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Review Article

Review on Cereal crop production and their management practice in Ethiopia

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Abstract

Agriculture is the backbone of the Ethiopian economy which accounting for nearly 46% of GDP, 83% of employment, and nearly 80% of foreign export earnings and it is virtually small-scale, subsistence-oriented and crucially dependent on rainfall. The country is a centre of origin and diversity for several crops, which is one of the largest grain producing nations in Africa, there are still large pockets of food insecurity in various regions. The major crops grown in the country are include cereals, pulses, oilseeds, vegetables, root crops, fruits, coffee, Enset, Chat, hops, sugarcane, cotton, tobacco, etc, are produced for food, making drinks, stimulation and making fabrics or clothing. Among these, cereals are the major food crops both in terms of the area they are planted and volume of production compared with other crops because they are the principal staple crops and grown in all the regions with varying quantity and also in the main grain producing areas. Being the cereal crops such importance in the socio-economic situation of Ethiopia, the information related with the agronomic practice of the major cereals crop production in Ethiopia is scanty and not documented well. Hence, documenting and publishing those important crop information can help producer to get better information on the crops management and the researcher can may explore more research gap in the future. Therefore, the current review was made with the objective of to the production and management practice of important cereal crops in Ethiopia.

INTRODUCTION

Rain fed agriculture is the world's predominant agricultural production system, but increasing climate variability is bringing greater uncertainty in production levels [40]. Among the world cultivated cereals are maize, wheat, rice, barley, sorghum, millet, oats, rye, triticale, buckwheat and quinoa, which they are the most important food crops and they provide the world with a majority of its food calories and about half its protein [92]. A majority of the African population can live in rural areas where poverty and deprivation are the most severe, which depends directly or indirectly on agriculture.

Besides, agriculture is the backbone of the Ethiopian economy which accounting for nearly 46% of GDP, 83% of employment, and nearly 80% of foreign export earnings and it is virtually small-scale, subsistence-oriented and crucially dependent on rainfall [24]. The country is a centre of origin and diversity for several crops, which is one of the largest grain producing nations in Africa, there are still large pockets of food insecurity in various regions [19].

The major crops grown in the country are include cereals, pulses, oilseeds, vegetables, root crops, fruits, coffee, Enset, Chat, hops, sugarcane, cotton, tobacco, etc, are produced for food, making drinks, stimulation and making fabrics or clothing. Among these, cereals are the major food crops both in terms of the area they are planted and volume of production compared with other crops because they are the principal staple crops and grown in all the regions with varying quantity and also in the main grain producing areas [31].

In the country cereals, among which teff, maize, barley, wheat, sorghum, rice, oats, and finger millet make up 85% and 90% of the total cultivated area and total production of field crops respectively and accounts for over 90% of modern input consumption [18]. These crops could be cultivated either under rain-fed or irrigated conditions, but currently they are

largely cultivated as rain-fed crops; predominantly, in Ethiopia the four main regions producing cereal crops are namely, Amhara, Oromia, South Nation Nationalities and People, and Tigray [54].

Therefore, the development of the agriculture in the country has been hampered by a range of constrains which include land degradation, limited use of inputs (seed, fertilizer and agricultural implements), weak institutions, price fluctuations on international markets for agricultural products, climate change and recurrent drought, undesirable insect pest (Fall Army Worm, Army Worm, boll worm, etc) and disease (bacteria, fungi and Viruses) and parasitic weeds [18]. The information related with the agronomic practice of the major cereals crop production in Ethiopia is scanty and not documented well. Hence, documenting and publishing those important crop information can help producer to get better information on the crops management and the researcher can may explore more research gap in the future.

Objectives

To review the cereal crop production and their management practice in Ethiopia

REVIEW OF LITERATURE

Wheat (*Triticum aestivum*)

Wheat production in the World

Wheat is one of the most important cereals grown in the world, with China leading the ranking of producers, which is insufficient to supply its domestic market [42]. The main wheat producing countries in the world are China, India, USA, Russia, France, Pakistan, Germany, Canada, Turkey and Kazakhstan, and the main producing countries in Africa are South Africa, Ethiopia, Kenya, Sudan, Zimbabwe, Zambia, Tanzania and Nigeria [42]. There are different classifications of wheat species cultivated in the different parts of the world, like Bread Wheat or Common Wheat, Macaroni wheat or Durum Wheat, Emmer wheat, Einkorn, Indian dwarf wheat, Spelt wheat and Kamut or QK-77 wheat [92]

Wheat Production in Ethiopia

After South Africa, Ethiopia is the second largest wheat producer in sub-Saharan Africa [43]. Wheat is among the most important crops in Ethiopia, ranking fourth in total cereals production (16 percent) next to maize, sorghum and teff, which is produced by close to 5 million smallholder farmers, which makes about 31 percent of all small farmers in the country [31]. It is an important staple food crop in the diets of several in Ethiopian, providing about 15 percent of the caloric intake for the country's over 90 million population especially, in rural and urban areas [39].

In Ethiopia, both the bread and durum wheat are widely cultivated in the highlands part of the country, largely in the areas like South East, Central and North West parts in the main wheat producing region such as Oromia, Amhara, Southern Nation, Nationalities and peoples and Tigray [67]. Nearly both wheat varieties in country is produced under rain-fed conditions, predominantly by small farmers and a few governments owned large-scale (state) farms and commercial farms also produce wheat [54]. Currently, in Ethiopia between 2013-2015 year 15 bread and durum wheat variety were released by the Ethiopian Institute of Agricultural Research [62].

At national, during the meher 2008/09 E.C. season 1.6 million hectare of land is covered with wheat and total of more than 42.1 million quintals are produced annually, it contributes out of total grain 13.3%, 15.8% at national area and production respectively, with national average yield of 25.35 quintals/hectare [30].

Also, in meher 2009/10 E.C. season 1.6 million hectare of land is covered with wheat and total production of more than 45.3 million quintals are produced annually, while it contributes out of total grain 13.49%, 15.63% at national area and production respectively, with national average yield of 26.75 quintals/hectare [31].

But low soil fertility, soil erosion, weeds, disease and insect pests, low and poor distribution of rainfall in lowland areas, unavailability of improved inputs (seeds, pesticides, fertilizers, farm implements, etc), seasonal labor shortage, draft power shortage, land shortage, low prices and lack of credits are the major constraints of wheat production in Ethiopia [43].

Agro-Climatic Requirements for Wheat Production

In Ethiopia, both the bread and durum wheat are widely cultivated in the highlands of the country, which ranging between 6 and 16°N and 35 and 42° E, at altitudes ranging from 1500 to 3000 meters above sea level and with mean minimum temperatures of $6^{O}C$ to $11^{O}C$ [67]. Predominantly, it is highland crop that grown well in a wide range of climates i.e. from tropical to temperate zones, grown on a well- drained fertile on a loam and clay loams soils, whereas soils with clay loam or silt loam are the best for wheat cultivation because wheat is sensitive to water logging, but soils should be neutral in reaction and heavy soils with good drainage are suitable for wheat cultivation under dry condition [52].

Also, the annual rain fall for wheat is 500-1200mm, which requires medium (50–60%) humidity for their growth, but at the time of maturity, crop requires less humidity and warm season and also the optimum temperature for wheat is 20-25^{o}c for to germinate from the soil, for tillering 16-20^{o}C and for proper development 20-23^{o}C [39].

Crop Managements

Land Preparation: -Wheat crop requires a well pulverized seed bed for good and uniform germination, clods should be broken down, field should be leveled & free from weeds, which depending on type of soil, rainfall and cropping system 2-4 ploughing with local implement and tractor is necessary prior to seeding to get maximum yield [39]. One of the major problems to increased production of wheat on vertisols is late sowing due to water logging problems that expose the crop to water deficiency at grain filling and maturity stage [18].

In significant improvement in the yield of bread wheat can be achieved drainage facility, therefore camber bed, broad bed (BB), and normal ridge and furrow (shurube in Ahmaric) can be adopted to drain water from vertisols [67].

Sowing: - Wheat is propagated by seed, so sowing date is generally depends on location, soil type, onset and distribution of rain fall and the variety to be used recommended to start planting after the onset of the main rainy season, therefore recommended wheat planting time ranged between early June and mid-August [84]. Wheat is sown by hand or machine, while optimum seed rate vary with variety, location and method of sowing, for example for broadcast sowing the seed rate is 175-200kg/ha and for row sowing 100-125kg/ha for normal and large size respectively, seed rate is recommended [87].

Spacing: - Drilling is most efficient method of sowing, while for normal spacing 20-25cm b/n rows depending on cultivars, for tillering cultivars row spacing 22.5-25 cm, 20cm for non tillering cultivars are optimum and for delayed sowing spacing of 15–18 cm [66]. Whereas, the optimum sowing depth is 2-5cm, with deeper planting required in dry conditions and when broadcasted, the seed is incorporated in the soil using an animal drawn plough or machine drawn disc [84].

