earned from ginger. The potential and importance of this spice crop has been expressed via different conditions. The area covered by ginger which was 3760 ha with annual production of 224,932 t in 2005 increased to 17,550 ha in 2007 with annual production of 224,580 t (Engineering Capacity Building Programme (ECBP, 2008) and Bekele *et al*. (2013) project working document). Endrias and Asfaw (2011) also discussed the production and productivity of ginger in southern Ethiopia that had been promising for smallholder farmers. The Authors, citing the report from Bureau of Agriculture and Rural Development (BoARD, 2008) reported that 2896372 Q of fresh ginger was produced from an area of 18,240 ha with average rhizome productivity of 160 Q/ha in the region (Q= quintal =100 Kg). For the past five consecutive years (2006-2011), Ethiopia stood 10th and 14th position in terms of area harvested and total production of ginger, respectively among the 36 countries engaged in ginger production globally (FAO, 2013) and (Tadesse and Asfaw (2013)

The spices research accomplished different agendas and achieved significant number of results and/or recommendations. Collections of more than 90 accessions from domestic and introduction from foreign sources, development of suitable varieties (Yali and Boziab) with possible crop management recommendations were some of the achievements. Research on intercropping of ginger with associated crops, identification of major pests and possible management practices conducted. Harvesting and post harvest management practices, seed multiplication and distribution of the released varieties have been conducted. Evaluations of the quality standards of the ginger varieties were also conducted and were proved promising as they possess international standard.

Production and productivity of ginger significantly reduced to a minimal due to various facts. A number of factors can be mentioned here; shortage of high yielding, disease resistant and high quality varieties, shortage of suitable crop management recommendations such as seed rate/population density, effective weed management practices, harvest and postharvest management. Weak extension system to popularize available ginger technologies, lack of value chain and value addition and weak market linkage are some of the factors responsible for low production and productivity. In addition, the incidence of ginger bacterial wilt disease because of *Ralstonia solanaceurum* in 2011/12 has been devastating to ginger in the country and almost all ginger producing areas had been affected by the disease and production reduced by more than 90 percent (Tariku *et al*., 2016). According to the survey results conducted in 2012, the wilt incidence in some of the survey areas such as Sheka zone was 93.5% (Habetewold *et al.,* 2015). The very important spice crop, ginger with such potential and challenges need to be considered as important intervention area at a national level. This paper reviews the research achievements so far, production status, potentials and opportunities, challenges and future prospects of ginger in Ethiopia. The following objectives were the targets of this review paper; to give summary picture of ginger research achievements, challenges and future prospects and give research direction and to put clear image on status of ginger production in Ethiopia.

RESEARCH ACHIEVEMENTS/FINDINGS

Germplasm Enhancement and Variety Development

Germplasm enhancement

The first strategy to achieve good research in breeding is to acquire sufficient number of accessions in the respective or target crop. Two major approaches were followed to accomplish this objective; collection from domestic sources and introduction from abroad. The spices research team started before 4 and half decades since the start of coffee research as diversification. Some years later, there was start of introduction of ginger accessions and at the same time collection from different potential ginger growing areas had started. Collection is always conducted in collaboration with the expertise from Institute of Biodiversity and Conservation (IBC). Collected and introduced materials were maintained in research plots of Jimma Research Center and mainly in Tepi Agricultural Research Sub center before, currently upgraded to Tepi National Spices Research Center. In spite of the challenge/threat from the ginger bacterial wilt disease that devastated more of the collections, more than 90 accessions were collected and some introduced since beginning. Collected and introduced ginger germplasms undergo evaluation based on different parameters. The following list (Table 1) shows some of the list of accessions with their source.

Variety development

Evaluation of the ginger accessions gives high attention for wider adaptation, vegetative performance (sprouting, uniformity, plant height, leaf, etc.), rhizome parameters including yield. Disease resistance and quality (essential oil and oleoresin content) are some of the parameters considered in the evaluation of the ginger accessions.

The increment of the number of accessions was has been sluggish as the human power and other related facilities were not organized in such way to perform as deemed expected. The research data indicated that about 12 accessions were introduced from five countries like Mauritius, Australia, Riodjienero, Surinam and Rafinufa while about 33 accessions were collected from different Regions of Ethiopia (Table 1). Some candidate varieties were at the final stage to be verified and released, but the incidence of ginger bacterial wilt devastated the whole activity. Currently, there are about 45 accessions and high struggle continued to save these materials from loss due to bacterial wilt disease of ginger.

Once some germplasm of ginger were attained evaluation continued and five accessions were promoted to users with recommendation. Evaluation of the ginger accessions gives high attention for wider adaptation, vegetative performance (sprouting, uniformity, plant height, leaf, etc.), rhizome parameters including yield. Disease resistance and quality (essential oil and oleoresin content) are some of the parameters considered in the evaluation of the ginger accessions. Accordingly, two ginger varieties; Boziab (Maw.37/79) and Yali (Miz.180/73) were released in 2005. Fresh rhizome yield (Q/ha) 37.2 and 34.3, oleoresin yield % (w/w) 10.8 and 9.7 and essential oil yield % (v/w) 1.8 and 1.3 were reported (Girma *et al*., 2016) and Edossa, 1998) (Table 1).

CROP MANAGEMENT

Planting Material and Land Preparation

Spacing or Seed Rate

Plant/rhizome spacing can vary based on different environmental factors; mainly moisture, soil types and status of fertility. As reported in Edossa (1998) spacing of rhizomes; 20 cm between rows and 15 cm between plants gave highest fresh rhizome yield (200 Q/ha). However, practical experiences in field indicated that the rhizomes planted with this spacing combination resulted in congested and intermingled rhizomes and this finally created problem to harvest quality rhizomes. Accordingly, spacing of 30 cm X 15 cm between rows and between plants has been recommended (Girma *et al*., 2008). The researchers also indicated that this issue should be further studied to have location specific recommendations. The amount of seed rhizome or seed setts required to sow one hectare of land varies based on the spacing, size (length and weight) of the seed rhizomes used for planting. Research results indicate that as the size of the seed rhizome increased, the fresh rhizome also increased in parallel. As the seed is the commercial produce itself, high care should be taken not to miss the marketable rhizomes because of extra seed. Accordingly, even if seed rhizome with 2.5 - 5 cm with at least 1 bud is possible, for high fresh rhizome yield rhizome with 10-20 cm is highly recommended as marginal rate of return is considered (Girma and Kinde, 2008). The Authors reported that with 10-20 cm size, seed rate of 25-30 Q/ha of ginger is recommended for optimum production.