Fertilization: - Fertilizer application should be made based on the soil test recommendation, which is fertilizer rate vary from location to location depending on fertility status of the soil, cropping sequence, and varieties used [6].

But a recomm endation of 50 kg Urea and 100kg NPS per hectare in red soils and 100kg Urea and 100kg NPS per hectare in black soils is used and application of FYM or compost at 12.5 t/ha at the time of last ploughing is recommended [57].

The whole amount of NPS should be applied at sowing, whereas the nitrogen does in split applied, 1/3 at sowing and 2/3 at tillering (30-40days after emergence) 3-5cm from plant apply [17].

Water Management: -Wheat requires 440–460 mm of water, while irrigation at 50% available soil moisture or 50% depletion of available soil moisture is optimum [64]. The critical stages of crop for irrigation of these, irrigation at crown root initiation stage is the most important and delay of every day results in reduction of 1.4% grain yield/day [64].

Weed control: - Weeds are one of the major constraints in wheat production as they reduce productivity due to competition, allelopathy, by providing habitats for pathogens as well as serving as alternate host for various insects and fungi and increase harvest cost [83]. Both broad leaf and grass weeds are the major problems in most wheat growing areas [48]; they reduce the quality and quantity of agricultural produce through competition for growth resources like nutrients, water and sunlight or by their parasitic behavior, utilizing water and assimilates directly from the host plant; critical weed free period is 2-4 weeks after emergence (3-6 leaf stage) [80]. However, they can control the use of suitable cultural practices, such as the use of clean seed, sowing on clean seed bed, early hand weeding, crop rotation or cultivating crops such as sorghum, or ploughing wheat fields soon after harvesting and keeping them clean until planting time [14]; twice weeding at 21 and 45 days after crop emergence and use herbicides (topic, phalas 45 OD, Suffix to control grass weed and 2,4-D, Starane to control broad leaved weeds) has shown best results [91].

Disease control: - The common diseases on wheat are smut and rust, so the most important wheat rusts, a group of diseases cause by fungal pathogens, are stem rust (black rust), stripe rust (yellow rust) and leaf rust (brown rust) are the most prevalent ones [4]. These three rust diseases have the potential to infect wheat and cause economic damage in susceptible wheat varieties, which is damage caused by the rusts is due to the destruction of photosynthetic tissue, the withdrawal of water and nutrients from the plant by the fungus, and increases water loss through the epidermis of the plant, also the grain produced is mostly shriveled, and has low protein content [65].

To control rust and smut disease in wheat fields by cultural practices, such as growing rust resistant varieties, crop rotation, removal of smutted plants, avoid late sowing, do not use excess N-fertilizer as high N favors rust development and use of chemical such as Tilt-half lit/ha by mixing with 150-200 lit water, Baylaton (1lt/ha with 150-200 lit water and use of clean seed, seed treatment with fungicides such as (Carboxin, Hexachloro benzene, thiram, benomyl) and use of Integrated Pest Management [53].

Insect pests Control: - Under favorable conditions, several insects can cause significant yield loss in wheat; major insect pests of wheat are armyworm, aphids, grass hopper, cut worms and other storage pest rodents mainly the black rat (Rattus Rattus) [5]. Infections can occur during seedling emergence to heading to be sucking and chewing the leaves to reduce the photosynthesis efficiency cause yellowing and death of leaves, so damage can occur to reduce the kernels size, reduce grain size and losses yields, also damage stored seeds. Different types of chemicals can be used to control insect pests such as malathion 5%, 8% and 57% E.C, Adrin 5%, dursban 48% E.C, carbaline, modem 5%, etc, and clean storage conditions and maintaining grain moisture and temperature at sufficiently low levels inhibit insect activity and development to control storage pest [52].

Cropping system: - Wheat is mostly grown in sole stand, but sometimes mixed with barley and faba bean and also, best rotated with pulses, while in the highlands of Ethiopia, wheat is grown continuously or in rotation with other cereals, pulses or oilseeds such as gomenzer or rape seed(from encyclopedia http/www.com).

Harvesting: -Wheat matures in 4-7 months after planting; the maturity period depends on variety & altitude of the area, while it usually ripens about 30 days after the blooming of the florets [72].
The kernels are completely filled when they reach the dough stage, at which time the leaves, stalks and spikes begin to lose their green color and become golden yellow, but harvest when the leaves and stems turn yellow and becomes fairly dry; when there is about 20–25% moisture content, also harvesting is done by using sickle or bullock driven reapers or by using combine harvester (from encyclopedia http/www.com).

Post- Harvest Management: - Harvested crops should be threshed on a clean threshing floor. When possible, use plastic sheets to cover the threshing floor to avoid contact of the produce with soil; a practice few farmers are adopting these days [51]. After threshing and cleaning, the grain is dried in the sun for 3–4 days for getting 10–12% moisture for storing and storing at optimum temperature and moisture [72].

Maize (*Zea mays* L.)

World Maize Production

Maize is the world second important food crop next wheat, both in terms of calorie and value of production, which is an important and the highest yielding crop among cereals called" queen of cereals" grain crop of the world (Adeyabo and Ibraheem, 2017.

The main top ten maize producing in the world countries are USA, Brazil, Argentina, Ukraine, India, Mexico, Indonesia, South Africa and Romania [42].

Maize is the most-produced cereal worldwide, while they account for almost 80% of the world's total maize production, and more than 60% originates from the top three countries, also it is the basis for food security in some of the world's poorest regions in Africa, Asia and Latin America. In Africa, 51 countries produced approximately 75 million tons of maize in 2014 (7.4% of the total world production) on 37 million hectares (20.44% of the total area planted worldwide) (Melinda et al., 2011). Maize occupies approximately 24% of farmland in Africa, which is more than any other staple crop, and is a food crop accounting for 73% and 64% of the total demand in Eastern and Southern Africa and Western and Central Africa, respectively [15].

South Africa is currently the main maize producer of the African continent, and almost half of its production consists of white maize meant for human consumption [41]. Several 1000 (thousand) cultivars of maize are now grown throughout the world and they can be allocated to one of 7 types based mainly up on the characteristics of the seed such as dent maze, flint maize, sweet corn, soft or flour maize, pop corn, waxy maize and pod maize [63].

Maize Production in Ethiopia

Maize is Ethiopia's largest cereal crop in terms of total production, area planted, and number of farm holdings, with accounts for 22 percent of the total area covered by cereal and around 30 percent of the total cereal production [35]. In addition to the highest total production per annum and the highest per hectare yield, also the single most important crop in terms of number of farmers engaged in cultivation, which is staple food in at least some part the country, especially in the Western & Southern parts of Ethiopia[26].

The lion's share of maize production comes from three regions: the Oromia region (61%), Amhara (20%) and SNNPR (12%), with about 40% of the maize area is in the Southern region, which includes Shoa, Sidamo, Gamo Gofa, Arsi & Bale, the Western region, 29% of maize area, covers Wollega, Ilubabor, and kefa province, the Eastern region grows about 70%of the maize crop in the Hararghe and 18% in Gojjam & Gondar [86]. Maize is instrumental for the food security of Ethiopian households, the lowest cost caloric source among all major cereals, which is significant given that cereals dominate household diet and farmers also use maize stalks for fuel, cattle feed, and construction material for houses in rural areas [18].

The Ethiopian National Agricultural Research Systems (NARS) has released a total of 61 maize varieties between 1973 and 2013, also the Ethiopian Institute of Agricultural Research were released 12 maize varieties in between 2013-2015 year [62]. So, the first locally developed hybrid (BH140), in the early to intermediate maturity group was released in 1988, followed by a late maturing hybrid (BH660) in 1993, BH540, the Pioneer H-bred Seed Ethiopia and hybrid PHB3253 in 1995 (Ethiopian Seed Association, 2014).

There were a total of 16 hybrids and 4 Open Pollinated Varieties (OPVs) under production in 2013, which hybrids accounted for 97% while OPVs represented only 3% of the total seed market [62]. The Ethiopian seed market has been dominated by BH660 and BH540, with the average age of 80% of the currently grown varieties is more than 20 years (Ethiopian Seed Association, 2014). There are also hybrids that came into production between 2005 and 2008, but their amounts remain limited, with the exception of the Pioneer hybrids, Shone and Agar [58]. Only four OPVs are at all common but their use is limited to the more drought-prone areas such as the central rift valley, like Melkassa2 and Melkassa4 have been used extensively in the last several years and the two new ones (Melkassa6 and Gibe2) were recently introduced into the market and their use is expected to expand before getting replaced by higher yielding hybrids that are in the process of development [86].