Land selection, land preparation

Site for ginger planting should not be on sloppy area but it is important we select gentle slope to avoid water logging and incidence of disease. If it is sloppy land water can deplete the soil around the plant rhizome and reduce the growth, production and quality of ginger. The nature

Table 1. Germplasms and varieties of ginger in Ethiopia

No.	Entry code	Origin	No.	Entry code	Origin
1	Ging.28/79	Mauritius	23	Ging.52/86	>>
2	Ging.36/79	Australia	24	Ging.30/86	Collected
3	Ging.41/79	Riodjenero	25	Ging.24/86	>>
4	Ging.316/73	Surinam	26	Ging.85/86	>>
5	Ging.296/79	Rafinufa	27	Ging.45/86	>>
6	Ging.305/73	Collected	28	Ging.75/00	>>
7	Ging.25/86	>>	29	Ging.61/00	>>
8	Ging.28/86	>>	30	Ging.307/72	>>
9	Ging.61/86	>>	31	Ging.087/00	>>
10	Ging.10/86	>>	32	Ging.15/79	Rafinufa
11	Ging.48/86	>>	33	Ging.38/79	Australia
12	Ging.57/86	>>	34	Ging.39/79	>>
13	Ging.84/86	>>	35	Ging.180/73	Collected
14	Ging.70/00	>>	36	Ging.181/73	>>
15	Ging.74/00	>>	37	Ging.47/86	>>
16	Ging.41/00	>>	38	Ging.53/86	>>
17	Ging.16/79	Rafinufa	39	Ging.58/86	Collected
18	Ging.37/79	Australia	40	Ging.59/86	>>
19	Ging.40/79	Riodjenero	41	Ging.56/86	>>
20	Ging.141/73	Australia	42	Ging.54/86	>>
21	Ging.190/73	Collected	43	Ging.26/86	>>
22	Ging.29/86	>>	44	Ging.86/00	>>
			45	Ging.63/00	>>

Sources: Edossa, 1998 and Girma *et al*., 2008

Table 2. Mean fresh rhizome yield of ginger (Q/ha) planted on different land preparation

Land preparation	Fresh rhizome yield (Q/ha)
Flat land	192.6
Planting on open ridges	148.7
Planting on open ridges after emergence	195.1
Planting on raised bed	207.7
Planting on tide ridges	173.9
Tide ridges after emergence	192.8
Over all mean	185.2

Source: Edossa, 1998

of growth of rhizomes is horizontal expansion and for this light, workable and easily moving loam soil is required for ginger production. Edossa (1998) and Girma *et al*. (2008) reported that land for ginger planting should be thoroughly ploughed before the rainy season starts. Different types of land preparations (raised bed, flat land, ridge, etc.) were tested for high rhizome yield. Maximum and minimum fresh rhizome yield (Q/ha) of 207.7 and 14.87 was recorded from raised bed and from open ridge planting, respectively (Edossa, 1998). Results of effect of different land preparation methods on ginger growth and yield of ginger is presented in the following table (Table 2).

Suitable seed rhizome storage

Ginger rhizome used for planting material is a bulky material and need high care of handling for successful germination and final yield. The duration between first harvest and next planting is 120-150 days at Kerala, India. As ginger is vegetatively propagated, the rhizomes should be stored safely during the off-season; but it is a highly perishable commodity and is susceptible to soil-borne fungi and insects. The seed rhizomes should be stored appropriately so that rotting, shriveling, dehydration and sprouting can be avoided until the next season planting. Different methods are being adopted by farmers for storage of seed ginger (Kannan and Nair, 1965; Pruthi, 1993 Cited from Kandiannan *et al*., 1996). Different types of seed rhizome storage methods and treatments were tested. Shadap *et al*. (2015) reported that storage of seed rhizomes in zero energy cool chamber (ZECC) treated with *T. harzianum* resulted in higher vegetative performance and high rhizome yield. Different storage methods of seed rhizome ginger; storing under thatched roof shelter on the ground, under thatched roof shelter on one meter raised shelf, in pits covered with thin grass mulch, buried in pits and under tree shade covered with mulch materials with ginger Yali (Miz.180/73) and Tepi local with factorial combination and randomized complete block design with three replications. The result indicated that storage methods that can help to have more or less anaerobic conditions during storage time to facilitate high sprouting and fast recovery of seed rhizomes should be designed from local materials. Ginger growing farmers can keep seed rhizomes: in pits covered with thin grass mulch, under tree shade covered with mulch materials, or kept (buried) in pits. This can be arranged based on the moisture of the environment, that if the area has high moisture (short dry season), seed rhizomes can be stored under tree shade covered with mulch materials or in pits covered with thin grass mulch, and the second alternative (buried in pits) can be used if the area is with longer dry season (Girma and Mesfin, 2016). Results of the different storage methods and their consecutive performance are presented in Table 3.

Planting time

Growth and yield of ginger is affected by planting time. However, it varies from place to place depending on climatic and soil conditions of the area. A number of research results indicate that planting ginger early in the season when rainfall starts and reliable moisture appears is beneficial. Early planting ensures that the crop will make sufficient growth to withstand heavy rains and will grow rapidly with the receipt of the consecutive heavy rains (Purseglove *et al*., 1981). Result of a research conducted in Tepi National Spice Research center revealed that sowing in 5th March and 5th April is good for ginger growth and yield (Edossa,1998) (Table 4). Currently because of dynamic climate change, determination of planting/sowing time as indicated above may not be recommended; rather planting/sowing following the moisture availability is highly recommended (Girma *et al*., 2008). Therefore the time of planting ginger should be decided based on the availability of rain, since the ginger crop needs elongated rain/moisture. According to the results indicated in Table 4, planting from 5th March to mid of April can be recommended.

Crop Rotation

The ginger plant can heavily use the soil nutrient, thus using crop rotation with the legume crop is good for producing high yield. If not, it leads to high expenses for fertilizer, outbreak of ginger diseases, insect pest and weed which can directly decrease the production. Rotate ginger with crops that are not hosts of the bacterial wilt pathogen, such as sweet potato and taro. It is not recommended to intercrop or rotate ginger with solanaceous crops, including tomatoes, peppers, and eggplant. The pathogen can reproduce in these crops and build up levels of bacterial wilt in the field. Ginger may also be rotated with grain crops such as corn or upland rice. Other possible crops for use in rotation or intercropping include green onion, soybean, sweet corn, cabbage, and Sunn hemp (Scot, 2013).

Intercropping

Intercropping practices of different crops is highly recommended with respect to the maximizing yield per unit of land as the land owning by smallholder farmers is decreasing time to time. Intercropping of ginger with coffee was found effective under recommended agro ecologies (Tepi, Anfillo and the like) (Zenebe and Bereke-Tsehay, 1991) while no significant yield reduction was recorded from the integration of turmeric with coffee. These findings revealed that turmeric can perform well under moderate shade levels (IAR, 1997). On the other hand, supplementary irrigation was proved to increase ginger rhizome yield by 72% over non-irrigated plot (IAR, 1985).

Anteneh and Taye (2015) also recently proved and reported the advantage of intercropping of ginger and coffee. According to the authors, the land equivalent ratio (LER) depicted the yield advantage of growing coffee and turmeric and ginger together, suggesting their complementary to utilize efficiently the available resources and their beneficial effects on each other. It has been further stated that coffee can be grown with

Table 3. Percentage of rotting, sprouting, shriveling, viable and fresh rhizome yield (Q /ha) of seed rhizome of two ginger cultivars under different storage methods.

Treatments	Percentage of seed rhizome Rotted	sprouted	shriveled	Viability	Fresh rhizome yield (Q/ha)
I. Cultivars					
180/73	10.8	88.5	11.7	88.3	266.3
Tepi local	2.2	92.0	41	89.5	243.4
II. Storage methods					
1. Under thatched roof shelter on the ground	0.9b	1.5c	17.2a	80.0ab	275.2a
2. Under thatched roof shelter on one meter raised shelf	0.0b	0.17c	26.4a	73.0b	264.7ab
3. In pits covered with thin grass mulch	2.5ab	87.6a	1.3b	85.4a	226.1b
4. Buried in pits	6.5a	80.9a	0.83b	80.9a	226.0b
5. Under tree shade covered with mulch materials	0.9b	29.8b	5.3b	85.7a	282.4a
CV (%)	10	11	8	7	15
Significance					
Cultivars	NS	NS	0.0003	NS	NS
Storage methods	0.0031	0.0001	0.0001	0.027	0.016
Cultivars*Storage methods	NS	NS	0.0028	0.0001	NS

Means within a column having different letters are significantly different ($P \leq 0.05$).
Source: Girma and Mesfin, 2016
Q= 100 Kg

Table 4. Mean fresh rhizome yield of ginger (Q/ha) as influenced by different planting times (months) (average of three seasons)

Planting time	Fresh rhizome yield (Q/ha)
5th March	340.9
5th April	303.8
5th May	271.2
5th June	222.5
5th July	160.4
5th August	102.1
5thSeptember	53.9
Over all mean	207.8

Source: IAR Jimma Research Center Progress Reports (1983/84,1984/85,1985/86, Girma *et al*., 2008) ginger and turmeric without significant yield reductions. The compact cultivars were found to be more suitable for intercropping with turmeric and ginger than intercropped coffee type. As a whole, coffee intercropping with turmeric and ginger was found to stabilize yield advantages and gross economic returns, particularly at the early year of stand establishment. Hence, the small holding farmers can more or less be buffered against crop failure and low market price of one crop (Anteneh and Taye, 2015). Mean clean coffee yield (Qt ha^{-1}) and fresh rhizome yields of spices (Qt ha^{-1}) as influenced by the intercropping practices at Tepi over six crop years is presented in Table 5.

FIELD MANAGEMENT

Identification of major pests (weeds, insects and diseases)

Major weeds and management

Identification of major weeds of ginger was conducted in different sites in Southwestern Ethiopia. All noxious and important weed species were abundantly growing in the experimental site and the surrounding. The classification as noxious and important was based on the species competitive ability and time and money spent for their control. The noxious species are highly competitive for essential growth requirements and are also too difficult to control once they are established in the field. The Cynodon spp, Cyperus spp, Cyperus spp, and Digitaria are those growth nature are perennial and their economic importance were notious while *Gyzotia scabra* and *Commelina benghalensis* were annual growth nature. In another way *Bidens pilosa*, *Ageratum conyzoides* and *Plantago lanceolate* were annual growth nature and their economic importance were important (Habetewold *et al.,* 2015; Tadesse *et al*., 2015) (Table 6).

Study has clearly demonstrated that ginger responded well for hand weeding that as weeding frequency increased yield of ginger also increased. As ginger is inherently low germinating and slow growing crop it suffers serious weed competition especially during early establishment period. The experiment result showed that one early hand weeding at 30 days after planting was critical for high yield of ginger. If the first hand weeding is delayed up to 45 and 60 days yield was reduced tremendously. Mulching ginger at planting followed by two hand weeding at 60 and 90 days after planting or hand weeding ginger at 30 and 60 days followed by mulching or weeding ginger at 45 and 75 days after planting is recommended for good weed control and high yield of ginger (Tadesse *et al*., 2015) (Table 7).

Major insect pests and management

Ginger plant can be affected by various species of insects, among which the shoot borer (*Conogetbes punctiferalis*_ Guen.) and rhizome scale (*Aspidiella bartii* Sign) are major pests in field and during storage of rhizome respectively. White grub (*Holotrichia setticollis*), skipper (*Udaspis folus*) considered as minor insect pests (Ragunathan, 2002). Dry ginger also affected by many species of insects, most importantly; cigarette beetle (*Lasioderma serricorne*_ Fab.), drug store beetle (*Stegobium paniceum* L.) and coffee bean weevil (*Araeserus fasciculatus*_ DeG.) (Ragunathan, 2002).