At national, during the meher 2008/09 E.C. season 2.11 million hectare of land is covered with maize and total of more than 71.5 million quintals are produced annually, it contributes out of total grain 16.9%, 26.8% at national area and production respectively, with national average yield of 33.87 quintals/hectare [30]. Also, in meher 2009/10 E.C. season 2.13 million hectare of land is covered with maize and total production of more than 78.4 million quintals are produced annually, while it contributes out of total grain 17.0%, 27.0% at national area and production respectively, with national average yield of 36.75 quintals/hectare [31].

Agro-climatic requirements for Maize Production

In Ethiopia, maize are widely cultivated in the tropical part of the country, which lie between 55°N and 45°S, at altitudes ranging from 500 to 2500 meters above sea level [86]. Mostly, it is tropical crop that grown well in a wide range of climates, which grow on a deep medium texture well drained loam or silty loam fertile soil with a high water holding capacity and rich in organic matter, in addition soils with deep, fertile rich matter and well drained loam or silt loam soil are the best for maize cultivation [15].

Also, the annual rain fall for maize is 500-1000mm well distributed over the growth and the optimum temperature for maize is 21^{o}C for to germinate from the soil, for growth 32^{o}C, not suitable to growth when night temperature below 15.6^{o}C and cease growth when temperature above 32^{o}C [15].

Crop Managements

Land Preparation: - Maize seed needs soils that are warm, moist, well aerated, weed free and only fine enough to give contact between the seed and the soil ((from encyclopedia http/www.com). The field should be well ploughed in advance of sowing and the field is ploughed to a depth of 25–30 cm using mould board plough, followed by 3–4 ploughing with disc plough or harrow ((from encyclopedia http/www.com).

Sowing: - Time of sowing is the most critical factor affecting maize yields, therefore time of sowing varies from region to region. In lowland areas sowing date is mid- June, in mid altitude areas sowing date is mid-April to mid may and in high land areas sowing date is mid-march-mid April, but in most regions sowing date is April to May [35]. Mostly, maize is adopted by hands direct seeding, sowing or dibbling, generally depending on the cultivars the optimum seed rate for sowing maize is 25-35kg/ha when sown by line is recommended [18].

Spacing: - The spacing is depending on the type of cultivars, which is for delayed matured cultivars spacing between plant and row 80cmx45cm cm (55, 555 plants/ha) i.e. two seeds in one hole, for medium matured cultivars spacing between plant and row 80cmx40cm (62, 500 plants/ha) i.e. two seeds in one hole and for early matured cultivars spacing between plant and row 75cmx25cm (53, 333 plants/ha) i.e. one seeds in hole are optimum [62]. The optimum sowing depth is 7-12cm, depending on the type of soil moisture and when broadcasted, the seed is incorporated in the soil using an animal drawn plough or machine drawn disc [62].

Fertilization: - Maize has high demand for N and this is often the limiting nutrient in maize production, so the amount of fertilizer to be applied depends mainly on maize yield and the fertility level of the soil as determined by soil tests (from encyclopedia http/www.com). In general 100kg NPS and 75 kg/ha UREA, but the whole NPS is applied at the time of sowing and Urea should be applied in split i.e. 2/3 after sowing at knee height (30-40) days and 1/3 at the time of flowering (45-55) days [27]. Before side-dressing N all the weeds should be removed from the field so that only the maize plants are able to utilize the applied Nitrogen, also application of 12.5 t of FYM/ha [27].

Water Requirements: - The Critical stages of maize for irrigation are at taselling and silking, while peak consumption of water also occurs during this period at (taselling and silking). So, in Clay/clay loam soils, totally 8 irrigations are required and for light soils, two more irrigations are needed (Muktar and Yigezu (2016).

Weed Control: - The period between seedling emergence and tasseling is the most critical period for weed competition in maize [61].

If maize growth is checked by weeds in its early stages it never recovers fully, therefore, the 1st weeding is done about 3 week after sowing when the crop is 8-10cm high and two more weeding are done at equal intervals, also the second weeding is done at knee height and the third at tasseling stage [61].

Application of pre-emergence herbicides like Simazine and Atrazine at 0.25 kg/ha, followed by one hand hoeing and weeding on 30–35 days is recommended. For intercropping systems, atrazine should not be used and for maize + pulse intercropping system, pre-emergence application of pendimethalin 1.0 kg a.i. /ha followed by one hand weeding on 30–35 days is recommended (Tesfaye *et al.*, 2015). If pre-emergence herbicide is not applied, post emergence application of 2, 4-D Na salt (Fernoxone 80 WP) at 1.0 kg a.i. /ha on 2 or 3rd leaf stage for sole crop of maize is recommended [83].

Disease Control:- The most common disease of maize are Maize lethal necrosis disease, Maize Cob rot, Maize Grey leaf spot, Maize Rust and Maize Leaf Blight caused by virus, bacteria and fungi (IPBO, 2017). A symptom like premature plant death, drying of leaves, and failure of tassel/sterility in male plants, malformed /no ears, premature drying or rotting of cobs and cut down the photosynthetic activity in the leaf and slows growth. They can be controlled by the use of cultural practices such as crop rotation, use clean seed, treated seeds with chemicals, etc and use of different chemicals and Integrated Pest Management (IPBO, 2017)

Insect Control: - Under Favorable condition some of the common insect pests affect maize crops are stem borer, stalk borers, spotted stem borer, aphids, cut worms, fall armyworm, African bollworm and weevil (African Agriculture book (unpublished), 2017). They infect crops by boring, chewing and sucking leaves, stems and cobs, which results stunted and poor growth, yield losses, and are more susceptible to wind lodging and secondary disease infestations (African Agriculture book (unpublished), 2017).

They can be controlled by cultural practices, such as crop rotation, early planting, use of push-push technology, field sanitation treated seed with insecticides before sowing and apply insecticides (Thiodan 3.5 G or Ambush 0.5% or Bulldock at 2 Kg per Ha, Bestox 10 EC when soils are moist and apply insecticides like Dimethoate, Malathion, Karate, etc (African Agriculture book (unpublished), 2017).

Cropping System: - Maize is grown in monoculture, which in rotation or in intercropping with other crops. Maize can be grown in 1, 2 or 3 year rotations with crops such as wheat, legumes and groundnuts (from encyclopedia http/www.com).

Harvesting: - Maize harvested in three forms, green maize for human consumption, silage for livestock consumption and Shelled grain for human and livestock consumption and other industrial uses, such as starch and ethanol production, but the most suitable time to harvest is when the plants attain physiological maturity [5]. The grain cob is harvested, when cob sheath turns brownish and grains become hard. At the time of physiological maturity the moisture content in the grain averages about 30%-40% but, harvest maize when moisture content of the grain is reduced to 10-12 % [5].

Post- Harvest Management: - Only store maize that has less than 13% moisture content, free from live insect pests, protected from rain and ground moisture and the storage container should be rodent proof, insect proof land should seal tightly [89].

Sorghum (*Sorghum bicolor* (L.)

Sorghum Production in the World

Sorghum is the 5th most important world cereal following wheat, maze, rice & barley and the second most important cereal crop grown in Africa because of its drought resistance is the crop of dry regions and areas with unreliable rainfall [25]. Sorghum is a viable food grain for many of the World's most food insecure people who live in marginal areas with poor and erratic rains and often poor soils, which are the major cereal crops in arid and semi-arid areas of the world, particularly Africa and Asia [79]. Nigeria, India, USA, Mexico, Sudan, China and Argentina are the major sorghum producers in the world and it is grown in over 98 countries in Africa, Asia, Oceania and the Americas in 2015 [42].

Sorghum Production in Ethiopia

In Ethiopia, sorghum stands third in terms of area coverage after Teff and maize, and second in terms of yield per hectare after maize, which is the most drought tolerant cereal crops widely grown in the high lands, low lands and semi-arid regions of Ethiopia, especially in moisture stressed parts where other crops can least survive [79].

Ethiopia is probably the original home of sorghum and is the source of many wild and cultivated forms adapted to a wide range of growing conditions because of the great genetic diversity in the country [46]. The primary and most important source of sorghum germplasm introduction for Ethiopia has been the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) [33].

The main interest of introducing sorghum germplasm in Ethiopia is to evaluate and release high-yielding and early-maturing sorghum varieties that can escape drought occurring late in the season in the dry lowlands [58].

Over the years, a large number of early-maturing sorghum varieties and lines have been introduced and evaluated for yield and yield related attributes, but varieties have been released so far by the national sorghum research program for commercial production in drought stressed areas were from exotic sources except Gambella 1107 [16]. Currently, in Ethiopia between 2013-2015 year 7 sorghum varieties were released by the Ethiopian Institute of Agricultural Research [62]. Recently, two Striga resistant sorghum varieties, Gubiye (P9401) and Abshir (P9403), initially introduced from Purdue University, USA, were released for commercial production in Striga infested areas of the country and two better yielding sorghum hybrids (ICSA 21× ICSR 50 and ICSA 15× M5568) than the best open-pollinated standard check variety, Teshale are on the pipeline [58].

The crops which are early maturing, drought tolerant and resistant to higher temperatures are of great interest to the farmers [16].