The following recommendations can apply to manage the effects of insect pests on ginger; understanding life history of insects in concern, knowing insects seasonal incidence, identifying host plants for insects, using resistance variety, using natural enemies ,etc. However, using IPM method is the most important solution for insect pest management (Ragunathan, 2002).

Integrated pest management (IPM) method includes cultural ,mechanical, biological and chemical practices like deep ploughing of the field, solarization of beds for 20-30 days is beneficial in checking the multiplication , light trap will be useful in attracting and collecting the adult moths of shoot borer, collection of leaf roller larvae by locating the folded leaves is suggested, mechanical collection of white grub adults at dusk during emergence and destruction, use of *Lantana camara* and *Vitex negundo* as mulch may reduce the infestation of shoot borer, conserve the natural bioagents such as lady bird beetles, spiders, chrysopids, trichogrammatids, etc , release of trichogramma chilons @ 50,000/ha/week for lepidopterans, spray neem oil (0.5%) at fortnightly intervals, if shoot borer is noticed. Or, spray dimethoate or quinalphos (0.05%), spray carbaryl (0.1%) to control leaf roller, dip the seed rhizome in quinalphos (0.1%) twice before storage /sowing to get rid of rhizome scale, spraying of dimethoate and quinalphos is effective against rhizome fly (Ragunathan, 2002).

Major diseases and management

Ginger product and production can be reduced due to different diseases. Ginger is prone to many diseases of which rhizome rot, bacterial wilt, phyllosticta leaf spot, storage rot, etc. It has been reported by Habetewold *et al*. (2015); Tariku *et al*. (2016) ginger production had been devastated almost 90% because of ginger bacterial wilt disease. Major diseases and possible control measures are presented in Table 8.

Fertilizer recommendations

Ginger is an exhaustive crop and requires heavy

Table 6. List of the noxious and important weed species of ginger in Ethiopia

Botanical name	Family	Growth nature	Eco-physiology definition	Economic Importance
Cynodon spp	Poacea	Perennial	C4	Noxious
Cyperus spp	Poacea	Perennial	C4	Noxious
Digitaria	Poacea	Perennial	C4	Noxious
Gyzotia scabra	Asteracea	Annual	C3	Noxious
Bidens pilosa	Compositea	Annual	C3	Important
Commelina benghalensis	Commelinacea	Annual	C3	Noxious
Ageratum conyzoides	Compositea	Annual	C3	Important
Plantago lanceolata	Plantaginaceae	Annual	C3	Important

Source: Habetewold *et al*., 2015 and Tadesse *et al*., 2015

Table 7. Yield of ginger as affected by weed management methods

Treatment	Weed dry weight (Kg/plot)	Weed control efficiency	% yield loss	Yield (Q/ha) 2009	2010	2011	Mean
Hand weeding at 30,60,90, days after planting	31.3	64.6	3.0	8.2	47.6	27.4	27.7
Hand weeding at 45,75,105,135 &165 days after planting	11.3	87.2	16.0	18.2	114.5	65.1	65.9
Mulching at planting followed by hand weeding at 45 and 75 days after planting	32.7	63.1	42.3	35.9	84.8	51.6	57.5
Hand weeding at 60,90,120 ,150 days after planting	43.3	51.0	7.6	7.3	33.7	20.7	20.6
Mulching at planting followed by hand weeding at 60 and 90 days after planting	12.7	85.6	11.3	28.7	131.5	78.6	79.6
Hand weeding at 30 and60 days after planting followed by mulching followed by one hand weeding as needed	7.7	91.3	15.5	26.9	103.7	63.7	64.8
Hand weeding at 45 and 75 followed by mulching followed by one hand weeding as needed	8.6	90.3	1.7	24.6	115.8	72.3	70.9
Clean weeding	0.0	100.0	-	23.7	107.3	78.1	69.7
Weedy control	88.5	0.00	100.0	0.00	0.9	8.1	3.0
CV %	22.0			23.1	18.9	21.2	27.7
LSD 5%				9.3	27.9	15.5	
LSD 1%				14.5	38.3	24.3	

Source: Tadesse *et al*., 2015

manuring to obtain high yield (Borget, 1993 and Purseglove *et al*., 1981). As reported by Paulos (1973), in India, 25-30 tons per hectare of well decomposed cattle manure or compost is applied at the time of planting. A factorial combination experiment of coffee husk compost at 0, 45 and 90 tons/ha; N: 0, 75, 150 kg/ha; P: 0, 33 and 66 kg/ha were tested on ginger in Tepi areas. In the study there was a general increase in yield of ginger as the levels of N and coffee husk increased, but there was no significant yield difference among the rates used as reported by Edossa (1998) citing from Paulos (1986). Therefore, according to this result, it was not recommended to apply fertilizer and if it is required to get higher yield up to 500 Q/ha; 90 ton, 150 kg/ha, 66 kg/ha (coffee husk, nitrogen and phosphorus) combinations respectively can be applied (Paulos, 1973). However, it is highly recommended to run the fertilizer study to have optimum recommendation to different areas including south Ethiopia. Application of 75 Kg/ha N and 33 Kg/ha P with no application of husk gave reasonable yield (Edossa, 1998) and can be alternate recommendation (Table 9).

Harvest and postharvest management

Harvesting time and maturity

Morphological changes such as leaf turning from green to yellow, drying and finally the pseudostem degenerated and falls down. Determination of suitable harvesting stage depends on location, product type and processing type. For preserved ginger, harvesting should be at seven months of planting, but for dry ginger, suitable harvesting at 8-10 months of planting (Purseglove *et al*., 1981). Harvesting stage is governed by the demand of the end users of the produce; if the produce if for extraction harvesting 7-8 months after planting is recommended while for the whole home use of dry ginger harvesting 8-10 months after planting is recommended (Girma *et al*., 2008).

Late harvesting of ginger such as more than 10 months and above can significantly reduce the quality of ginger while it increases the rhizome yield. The fibrous part of ginger increases on the penalty of extraction parameters (essential oil and oleoresin). Edossa (1998) and Girma *et al*. (2008) also discussed that as the duration of the ginger rhizome in the field increased, then the quality significantly reduced as the rhizome increases it fiber content and this can reduce the need of ginger on market and directly reduce its production.

Recommended postharvest practices

Recommended postharvest practices to attain quality product includes; care during harvesting (not to have broken rhizomes) thus it was well documented that ginger spoilage was mainly associated with injuries and damages induced during harvesting and postharvest handling practices. The injured, damaged and cut ends (if not carefully cured), may serve as starting point for mould growth and rot, and may also serve as inoculums sources for the spread of deteriorating and pathogenic fungi to the whole/stock ginger and hence facilitate spoilage and deterioration (FAO, 2004; NARI, 2004 ; Yiljep *et al*., 2005 and Belay *et al*., 2012).

Washing of harvested rhizomes is one of the important postharvest practices in order to get quality product of ginger. Water from spring, rain or well is recommended for washing rhizomes. Belay *et al*. (2012) reported that it was observed at Hadaro that farmers put fresh harvested ginger with sack on unclean ground which initiates mould growth that further facilitates spoilage of fresh ginger. The survey also indicated that cleaning and washing are not common activities in both sites (Hadaro-Tunto and Boloso-Bombae), where 93% of the respondents do not wash their ginger. Therefore washing should be practiced mainly before storing the rhizome. Following recommended drying structures such as clean surfaces, raised beds, frequent turning over of the rhizomes for uniform drying, etc. are very important practices. Rhizomes can also preferably be grouped into large and small based on their size and this helps to treat drying process according to their size.

Results of investigation revealed that the average moisture content of dried and stored ginger was 13.39 and 13.79 % at Hadaro-Tunto and at Boloso-Bombae, respectively. This moisture level was above the recommended moisture level which is 7-12%. Inappropriately prepared ginger storage places may increased the possibility of absorbing moisture from the surrounding condensation and increase the moisture content of dried ginger (Belay *et al* ., 2012).

Suitable packing and storage is also another important postharvest practice to maintain the quality of the dried ginger produce. The packing materials or containers should ensure to prevent the spoilage of the product before arriving at the hands of the consumers. Only new and clean bags should be used for packing dried ginger. It is preferable to use polythene laminated gunny bags for packing dried ginger. In the Ethiopian context, clean sisal sacks can be used as alternate packing materials for dried ginger.

Storage of the dried ginger is necessary until transport to market areas and the following important points should be given a due attention in the storage. The storage area should be free from domestic or wild animals, dry, cool, ventilated and should not be in front of the long sunny hour at the day time (Girma *et al*., 2016).

Table 8. Major diseases, causal agents and control measures.

Diseases	Causal organism	Control measures
Soft rot (rhizome rot)	*Phythium* spp	1.Healthy rhizome selection 2. Soil solarization 3. Biological control by using Trichoderma 4. Chemical control by seed treatment 5. Soil drenching with fungicides viz. Diethane M-45, Difolatan, Metalayxl ,Bordeaux mixture etc.
Bacterial Wilt	*Ralstonia solanacearum*	1.Selection of disease free rhizomes 2.Soil solarization 3.Rhizome solarization 4.Crop rotation 5.Hot water treatment of rhizome(50^{0c} for 10min or 40 ^{o}C for 15 min) 6. Biological control using *Pseudomonas fluorescens.*
Phyllosticta leaf spot	Phyllostict zingiberi	1. Crop sanitation 2. Providing shade 3. Chemical control using Bordeaux mixtures.

Source: Nybe *et al.*, 2007

Table 9. Fresh rhizome yield (Q/ha) as influenced by different rates of fertilizers (nitrogen, phosphorous and potassium)

Coffee husk (t/ha)	N (Kg/ha)	P (Kg/ha)			Mean
		0	33	66	
0	0	410.3	430.5	454.4	431.8
	75	470.8	492.7	480	481.1
	150	427.8	442.7	474.2	448.2
	Mean	432.3	455.7	469.6	453.7
45	0	434	419.1	462	438.4
	75	491	480	514.6	496.2
	150	468.2	538.2	439.6	481.8
	Mean	464.4	479.1	471.8	471.8
90	0	425.2	403.1	426.8	418.4
	75	433.2	418.4	425.1	458.9
	150	498.5	426.6	450.9	454.4
	Over all mean	426.1	453.6	464.1	459.9

Source: Paulos, 1986 and Edossa, 1998

Table 10. Ginger varieties and their essential oil and oil contents

Variety	Source	Color	Volatile oil content of oleoresion (%)	Essential oil % (V/W)	Oleoresin (%) (w/w)
Miz.180/73 (Yali)	Mizan	Light yellow	34.3	1.3	9.7
Maw.37/79 (Boziab)	Australia	Yellow	37.2	1.8	10.8

Source: Edossa, 1998, Girma *et al*., 2016

Quality of ginger

Quality of ginger can be physical quality or extraction quality. These important quality parameters are highly related with harvesting stage at maturity. From late harvesting (8-10 months after planting), improved physical appearance and plumpy and whitish gray coloured rhizomes are obtained (Girma *et al*., 2008). On the opposite if the target of the production if for extraction, there is no need to consider the physical appearances as the important is extraction volume per unit weight of the produce. The quality status of ginger varieties in Ethiopia were assessed based on general appearance, size, physical form of rhizomes, aroma, flavor, oleoresin content, etc. Based on Indian standard the volatile oil content of ginger oleoresin was 16-35%. Nevertheless, the volatile oil content of ginger cultivars evaluated from Tepi was from 28.9 to 43.76%. The two released varieties of ginger in Ethiopia were evaluated for quality and results are presented below. Detail results of analyses of the two ginger varieties are presented in the following table. All the quality parameters were satisfactory to the international standard level (Table 10).