At national, during the meher 2008/09 E.C. season 1.85 million hectare of land is covered with sorghum and total of more than 43.2 million quintals are produced annually, it contributes out of total grain 14.9%, 16.2% at national area and production respectively, with national average yield of 23.31 quintals/hectare [30].

Also, in meher 2009/10 season 1.88 million hectare of land is covered with sorghum and total production of more than 47.5 million quintals are produced annually, while it contributes out of total grain 15.0%, 16.4% at national area and production respectively, with national average yield of 25.25 quintals/hectare [31].

The major problems that affect sorghum production in the dry land areas of the country include lack of early maturing varieties that can escape drought, poor soil fertility, poor stand establishment due to reduced emergence in characteristically crusty soils, insect pests like the spotted stalk borers (Chilo partellus) and birds [25].

Agro- Climatic Requirements for Sorghum Production

In Ethiopia, Sorghum is widely cultivated in the lowland part of the country, at altitudes ranging from 500 meters to 2300 meters above sea level [33]. Mostly, it is warm season crop that grown well in a wide range of ecological conditions on a soil with clay loam or loamy texture having good water retention is best suited, which does not thrive in sandy soils, but does better in heavier soils [16]. Also, the annual rain fall for sorghum is 250-750mm well distributed over the growth and the optimum temperature for sorghum is 18^{o}C for to germinate from the soil, for growth is 27-32^{o}C and minimum and maximum temperatures for growth are 15 ^{0}C and 40 ^{0}C and also, decrease in yield, flower initiation and development flower premordia are delayed when temperature above 40^{o}C [3]

Crop Managements

Land preparation: - Ploughing 2-3 can be done with oxen or tractor and the seed bed should be free from weeds, and large soil clods; the crop must be provided with a fine seed bed to ensure uniform emergence [45].

Sowing: - sowing in rows & broadcasting are the two common planting methods, thus time of sowing varies from region to region, for example in lowland areas sowing date is 1-15 June, in mid altitude areas sowing date is 1-15 may and in high land areas sowing date is 15 April-10 May and the seed rate for row sowing is 8-12kg/ha is recommended [62].

Spacing: - The spacing is depending on the type of cultivars, however for delayed matured cultivars spacing between plant and row 75cmx25cm, for medium matured cultivars spacing between plant and row 75cmx20cm and for early matured cultivars spacing between plant and row 60cmx15 are optimum, with the optimum sowing depth of 2.5-4cm, depending on the type of soil moisture [33].

Fertilization: - Generally depending on soil moisture 100kg/ha NPS and 50kg/ha UREA is recommended for sorghum Shiferraw *et al*, 2015). The whole NPS is applied at the time of sowing and Urea should be applied in split i.e. 1/3 at the time of sowing, 2/3 after seedling emergence 30-40days, but fertilizer should be placed 7-8 cm away from the row and 3-5 cm below the seed [75].

Weeding: - The parasitic weed striga is the most serious weed of sorghum & should be removed before it sets seeds, with the symptoms of severe striga attack resemble drought i.e. the leaves wilt, and turn yellow and plants remain stunted and may die before setting seed [25].

Two hand weeding are necessary, the 1st may be done 20-25 days after emergence and the 2nd is done 45-50 days after emergence. Therefore, rotation with cotton, groundnut, cowpea and pigeon pea, hand pulling the plants before flowering, post emergence application of 2, 4-D Na salt at 2.0 kg/ha at 25–30 days to control striga [26].

Water management: - There are four critical stages water requirements viz. seedling, vegetative, flowering and dough stages. Stress at one week before and one week after flowering is very critical [2].

Disease Control: - Diseases like head smut, downy mildew, damping off, root, leaf, panicle and stalk disease caused by fungi which can infect crop by destroying the germinating seeds, stunting of the crop, premature death and reduce the yield [56]. They can be controlled by development of resistance varieties**,** crop sanitation (destruction of residues, alternative host Plants), crop rotation, seed treatment and use of different fungicides [56].

Insect pest- The most common insect pests affects sorghum are Army worm, Grass Hoppers, Cut worms, sorghum shoot fly and stem bores by chewing and sucking the leaves reduce yields of the sorghum [56].

However they can be controlled through a combination of cultural practices, most notably intercropping and the 'push-pull' system and pesticides can also be effective, but must be applied in the early crop stage before the larvae bore into the stem [56].

Cropping System: Sorghum follows other crops readily in rotation but care should be taken in the choice of crop to follow sorghum as sorghum greatly impoverishes the soil.

Harvesting: - Most of the high yielding varieties and hybrids mature in about 100–115 days, however harvest may be done at physiological maturity, which is done by cutting the entire plant or removing the ear heads first and cutting down the plants later and is allowed to dry for 2–5 days [63].

Post-Harvest Managements: - The threshed grain is dried in the sun for a week to bring the moisture content to 10–12% for safe storage, but for safe storage the moisture content of the grain should not exceed 12% (from encyclopedia http/www.com)**.** Storing only clean grain is important and the storage should be also clean and the seed store must be fumigated to control storage pests (from encyclopedia http/www.com).

Teff (*Eragrostis teffZucc*)

Teff Production in the World

Teff is the tiniest known grain in the world, which is remained an East African secret for centuries, and became a staple crop in the Ethiopian diet. In fact, Teff only grows well in the highlands of East.

Teff Production in Ethiopia

In Ethiopia, Teff is the most important cereal crops in terms of both production and consumption, which is mostly produced by small holder farmers at the central, eastern and northern highlands of the country on fragmented lands with rain fed conditions in both, Meher and Belg, seasons, but it is typically concentrated in the centre and the northwest of the country [31]. East and West Gojam of Amhara and East and West Shoa of Oromiya are particularly known teff producing areas in the country, also smaller quantity is produced in the Tigray and SNNP regions, entire Wollo, and the

Harar/ Dire Dawa region in eastern Ethiopia and most of the pastorals area of the country are considered as deficit areas of the country [29]. In addition to this, it is relatively resistant to many biotic and abiotic stresses and can be grown under different agro-ecological conditions, ranging from lowland to highland areas [63].

It is nutritionally rich with high levels of iron and calcium, gluten-free, rich in phosphorous, copper, aluminum and thiamine and is an excellent source of protein, amino acids and carbohydrates has consumed in Ethiopia [73].

It is the second most important cash crop after coffee and generating almost 500 million USD incomes per year for local farmers.

Table-1: Trends of Teff Cultivated Area, Production and Yield in Ethiopia.

Year	Area (1000ha)	Production(000 qt)	Yield(qt/ha)
2009/10	2588.66	31793.7	12.28
2010/11	2761.19	34834.8	12.62
2011/12	2731.11	34976.9	12.81
2012/13	2730.27	37652.4	13.79
2013/14	3016.52	44186.4	14.65
2014/15	3016.06	47500	15.75
2015/16	2866	44713	15.61
2016/17	3017	50204	16.64

Source: - Data from CSA survey of different years.

Agro- Climatic Requirements for Teff Production

In Ethiopia, Teff are widely cultivated in the central and highlands of the country, at altitudes ranging from 300-2800m, but best performance occurs at altitudes ranging from 1800 to 2100 meters above sea level [27]. Largely, it is tropical crop that grown well in a wide range of agro-ecological conditions, which is grown on a Well- drained fertile black and light soils, but bulk of production comes from black soils, therefore sandy loam to black clay soils are the best for wheat cultivation because Teff is resist water logging better than other crop [79].

Also, the annual rain fall for Teff is 300-700mm and the optimum temperature for Teff is 10-27^{o}c for to germinate from the soil, growth and development.

Crop Managements

Land Preparation: - Since teff seeds are very small the seed bed needs frequent ploughing may be 2-5 times depending on soil type, weed condition, water logging, and number of oxen and preceding crop to make it fine, firm and weed free [12]. For example, heavy clay ploughing more frequently than loam or sandy soils and vertisols found in areas where there is a problem of water logging are ploughed more than those without such problems for the purpose of opening up drainage furrows [44].

Sowing: - Teff is mostly sown by hand broadcasting, which has sown from early July to early august but time of sowing varies from region to depending on climatic conditions, soil type & maturity period of variety [18]. In our farmers production system teff seed are sowing on the surface of the field and left uncovered or covered very lightly by pulling woody tree branches over the field using oxen [13].

The seed rate for teff is 3-8kg/ha and 25-30kg/ha is recommended for line sowing and broadcast sowing, respectively [13].

Spacing: - The spacing for teff is depending on the type of cultivars, so the recommended spacing between rows is 20cm and if transplanting spacing between row and plant is 20cmx10cm, respectively, with the optimum sowing depth of 2-3cm, depending on the type of soil moisture [59].