CHALLENGES OF GINGER RESEARCH AND PRODUCTION IN ETHIOPIA

Research

In Ethiopia ginger research remained very undeveloped was limited due to different challenges such as inadequate capacity in research and extension, shortage of qualified human power, shortage of research facility, lack of improved variety, lack of wider gene pool of wild and relative species in some of the spices species specially for introduced ones. Wider gene pool is the basis to carry out further selection for pest resistance, wider adaptation and quality. Lack or shortage of the biotechnological facilities to carry out genetic engineering is also another challenge for spices research in Ethiopia.

Production

Ginger Production in Ethiopia was handicapped by shortage of high yielding & good quality varieties, incomplete package, inconsistent market, inappropriate practices of Pre and post harvest handling, lack of factory which process ginger in the modern way, lack of value addition, absence of Innovate technologies (farm management, drying, storage),weak role of private commercial investors in spices production, etc.

EMERGING ISSUES; GINGER BACTERIAL WILT (GBWD)

Ginger bacterial wilt caused by *Ralstonia solanacearum* is seed/rhizome, soil and water borne disease. In Ethiopia the losses from bacterial wilt was not estimated before. *R. solanacearum* strains that affect Zingiberaceae crops have been widespread and exceedingly destructive in many parts of the world, including Hawaii, Africa, several Asian countries and Australia (no severe recurrence since 1970) in the last decades. Very recently a severe outbreak of ginger wilt disease was reported by agricultural bureau experts in Ethiopia, particularly in the Southern Nations, Nationalities and People and Gambela Regional States. Based on the report, continuous survey was conducted during the 2011/12, 2012/13 and 2013/14 to investigate the status of the disease, pathogen. However, based on the preliminary survey report, a serious economic loss has been reported from southern part of the country. In subsequent year 2014 survey result, SNNPRS (Dawro, Wolayta, Kenbata tenbaro, Hadiya, Gomogofa, Konta, Alaba, Sheka, and Bench maji) and Gambella region (Majang) zone ginger was found devastated by the bacterial wilt and cause yield loss up to 98%. This is due to the prevailing ideal weather condition for the bacteria epidemics (average rain fall, 287.9 mm, maximum and minimum temperature 27.8 ^{O}C and 17.1 ^{O}C, respectively) and using of latently infected seed rhizome (Habetewold *et al*., 2015). Because of lack of internal quarantine regulations in seed system in the country, the disease can be a threat in other ginger growing parts of the country (Tariku *et al*., 2016). Direct yield losses and incidence by *R. solanacearum* vary widely according to the host, cultivar, climate, soil type, cropping pattern, geography and strain (Yuliar *et al.*, 2015 and Habetewold *et al*., 2015).

Symptoms and signs of ginger bacterial wilt (GBW)

First yellowing and wilting of the lower leaves appears which quickly spread upwards. In advance stages, the base of the pseudo stem become water soaked and rapidly breaking away from the rhizome, the vascular tissue become dark brown or black ,the cut pseudo stem and rhizome give a white, milky exudates etc. (Yuliar *et al.*, 2015 ; Habetewold *et al*.,2015).

Current research status of GBWD

Currently the ginger issue is one of the majorly concerned research strategies of Ethiopian Institute of Agricultural Research under which different researches were proposed by Biotechnology (Jimma, Holeta) to get clean initial seed/rhizome under different procedures. In addition to this, various mechanisms of seed rhizome treatments and cultural practices were laid out and under accomplishment by different research centers like Tepi, Jimma, Areka including Jimma and Holeta biotechnology laboratories.

Recommended management practices of GBWD

Management of ginger bacterial wilt (*Ralstonia solanacearum*) with different methods undertaken is integrated type which includes: selection of disease free rhizomes, soil solarization, rhizome solarization , crop rotation, hot water treatment of rhizome (50 ^{0}C for 10 min or 40 ^{o}C for 15 min), biological control using *Pseudomonas fluorescens,* using animal dung (farmyard manure),etc *(*Nybe *et al.*, 2007*).*

Organic soil amendment:- mulches and composts amended with effective microorganisms promote microbial activity that may suppress *R.solanacearum by competition and/or antibiosis.*

Crop rotation:- Rotate ginger with crops that are not hosts to the pathogen , *R*. *solanacearum*. Such root/tuber crops include sweet potato, taro, maize, haricot bean and other crops which are grown in the cropping system.

Soil drainage:- Ensure adequate soil drainage and diversion ditches to prevent the runoff of infected water sources into fields that are down slope from an infected field. In other word field preparation on which the crop grown need to be gentle slope and high care of drainage.

Solarization:- solarization of seed rhizome and soil is the exposure of the seed material covered by plastic sheet and exposed to sun heat for hours. After the treatment, the pathogens into the surface of the seed and to some degree in the internal tissue and in the soil will be killed.

Bio-fumigation:- Is the use of essential oils to kill or suppress the pathogen. Such oils are a natural component of certain green manures crops such as mint, palmarosa (*Cymbogogom artini) and lemongrass.* When these plants are turned or plowed into soils several months before planting, they decompose and release the essential oils which are toxic to the pathogenic bacteria. Plant essential oils have potential to control bacterial wilt by eliminating the disease causing bacteria in field soil.

Seed treatment:- Seed treatment help minimize the inoculums load in and outer parts of the tissue of rhizomes. Such chemicals are like Bordeaux mixture and other chemicals which have bactericide nature. Soil fumigation and seed treatment with chemicals that have bactericide nature; found to be effective to clean the pathogen present as latent in seeds and reduce the population of the pathogens in the soil.

Biological control:-Biological control assumed to be the direct and accurate management of common components of ecosystem to prevent plants against pathogens. It is acceptable as a key practice in sustainable agriculture, preserves environmental quality by reducing the dependency on chemical input and maintaining sustainable management practices, suppressing the population dynamics of *R. solanacearum.*

Soil conditions during planting and harvesting:- Which minimizes crop exposure to the pathogen and others control measures are factors to be considered in developing the integrated control of bacterial wilt in ginger.