Fertilization: - Fertilizer application increases teff productivity by early growth, & allowing rapid growing of leaves & it also increases water use efficiency by increasing depth of water extraction, however on vertisols 100 kg/ha NPS and 100kg/ha UREA is recommended, also 50kg/ha UREA and 100kg/ha NPS is recommended for light soils [73]. All the P and half of the N are applied at planting where are the remaining half N is applied at tillering stage [73].

Weed Control: - weeds in teff cause 23-65% yield loss, which compete for soil moisture and nutrient and utilize it much faster than the crop, consequently decrease the yield and they harbor several pests & diseases [44]. The recommended weeding practices are first hand weeding at 25-30 days after emergence and 2nd weeding at stem elongation stage.

Moreover, to control weed problem in teff use weed free seed and clean fields that have been ploughed frequently enough to kill weeds and use of herbicide Phalas 45-OD at a rate of 0.4 lit/ha for grass weeds [12].

Water Requirements: - Due to its small seed size, Teff cannot be planted deep into moisture as some crops, therefore like most grasses, keeping Teff seed exposed to adequate moisture during the germination period can often be challenging.

Water requirements vary depending on the climate and length of growing season (From Encyclopedia http/www.com).

Disease Control: - Teff suffers less from diseases than most other cereals grown in Ethiopia, which are seeds can be stored for many years without being seriously damaged (from internet). However, teff rust & damping off are identified as the major once prevalent diseases in teff, so rusts are widespread diseases of teff which can cause considerable losses in yield 10-25% and the damping off to be serious (severe) and damaging with higher than lower seed rate & earlier rather than late sowing dates [63]. They can be controlled by using cultural practices such as, the use of disease free seed and clean seed, fungicide spraying with tridemorph decreases rust infection level from 75-80% and dressing of seeds with 2 methoxyethly mercury chlorides [63].

Insect Pest Control: - Major insect pests of teff are Shoot fly, Wello Bush Cricket, Red Teff worm, thrips, Armyworm, Grass hopper and Black Teff Beetle [1]. Use of cultural practices, use of Integrated Pest Management and apply of different types of insecticides such as lindane dust, seed dressing before sowing with 40% Aldrinwp at a rate of 50 g/kg of seed, using carbryl 85% WP mixed in 100-300 water/ha, Endosulfan, Diazinon and Cypermethrin can be used to control insect pests [73].

Cropping system: -Teff is mainly cultivated as a mono crop, but occasionally under multiple cropping systems. It is commonly involved in crop rotation with legumes and other cereal, like wheat, field pea or fababean [29].

Harvesting: - Teff is harvested when the straw color turns yellowish and harvesting before the plant gets too dry helps to prevent losses due to shattering, where are results in poor quality seed & loss of natural color respectively (early & late) [18].

Post- Harvest Management: - Threshing is undertaken manually or by using combines, which drying and store under favorable moisture and temperature (From Encyclopedia http/www.com).

Rice (*Oryza sativa* L.)

Rice Production in the World

Rice is the most widely grown & consumed cereal crop in the world, which is the most important food crop for about 65 % of the world's population [49]. In the world, the largest volume of rice production is concentrated in countries China, India, Indonesia, Vietnam, Thailand, Bangladesh, Burma, Philippines, Brazil and Japan, however over 90% of the total rice is grown in south & East Asia, so Asia is considered the rice bowl of the world [42].

Rice is the most popular food grain across the world providing food for more than 1.6 billion people and it is vital for the nutrition of much of the population in Asia, Africa, Latin America and Caribbean's, however there are about 25 species Oryza, of these only two species are cultivated in the world namely, Oryza sativa and Oryza glaberrima [31].

Rice Production in Ethiopia

Rice is a recent crop introduced to the Ethiopian farming systems, which the cultivation of the crop has begun at Amhara Region and Gambella plains in the early 1970's [77]. Currently, largely small-scale farmers and large-scale farms in few places mainly in lowlands of the country grow rice in different parts of the country like Amhara, SNNP, Oromiya, Somali, Gambella, Benu Shangul Gumuz, Tigray and Afar regions, which has a great potential to contribute to food self-sufficiency and food security in Ethiopia [49].

In the country, four rice ecosystems are identified and these are upland rice, hydro orphic (rain fed lowland) rice, irrigated lowland ecosystem, paddy rice (with or without irrigation) [77].

It has been recently introduced to Ethiopia, recognizing its importance as a food security crop and a source of income and employment opportunities, the government of Ethiopia has named it the "millennium crop," and has ranked it among the priority commodities of the country [77].

The Ethiopian Agricultural Research System has designated Adet Agricultural Research Center of Amhara Region Agricultural Research Institute (ARARI) to serve as the national coordination center for rice research the Ethiopian

Institute of Agricultural Research (EIAR), all regional agricultural research institutes (RARIs), Jimma and Sodo Universities, and Woreta Agricultural in Ethiopia, additionally Werer and Jimma Agricultural Research Centers of and Vocational Training (ATVT) College are involved in the research [37].

There have been twelve rain fed upland/lowland NERICAs and Sativa-type, and three irrigated rice varieties released in Ethiopia from 1999 up to 2007, but basic seed production and supply is the responsibility of Adet Agricultural Research Center for upland rice varieties and Werer Agricultural Research Center for lowland and irrigated rice varieties [32].

Both regional and federal research centers including Adet (national coordinator), Gonder, Bako, Bonga, Gambella, Gode, Maytsebri, Humera, Pawe, Assosa, and Werer Agricultural Research Centers are involved in rice research as collaborating centers mainly in the national variety and adaptation trials, which are organized and coordinated by the national coordinating center [68].

Recently, there are more than six rice seed varieties released for Fogera areas namely, NERICA-4, NERICA-3, SUPPERICA, TANA-, EDGET and GUMARA and X-Jigna [62].

At national, during the meher 2008/09 E.C. season 45,454.18 thousand hectare of land is covered with rice and total of more than 1.26 million quintals are produced annually, it contributes out of total grain 0.4%, 0.5% at national area and production respectively, with national average yield of 27.90 quintals/hectare [30].

Also, in meher 2009/10 E.C. season 48, 418.09 thousand hectare of land is covered with rice and total production of more than 1.36 million quintals are produced annually, while it contributes out of total grain 0.4%, 0.12% at national area and production respectively, with national average yield of 28.09 quintals/hectare [31]. The main constraints rice productions in Ethiopia are lack of inputs (seed, fertilizer, farm implement), lack of market information, lack of market linkage or liaison service, insect pests, disease, soil fertility status, flooding, lack of milling machines, price of improved seeds and capital [9].

Climate Requirements for Rice Production

Rice is widely cultivated in the hot and humid climates of the country, at altitudes ranging from 1600-1800 meters above sea level (From internet).

Largely, it is warm weather crop that grown on a well- drained and porous friable loamy to clay loams soils for upland rice, but low land rice impermeable clay soils are suitable, although sandy soils are usually unsuitable for growing rice because their low capacity for holding water & nutrients and their high permeability make it difficult to maintain the necessary flooded condition [77].

Also, the annual rain fall for rice is 800-1800mm is suitable, where are for up land rice 800-1000mm is enough for growth cycle of 4-5 months and the optimum temperature for rice is 30^{o}c for tillering, so the critical low and high temperatures for rice are normally below 20°C and above 30°C respectively [63].

Crop Managements

Land preparation: - for low land rice cultivation starts with the bunding & leveling off the field to permit even flooding, which the bunds are made with controlled opening for letting the water in and out of the field [24].

Sowing: - Upland and lowland rice is sown by broadcast and seeded directly into the fields, which sowing date is April or May with the recommended seed rate of vary from 75-100kg/ha [63].

Spacing: - The spacing is depending on the type of cultivars, but the recommended space for upland rice between rows and plants is 25cmx25cm and the transplanted lowland rice space between rows and plants 23 X 23cm with 4-6 plants per stand, with the optimum sowing depth of 2cm [63].

Fertilization: - Generally, the recommended applied fertilizer for rice was UREA 50 kg/ha and NPS 100kg/ha should be applied in two splits *viz*. 20–25 DAS (days after sowing) and the second at 40–45 DAS [63].

Weed Controls: - Both grass and broad leaved weeds are a major problem on rice crops. First weeding should be done at 15–20 DAS (days after sowing) and second weeding may be done on 45 days After Sowing, also application of Thiobencarb at 2.5 l/ha or Pendimethalin at 3.0 l/ha on 8 days after sowing as sand mix may be done, if adequate moisture is available followed by one hand weeding on 30–35 days after sowing [15].

Diseases Controls: - Leaf blast, panicle blast, bacterial panicle blight and smuts are a major serious diseases from vegetative to heading growth stage in rice, however they can control by cultural practices such as, using resistant varieties, infected plants should be removed and use of different fungicides [90].

Insect Pest Control: - The common types of insect pests on rice include stalked eyed flies, termite, stick bug, rice mealy bug, and weevils and stem borers, however they can be controlled by use of cultural practices and insecticides (From encyclopedia http/www.com).