OPPORTUNITIES AND FUTURE DIRECTIONS

Directions of research agenda

Germplasm enhancement and variety development by introducing different resistant/tolerant varieties, new accessions for further research to develop new resistant/tolerant variety to GBW, Using biotechnology tools to develop Clean rhizome seed, closely maintaining the ginger accessions found at Jimma Agricultural research center (JARC), Tepi, Areka and Jimma Biotechnology for further utilization of the accessions in the research processes.

Crop management practices (fertilizer, spacing/population) should coincide with the direction of overcoming the environmental (climate) changes, degradation of soil fertility, demand for production increment, outbreak of diseases, insect infestation and invasive weed problems. As the time go, the traditional methods of processing the product replaces by the modern factory, which need a huge amount of ginger rhizome, as a result of this, using fertilizer and adjusting the plant population per ha in such a way give a required yield that satisfy the demand of the factory.

Diseases and insect pest management- focus on integrated pest management which includes cultural, mechanical, biological and chemical practices (Ragunathan, 2002).

Cultural practices like deep ploughing of the field, solarization of beds for 20-30 days is beneficial in checking the multiplication, cow dung slurry or liquid manure may poured on the bed after each mulching to enhance microbial activities and nutrient availability, recommended fertilizer should be applied after soil testing, adopt crop rotation, provide proper drainage, use tolerant variety, application of Neem cake, weeding just before applying fertilizer and mulch, a big seed rhizome free from infection/infestation should be selected. The current research agenda should give priority to the above enlisted methods and mechanical practices such as light trap, biological control measures and application of chemicals.

REVITALIZATION OF GINGER PRODUCTION IN ETHIOPIA

The pathogen is soil and/or seed born, and disease management option focused on soil and seed is required. An urgent need also required on establishing diseases free ginger seed rhizome production scheme both tissue culture and greenhouse culture (Habetewold *et al*., 2015).

The following important points are discussed in the ginger revitalization approach (Ragunathan, 2002). Seed sources (disease free); farmers (domestic), foreign source (introduction) is the base for revitalization of ginger production. Since GBW is seed borne disease, it is mandatory produce disease free seed rhizomes by using biotechnological tools from farmer's seed rhizome and by introducing disease free planting materials from abroad. During introduction a restricted quarantine procedures should be followed. Avoid using local seed rhizome from farmers to farmers (informal seed) since, it is not quarantined for pathogen infected or not.

Seed/planting material multiplication should be undertaken by close follow up of the experts under controlled condition like Biotechnology (Tissue culture) and also at research station with great precaution and close follow up of multidisciplinary team.

Site selection (disease free area and farmers or groups selection) is a main procedure to revitalize the ginger production. Ginger bacterial wilt is soil borne pathogen and the pathogen inoculums can live in the soil for several years and can serve as source of inoculums, even though, the clean seed rhizome was used. Therefore before planting the clean seed rhizome, selecting the pathogen free site or area is a must.

Training of participants in seed multiplication should mainly concerned on how to revitalize the ginger production through getting clean rhizome seed, gentle field selection and through land preparation, using proper storage of seed rhizome, close understanding of previously grown crop on the field, organic soil amendment, crop rotation, seed rhizome solarization, understand soil conditions during planting and harvesting and using integrated disease management (IDP).

FUTURE PROSPECTS

Ginger production was limited below the crops potential as a result of shortage of improved varieties and poor diseases and pest management practices, poor agronomic practices, low soil fertility. Therefore, research should be further proposed to come up with proper improved varieties, agronomic practices, improved soil fertility and proper integrated pest management, ginger production should be on proper environment, proper seed rhizome treatment before planting on the field, soil treatment to control pathogen in the soil, adequate seed rhizome storage and handling for the sake of disease free, good quality seed material without adaptation problem. Application of all the cultural management practices on ginger bacterial wilt and utilization of all the recommended production and postharvest management practices can bring back ginger production to the competent level.

CONCLUSION

Demand of ginger in local and foreign market has been increasing. The diverse climatic and soil types in Ethiopia is very conducive for ginger production and these all are good opportunities to improve production and productivity of ginger and to benefit from attractive prices that can generate significant revenue and hard currency for the nation. However, challenges from emerging issues such as ginger bacterial wilt had been a severe threat on this important spices crop in Ethiopia. Therefore, the current research agenda should target on management of ginger bacterial wilt. This can be selection of disease-free ginger rhizomes, utilization of biotechnology, and application of different management practices.

REFERENCES

Abraham B, Taye B, Mesfin K (2014). The effect of NP fertilizer rates on the yield and yield components of ginger (*Zingiber offcinale* Rosc.) in Kindo-Koysha Woreda; Wolaita, South Ethiopia, Journal of Natural Sciences Research, 4 (16): 48-52.

Anteneh N, Taye K (2015). Intercropping of Arabica Coffee with Turmeric (*Curcuma longa*) and Ginger (*Zingiber officinale* Rose) at Tepi. Journal of Biology, Agriculture and Healthcare www.iiste.org, 5 (7): 65-68.

Belay B, Kebede A, Tameru A, Fasil A (2012). Isolation, characterization and identification of post-havest spoilage fungi of ginger (*Zingiber officinale*) at Hadaro-Tunto and Boloso-Bombae, Southern Ethiopia. 1(2): 19-27.

Bekele K, Digafe T, Kassahun S, Habtewold K (2013). Project proposal on integrated management of ginger bacterial wilt in small scale farming system in Ethiopia, Ethiopian Institute of Agricultural Research (EIAR), Addis Abeba Ethiopia (project document).