Harvesting:-Upland rice matures earlier than flooded rice but the exact time to maturity depends on the variety planted and this could 4-7 months after planting, where are harvesting is done by hand using sickle; either the whole plant is harvested or only the heads together with some of the straw are harvested.

Post-harvesting Management

Thresh by separation of the grains from the stalks, clean the removal of foreign materials such as particles of sand, stone, straw and other seeds, dry removal of moisture from the grains and store into optimum moisture and temperature (From encyclopedia http/www.com).

Barley (*Hordeum vulgare L. emend, Lam*.) Production and Managements

Barley Production in the World

Barley is the most widely grown crop over broad environmental conditions in the world and the fourth cereal after wheat, maize and rice [42]. The major producers of barley in the world were Russian Federation, Ukraine, France, Germany, Spain, Australia Canada, Turkey, United Kingdom and Argentina, also on the African continent, the top barley producers were Morocco, Ethiopia and Algeria followed by Tunisia and South Africa [88].

Barley Production in Ethiopia

Ethiopia is the second largest barley producer in Africa, next to Morocco, accounting for about 25 percent of the total barley production in the continent, which is the fifth most important cereal crop after teff, wheat, corn, and sorghum [69]. Barley is the staple food grain especially for Ethiopian highlanders who produce the crop with indigenous technologies and cultivated by small holders in every region of Ethiopia, since it is able to grow at all elevations, but it performs best at the higher elevations in the northern and central regions of the country [76]. In the highland of the country barley can be grown in Oromia, Amhara, Tigray Regional States and part of SNNP, which producers include smallholders and commercial farms [22].

Both food and malty barley were cultivated in highland parts of the country, so malt barley grain is mainly produced in the south eastern parts of Ethiopia in Arsi and Bale administrative zones and it is the major raw material (about 90% of the total raw material cost) for beer production [88]; whereas, food barley is principally cultivated in the highland where the highest consumption in the form of various traditional foods and local beverages from different barley types and accounts for over 60% of food for the highland in Ethiopia, for which it is the main source of calories [88].

Two new malt barley (HB1963 and HB1964) varieties with the potential to triple average yield in Ethiopia have been released in May 2016 by the Holetta Agricultural Research Center as a result of decades of research collaboration with ICARDA, which have yielding potential ranging from 3.3t/ha to 6t/ha [62]. Some of improved varieties recommendations in Ethiopia for food barely are Dimtu, Shepe, HB-40, AEDO12-608 IARH485, AHOR 88-061 and for malt barely are Beka, Holker, HB120, HB-52, HB1533 [74].

At national, during the meher 2008/09 E.C. season 9.44 thousand hectare of land is covered with barley and total of more than 18.5 million quintals are produced annually, it contributes out of total grain 7.6%, 6.95% at national area and production respectively, with national average yield of 19.66 quintals/hectare [30]. Also, in meher 2009/10 E.C. season 9.59 thousand hectare of land is covered with barley and total production of more than 20.24 million quintals are produced annually, while it contributes out of total grain 7.63%, 7.0% at national area and production respectively, with national average yield of 21.11 quintals/hectare [31].

Climatic Requirements for Barley Production

In Ethiopia, both barley types are widely cultivated in the temperate and sub-tropical region of the country, at altitudes ranging from 1500-3500m, but is predominantly grown between altitudes of 2000-3000 meters above sea level [76]. Largely, it is cool weather crop that grown on a well- drained loams and clay loams are suitable soils, generally it is grown on less fertile soils compared to wheat because it is susceptible to water logging (From internet unpublished paper). Also, the annual rain fall for barley is 1000-2000mm and the optimum temperature for germination & emergence is 15-20^{o}C (From Encyclopedia http/www.com).

Crop Managements

Land Preparation: - Barley being a shallow rooted crop, responds well to light textured, fine seedbed, which one ploughing with soil turning plough followed by 2–3 ploughing with disc plough or 2–3 harrowing by tractor or bullock power is done, also the seed bed should have a fine tilth & should be free from weeds particularly the grass weeds; [63].

Sowing: - Sowing time varies depending on variety and weather condition, usually last week of June to last week of July. When seeds are sown using broadcast method 125 kg/ha for food barley and 100 kg/ha for malt barley, where as if drill method is used a seed rate of 85 kg/ha for food barley and 75 kg/ha for malt barley is recommended [29].

Spacing: - The spacing is depending on the type of cultivars, sowing can be broadcasting or drilling in rows spaced 20-25cm apart, whereas, for irrigated crop is 23 cm row spacing and for rain fed crop, row spacing of 23–25 cm is followed, with optimum depth of sowing for irrigated crops of 5 cm and for rain fed crop 2.5–5 cm depth [63].

Fertilization: ZZZX- Application of 50kg/ha UREA and 100kg/ha NPS, so the whole NPS N should be applied during sowing but UREA in two splits viz, also application of FYM at 12.5 t/ha during last ploughing is recommended [29].

Weed Control: - Barley & wheat share the same weed species, thus the control measures are similar, so Avena spp (wild oat), Medicago polymorpha, Scorpiurus muricatus, Erucastrum arabicum, Cynodon dactylon, Lolium temulentum, Digitaria spp. are among the most dominant weed species affecting barley production, threfore post- emergence application of Isoproturan 0.75 kg/ha + 0.5 kg/ha of 2,4-D combination followed by one hand weeding on 35–40 DAS (3–5 leaf stage) is recommended for effective control both dicot and monocot weeds [29].

Irrigation: - The critical period of water requirements for barley is at the period of seedling elongation, growth and flowering stage, so during vegetation 650-700mm (400-500mm) in lower altitude areas is suitable (From Encyclopedia http/www.com).

Disease Control: - The most common diseases in barley are smut, damping off, root rots and rust. Rust such as stem rust, leaf rust, & stripe rust, while there is no control measure other than to use resistant cultivars if a valuable [47], where are powdery mildew is favored by conditions such as thick sowing & excessive nitrogen; it can be controlled by sulfur dust, but like many other diseases the best control is use of resistant cultivars [47].
Insect pest Control: - the major pests of barley are grass hoppers, army worm, shoot fly & Russian aphids [74]. They can be controlled by use of cultural practices and if possible use insecticides [74].

Harvesting: - If barley is combine harvested, it should be fully mature & the moisture content of the grass should be 14% or less so as to assure safe storage, if there is special drying facility barley can be harvested when moisture content is between 30-40% (From Encyclopedia http/www.com).

Post-harvest Management:-Threshing is an important operation in barley especially when it is grown for malting. Barley with more than 4% broken kernels is not acceptable as top grade malting barley and store in clean, favorable moisture and temperature (From Encyclopedia http/www.com).

CONCLUSION

From the above review we conclude that, agriculture is the backbone of the Ethiopian economy, which is virtually small-scale, subsistence-oriented and crucially dependent on rainfall. The country is a centre of origin and diversity for several crops, which is one of the largest grain producing nations in Africa, there are still large pockets of food insecurity in various regions, therefore the development of the agriculture in the country has been hampered by a range of constrains which include limited use of inputs (seed, fertilizer and agricultural implements), climate change and recurrent drought, status of soil fertility, lack of market information, capital, undesirable insect pest (Fall Army Worm, Army Worm, boll worm, etc) and disease (bacteria, fungi and Viruses) and parasitic weeds.

THE WAY FORWARD

To increase the production and productivity of cereal crops farmers maintain and strengthen the development of new, well-adapted crop cultivars with high yield potential and the genetic capacity to withstand major biotic and abiotic stresses, also adopt the use of appropriate new technology (fertilizer, pesticide, improved varieties and agricultural implements) to increase their production and productivity.

Also, government has setting up good agricultural system, Proper planning and management of resources, focusing agricultural investment on the small holders, creating favorable linkages between farmers, governments, researchers and

other agents of agriculture, creating new ways of science and technology on the sector, educate the rural farmers, creating National Agricultural Research Forums.

REFERENCES

1. Abebe Midheksa, Mulugeta Negeri, Tadele Shiberu, (2014). Management of Teff shoot fly, Atherigona hyalinipennis (Reg.) (Diptera): Muscidae) on tef at Ambo, West Shewa of Ethiopia, Journal of Entomology and Nematology. Vol. 6(9), pp. 134-139.
2. Abebe Shenkut, Kindie Tesfaye, Fentaw Abegaz, Tilahun Hordofa, (2013). Determination of Water Requirement and Crop Coefficient for Sorghum (Sorghum bicolor L.) at Melkassa, Ethiopia, East African Journal of Sciences, Vol. 7 (1) 41-50.
3. Abdulhamid Adamu Ibrahim, Friday Ojonigu Ati and Abel A. Adebayo, (2011). Effect of Climate on the Growth and Yield of Sorghum (Sorghum bicolor) in Wailo, Ganjuwa Local Government Area, Bauchi State. Research Journal of Environmental and Earth Sciences 3(5): 469-472.
4. Abraham Taddele, Alemayehu Balcha, (2014) Evaluation of Bread Wheat (Tritium aestivum L.) Varieties for Rust Resistance at Wolaita Zone, Southern Ethiopia; Journal of Biology, Agriculture and Healthcare, Vol.4, No.15, Wolaita sodo university, plant protection, Sodo Ethiopia.
5. Abraham Tadesse (ed.). (2008). Increasing Crop Production through Improved Plan Protection – Volume I. Plant Protection Society of Ethiopia (PPSE), 19-22 December 2006; Addis Ababa, Ethiopia, PPSE and EIAR, Addis Ababa, Ethiopia, pp 598.
6. Abreha Kidanemariam, Heluf Gebrekidan, Tekalign Mamo, Kindie Tesfaye, 2013. Wheat Crop Response to Liming Materials and N and P Fertilizers in Acidic Soils of Tsegede Highlands Northern Ethiopia, Journal of Agriculture, Forestry and Fisheries, Vol. 2, No. 3, pp. 126-135. doi: 10.11648/j.aff.20130203.12.
7. Addis Tadesse Tekle, 2016: Assessment on Distribution, Biology and Management of Maize Stem Borer (Busseola fusca Fuller) in Ethiopia, Journal of Biology, Agriculture and Healthcare. ISSN 2224-3208 (Paper) ISSN 2225-093X (Online), Vol.6, No.5.
8. Adebayo Oluwakemi O., Ibraheem Omodele, (2015). The current status of cereals (maize, rice and sorghum) crops cultivation in Africa: Need for integration of advances in transgenic for sustainable crop production. International Journal of Agricultural Policy and Research Vol.3 (3), pp. 233-245.
9. Afework H. Mesfin, Lemma Zemedu, 2016. Improved Rice Seed Production and Marketing: Challenges and Opportunities; the Case of Fogera District of Ethiopia, Journal of Agriculture and Environmental Sciences. Volume 1, No. 2, page 1-19.
10. African Agricultural Handbook Series (2017). Crop Production Field Guide Maize
11. Popescu, A., & Condei, R. (2014). Some considerations on the prospects of Sorghum crop. Scientific papers series management, economic engineering in agriculture and rural development, 14(3), 295-304.
12. Assefa, A., Liben, M., & Yeshalem, B. (2008). The effect of tillage frequency and weed control on yield of tef (Eragrostis tef) in Yielmana-Densa Area, northwestern Ethiopia. East African Journal of Sciences, 2(1), 35-40.
13. Amare, A., & Legas, A. (2015). Determination of seed rate and variety on the growth and yield of Teff in Eastern Amhara Region.
14. Amare, T., Raghavaiah, C. V., & Zeki, T. (2016). Productivity, yield attributes and weed control in wheat (Triticum aestivum L.) as influenced by integrated weed management in central high lands of Ethiopia, East Africa. Advances in Crop Science and Technology, 1-4.
15. Asea, G., Serumaga, J., Mduruma, Z., Kimenye, L., & Odeke, M. (2014). Quality protein maize production and post-harvest handling handbook for East and Central Africa. Association for Strengthening Agricultural Research in the East and Central Africa, Entebbe, Uganda.
16. Adugna, A. (2007). The role of introduced sorghum and millets in Ethiopian agriculture.
17. Menna, A., Semoka, J. M., Amuri, N., & Mamo, T. (2015). Wheat response to applied nitrogen, sulfur, and phosphorous in three representative areas of the central highlands of Ethiopia–I. International Journal of Plant & Soil Science, 8(5), 1-11.
18. ATA (2016). Ethiopia: Overview of the ATA and the Agricultural Transformation Agenda in Ethiopia's Growth and Transformation Plan (GTP) I & II, Agriculture and Transformation Agenda (ATA), Federal Democratic Republic of Ethiopia(FDRE), Addis Ababa.
19. Atilaw, A., Alemu, D., Bishaw, Z., Kifle, T., & Kaske, K. (2016). Early generation seed production and supply in Ethiopia: Status, challenges and opportunities. Ethiopian Journal of Agricultural Sciences, 27(1), 99-119.
20. Mulatu, B., & Grando, S. (2006, November). Barley research and development in Ethiopia. In Proceedings of the 2nd national barley research and development review workshop (pp. 28-30).
21. Mulatu, B., Belay, T., Dejen, A., Merine, Y., & Hunegnaw, B. (2011). Research achievements for the Russian Wheat Aphid (Diuraphis noxia Mord.) on barley in Ethiopia. Barley Research and Development in Ethiopia, 187.
22. Bedada Begna, Mesay Yami, Eshetu Lemma, (2014). Characterization of Barley- based farming systems in the Arsi Highlands, Ethiopia, Journal of Agricultural Extension and Rural Development, Vol. 8(10), pp. 309-320.

23. Bekele Hundie,Getaneh Woldeab, Kebede Taddese, Eshetu Belete and Birhanu Bekele, (2011). Achievements of research on barley Smuts, Ergot and Root and Foot Rot diseases in Ethiopia, Ethiopian Institute of Agricultural Research, International Center for Agricultural Research in the Dry Areas, pp. 273-278.
24. Belay Kassa and Dawit Alemu, (2017). Agricultural Research and Extension Linkages: Challenges and Intervention Options; Pan African University, African Union Commission, Institute of Agricultural Research, Ethiop, Journal of Agricultural Science, Vol. 27(1), p. 55-76, Addis Ababa, Ethiopia.
25. Beyene A Amelework, Hussein A Shimelis, Pangirayi Tongoona, Fentahun Mengistu, Mark D Laing, Dawit Getnet Ayele, (2016). Sorghum production systems and constraints, and coping strategies under drought-prone agro-ecologies of Ethiopia, South African Journal of Plant and Soil, Vol.33(3), p.207–217.
26. Berhane Sibhatu, (2016). Review on Striga Weed Management. Int. J. Life. Sci. Scienti. Res., VOL 2, Issue 2, pp: 110-120. (ISSN: 2455-1716).
27. Birhan Abdulkadir, Sofiya Kassa,Temesgen Desalegn, Kassu Tadesse, Mihreteab Haileselassie, Girma Fana and Tolera Abera, Tilahun Amede, Degefie Tibebe, 2017: Crop response to fertilizer application in Ethiopia: a review.
28. Berhanu A., Dereje A., Alemtsehay T., Addis, A., Kebede, M. & Girmay, S. (2016). Enhancement of barley productivity through improved crop management practices in the semi-arid highlands of northern Ethiopia, Fifth RUFORUM Biennial Regional Conference 17 - 21 October, Cape Town, South Africa, No. 14 (1), P. 743-749.
29. Birhanu Gizaw Tegene, Zerihun Tsegay, Genene Tefera, Endegena Aynalem, Misganaw Wassie, (2016). Farmers Traditional Knowledge on Teff (Eragrostistef) Farming Practice and Crop Rotation in PGP Microbes Enhancement for Soil Fertility in West and East Gojam, Computational Biology and Bioinformatics. Vol. 4, No. 6, pp. 45-54. doi: 10.11648/j.cbb.20160406.11.
30. CSA (Central Statistical Agency), (2016). Agricultural sample survey report on Area and production of major Crops (private peasant holdings, meher season 2015 /2016, Addis Ababa Ethiopia, the FDRE statistical bulletin 584, Volume I. CSA, April 2016.
31. CSA (Central Statistical Agency)., (2017). Agricultural sample survey report on Area and production of major Crops (private peasant holdings, meher season 2016 /2017; Addis Ababa Ethiopia, the FDRE statistical bulletin 584, Volume I. CSA, April 2017.
32. Dawit Alemu, Kiyoshi Shiratori, (2011). Stakeholder Analysis in Rice Research and Development Challenges and Opportunities of Rice in Ethiopian Agricultural Development, Ethiopian Institute of Agricultural Research, pp.20-31.
33. EIAR (Ethiopian Agricultural Research Institute)., (2014). Ethiopian strategy document for sorghum, Addis Ababa, Ethiopia.
34. Elias Meskelu, Abraham Wolde michael and Tilahun Hordofa, (2017). Effect of Moisture Stress on Yield and Water Use Efficiency of Irrigated Wheat (Triticum aestivum L.) at Melkassa, Ethiopia. Academic Research Journal of Agricultural Science and Research, Vol. 5(2), pp. 90-97DOI: 10.14662/ARJASR2016.055.
35. Endrias Geta, Ayalneh Bogale, Belay Kassa and Eyasu Elias. (2013). Productivity and Efficiency Analysis of Smallholder Maize Producers in Southern Ethiopia, Journal of Hum Ecol, Vol. 41(1): 67-75.
36. Ethiopian Seed Association., (2014). Hybrid Maize Seed Production Manual.
37. Esayas Kebede., (2011). Trends and challenges on Rice investment in Ethiopia, Challenges and Opportunities of Rice in Ethiopian Agricultural development, Empowering Farmers Innovation, Series No. 2. EIAR/FRG II, Addis Ababa, Ethiopia.
38. Encyclopedia: http/www.com.
39. Eyob Bezabeh, Tesfaye Haregewoin, Dejene Haile giorgis, Fitsum Daniel, Baye Belay., (2015). Change and growth rate analysis in area, yield and production of wheat in Ethiopia; Research Journal of Agriculture and Environmental Management, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia. Vol. 4(4), pp. 189-191.
40. FAO (Food and Agricultural Organization)., (2016). Food Outlook, Bi annual Report on Global Food Markets.
41. FAO (Food and Agriculture Organization)., (2016). Save and Grow in Practice Maize, Rice and Wheat, a Guide to Sustainable Cereal Production, Rome.
42. FAO (Food and Agriculture Organization)., (2017). Crop Prospects and Food Situations, No.1.
43. Gashaw Tadesse Abate, Alan de Brauw, Nicholas, and Minot Tanguy Bernard, (2014). The Impact of the Use of New Technologies on Farmers Wheat Yield in Ethiopia: Evidence from a Randomized Controlled Trial; Research for Ethiopia's Agriculture Policy, International Food Policy Research Institute Washington, DC.
44. Gebreyesus Brhane Tesfahunegn. (2014). Response of Yield and Yield Components of Tef [Eragrostis tef (Zucc.) Trotter] to Tillage,Nutrient, and Weed Management Practices in Dura Area, Northern Ethiopia, International Scholarly Research Notices Vol. 2014, pages 9.
45. Gebreyesus Brhane, Charles S. Wortmann, Martha Mamo, Heluf Gebrekidan, and Amare Belay, (2006). Micro-Basin Tillage for Grain Sorghum Production in Semiarid Areas of Northern Ethiopia.
46. G., Geremew., Asfaw Adugna, T., Taye, T., Tesfaye, B., Ketema1., and H. S., Michael, (2004). Development of sorghum varieties and hybrids for dry land areas of Ethiopia. Uganda Journal of Agricultural Sciences, 9:594-605.
47. Getaneh Woldeab, Bekele Hundie, Fekede Abebe, Asnakech Tekalign, Melaku Degefa, Kebede Taddese, Eshetu Belete and Birhanu Bekele. (2011). Achievements of research on Barley Rusts and Powdery Mildew in Ethiopia,