BoARD (Bureau of Agriculture and Rural Development, SNNPRS), 2008. Unpublished data

Borget M (1993). Spice Plants. The tropical agriculturalist. CTA, Macmillan

London
Bradley PR (1992). British herbal compendium Bournemouthe, 1:190.
Edossa E (1998). Research achievements and experiences. Ethiopian Institute of Agricultural Research (EIAR), Addis Abeba, Ethiopia, research report No. 3: 6-14.
Endrias G, Asfaw K (2011). Production, processing and marketing of ginger in Southern Ethiopia, Journal of Horticulture and Forestry, 3(7): 207-213.
Engineering Capacity Building Programme (ECBP, 2008). Status of dry ginger for export in Southern Nation Nationalities People regional State, Ethiopia
Ethiopian External trade statistics (EETS, 2008). Status of international spices trade, marketing report of international trade.
FAO (2004). Food and Agriculture Organization of the United Nations (GINGER: Post Production Management for Improved Market Access for Herbs and Spices – Ginger (François M,Alexandra R, Katja, S and Larissa D. eds.)
FAO (2013). FAOSTAT. Food and Agriculture Organization of the United Nations. RomeItaly.http://faostat.fao.org/site/567/desktopdefault.aspx?pageID=567
Girma H, Digafe T, Edossa E, Belay Y, Weyessa G (2008). Spices Research achievements EIAR Revised edition Addis Abeba Ethiopia ,P:12-23.
Girma H, Kindie T (2008).The effect of seed rhizome size on the growth, yield and economic return of Ginger (*Zingiber officinale* Rosc.): Asian J. Plant Sci. 7(2): 213-217.
Girma H, Mesfin S (2016). Influence of different storage methods on the viability and field establishment of seed rhizome ginger (*Zingiber officinale* Rosc.) in Ethiopia. Acad. Res. J. Agri. Sci. Res. 4(4): 117-123.
Girma H, Habtewold K, Haimanot M (2016). Spices research achievements, challenges and future prospects in Ethiopia. Acad. Res. J. Agri. Sci. Res. 4(1): 9-17.
Habetewold K, Bekele K, Kasahun S, Tariku H (2015a). Prevalence of bacterial wilt of ginger (*Z. Officinale* Rosc.) caused by *Ralstonia solansearum* (Smith) in Ethiopia. International Journal of Research Studies in Agricultural Sciences (IJRSAS), 1(6): 14-22.
Habetewold K, Tadesse E, Hailemariam A (2015b). Critical time of weed competition and evaluation of weed management techniques on ginger (*Zengiber officinale*) at Tepi in South West Ethiopia. International Journal of Research Studies in Agricultural Sciences (IJRSAS), 1(3): 5-10.
Institute of Agricultural Research IAR (1985, 1997). Jimma National Coffee Research Center Horticulture Division Progress Report for the period 1985-1997, Melko, Ethiopia.
Jansen PCM, (1981). Spices, condiments and medicinal plants in Ethiopia, their taxonomy and agricultural significance. Wageningen PUDOC., pp. 1-132.
Kandiannan K, Sivaraman K, Thankamani CK, Peter KV (1996). Agronomy of ginger (*Zingiber officinale* Rosc.), a review. Journal of spices and aromatic crops 5 (1): 1-27.
Katzer G (2007). Spices pages. http:www.uni-graz.at/~katzer/engl/index.html.
Ministry of Agriculture and Rural Development, (MOARD), 2007. Unpublished data
Momina A, Sintayehu A, Girma H, Abush T (2011). Variability of ginger (*Zingiber officinale*__ Rosc.) accessions for morphological and some quality traits in Ethiopia. Int. J. Agric. Res. 6(6):444-457.
National Agricultural Research Institute (NARI, 2004). Ministry of fisheries, crops and livestock, New Guyana Marketing Corporation (NGMC). GINGER: Post harvest care and market preparation. Tech. Bull. No. 23. May, pp1- 9.
Nybe EV, Raj MN, Peter KV (2007). Horticulture Science (Spices) 5:67-91.
Paulos D (1986). Response of turmeric (*Curcuma domestica* Val.) and ginger (*Zingibere officinale* Rosc.) to fertilizer treatments, pp. 60 - 61. In: Desta Beyene (ed.): Proceedings of the first Soil Science Research Review Workshop. Addis Ababa, Ethiopia.
Paulos TT (1973). Ginger cultivation in India, Proceedings of the conference on spices, 10 - 14, April 1972, London: Tropical Products Institute.
Purseglove JW, Brown EG, Green CL, Robins SRJ (1981). Spices: Volumes 1 and 2. Longman Group Limited, London.
Purseglove JW (1972). Tropical crops: Monocotyledons, 1st edition, Longman group Limited, UK, London, pp. 52-54.
Ragunathan V (2002). Integrated pest management package for ginger; government of India Ministry of Agriculture; Department of Agriculture and Cooperatives; Directorate of Plant Protection, Quarantine and Storage.
Scot N (2013). Bacterial Wilt of Edible Ginger in Hawai'i. Department of Plant and Environmental Protection Sciences.
Shadap A, Hegde NK, Lyngdoh YA (2015). Effect of storage methods and seed rhizome treatment on the field performance of ginger. Journal of spices and aromatic crops, 24 (1): 51–55.
Tadesse F and Asfaw K(2013). Ginger (*Zingiber oficinale* Rosec.) production,postharvesthandling, processing and marketing: *a comprehensive extensionpackage manual*
Tadesse E, Melaku A, Fantahun A (2015). Effect of weed management methods on the growth and yield of ginger in Metu, Illubabor, Ethiopia. Developing Country Studies, 5(13):82-86.
Tariku H, Kassahun S, Gezahegne G (2016). First report

of ginger (*Zingiber officinale*) bacterial wilt disease in Ethiopia. Res.J. Agriculture and Forestry Sci. 4(4): 5-9.

Weiss EA. 2002. Spices crops, CABI Publishing, www.cabi-publishing.org pp. 316-338.

Yiljep, GA, Fumen, Ajisegiri ESA (2005). The Effects of Peeling, Splitting and Drying on Ginger Quality and Oil/oleoresin Content. Agricultural Engineering International*: the CIGR E Journal* VII. pp1-8.

Yuliar ,Yanetri A ,Koki T (2015). Recent Trends in Control Methods for Bacterial Wilt Diseases Caused by Ralstonia solanacearum, Microbes Environ. Mar; 30(1): 1– 11.

Zenebe W, Bereke-Tsehay T (1991). Review of spices research in Ethiopia. In: Godfrey SA, Bereke-Tsehay T (eds) Proceedings of the first Ethiopian Horticultural Workshop, IAR, Addis Ababa, Ethiopia. pp 343 - 347.