Ethiopian Institute of Agricultural Research, International Center for Agricultural Research in the Dry Areas, p. 235-244.
48. Haile, D and Girum, F, (2010). Integrated Effect of Seeding Rate, Herbicide Dosage and Application Timing on Durum Wheat (Triticum Turgidum L. Var Durum) Yield, Yield Components and Wild Oat (Avena Fatua L.) Control in South Eastern Ethiopia; Oromia Agricultural Research Institute, Sinana Agricultural Research Center, Bale-Robe, Ethiopia. Volume 2 (2):12-26.
49. Hailegebrial Kinfe, Yiergalem Tsehaye, Alem Redda, Redae Welegebriel, Desalegn Yalew and Welegerima Gebrelibanos, (2017).Yield and Yield Related Performance of Upland Rice Genotypes in Tselemti district, North Ethiopia, Journal of Rice Research an open access, Vol. 5, Issue 4, and P.1-4.
50. Hailu Gebre- Marium: Wheat Production and Research in Ethiopia, Institute of Agricultural Research (IAR), P.O, Box 2003, Addis Ababa.
51. H. Hengsdijk and W. J. de Boer, (2017). Post-harvest management and post-harvest losses of cereals in Ethiopia, Food Section, and Vol. 9:945–958.
52. Habtamu Admassu, Mezgebu Getinet, Timothys, Thomas, Michael Waithaka, Miriam Kyotalimye, (2012). East African Agriculture and Climate Change: A Comprehensive Analysis— Ethiopia, International Food Policy Research Institute.
53. H. Sareta, Wogayehu Worku and Bedada Begna, (2016). Economics of Herbicide Weed Management in Wheat in Ethiopia; African Crop Science Journal, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia, Vol. 24, pp. 109 – 116. DOI: http://dx.doi.org/10.4314/acsj.v24i1.12S.
54. International Center for Agricultural Research in the Dry Areas (ICARDA), (2016). Wheat 4 Africa Updates is a newsletter of the SARD-SC Wheat program, an initiative Funded by African Development Bank, AfDB. The project is implemented by ICARDA in 12 countries across Africa in partnership with NARS, No.3.
55. International Plant Biotechnology Outreach (IPBO) (2017). Maize in Africa, for information available on: ipbo@vib-urgent.be-www.ipbo.vib-urgent.be.
56. Jéan du Plessis (2008). Sorghum Production Manual, Department of Agriculture of South Africa, available on the web: www.nda.agric.za/publications.
57. Kefyalew Endale, (2011). Fertilizer Consumption and Agricultural Productivity in Ethiopia, Ethiopian Development Research Institute Addis Ababa, Ethiopia, and EDRI Working paper 003.
58. Kidane Georgis, Alemneh Dejene, Meshack Malo, (2009). Agricultural based Livelihood Systems in Dry lands in the Context of Climate Change, Inventory of Adaptation Practices and Technologies of Ethiopia, Final Draft.
59. Kumela Bodena Jabesa, Thomas Abraham (2016). Performance of yield attributes, yield and economics of teff (Eragrostis tef) influenced by various row spacing, nitrogen and phosphorus fertilizers. Vol. 10(10), pp. 234-237.
60. Melinda Smale, Derek Byerlee, Thom Jayne, (2011). Maize Revolutions in Sub-Saharan Africa. The World Bank Development Research Group Agriculture and Rural Development Team, Policy Research Working Paper 5659.
61. Megersa Kebede, Fufa Anbasa, (2017). Efficacy of Pre-emergence Herbicides for the Control of Major Weeds in Maize (Zea mays L.) at Bako, Western Oromia, Ethiopia, American Journal of Agriculture and Forestry. Vol. 5, No. 5, pp. 173-180. doi: 10.11648/j.ajaf.20170505.15.
62. MoA (2016): Crop variety register, Issue no. 12, Plant variety release, protection and seed quality control directorate, Ministry of Agriculture (MoA), Addis Ababa, Ethiopia.
63. MWU (Madda Walabu University), (2017). College of Agriculture and Natural Resource, Department of Plant Science, Crop Husbandry Course Composite Crop Hand out, Robe, Ethiopia.
64. Omer Gebremedhin Mesfin, (2015). Bread wheat production in small scale irrigation User's agro-pastoral households in Ethiopia: Case of Afar and Oromia regional state, International Journal of Agricultural Economics and Extension ISSN: 2329-9797 Vol. 3 (5), pp.144-150, Available online at www.international scholars journals.org.
65. Netsanet Bacha Hei, (2014). Genetic Analysis of Stem Rust Resistance among Ethiopian Grown Wheat Lines; A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy (PhD) in Plant Breeding, Alemaya University of Agriculture, Ethiopia.
66. Rahel Tigabu, Fikadu Asfaw, (2016). Effects of Seed Rate and Row Spacing on Yield and Yield Components of Bread Wheat (Triticum aestivum L.) in Dalbo Awtaru Woreda, Wolaita Zone, Southern Ethiopia, Journal of Biology, Agriculture and Healthcare. ISSN 2224-3208 (Paper) ISSN 2225-093X (Online) Vol.6, No.7.
67. Samuel Gebresellasie, Mekbib G. Haile, Matthias Kaskuhl, (2017). The Wheat Sector in Ethiopia: Current Status and Key Challenges for Future Value Chain Development; Center for Development Research (ZEF), Working Paper 160, Genscherallee 3, D –53113 Bonn, Germany.
68. Sewagegne Tariku, (2011). An Overview of Rice Research in Ethiopia, Challenges and Opportunities of Rice in Ethiopian Agricultural Development, Ethiopian Institute of Agricultural Research, Adet Agricultural Research Center, Bahir Dar, Ethiopia, p. 32-37.
69. Shahidur Rashid, Gashaw T. Abate, Solomon Lemma, James Warner, Leulsegged Kasa, and Nicholas Minot. (2015). The Barley Value Chain in Ethiopia, Research for Ethiopia's Agriculture Policy, International Food Policy Research Institute (IFPRI) Washington DC.

70. Shiferaw T, Dargo F, Osman A., (2015). Agro pastoralist Evaluations of Integrated Sorghum Crop Management Packages in Eastern Ethiopia. Adv Crop Sci Tech 3: 195. doi:10.4172/2329-8863.1000195.
71. Sreepada Hegde and Vijayalaxmi Hegde. (2013). Assessment of Global Rice Production and Export Opportunity for Economic Development in Ethiopia: International Journal of Science and Research (IJSR), volume 2, issue 6, p.257-260.
72. Taddele Dessalegn, Tesfaye Solomon, (2017): Post-harvest wheat losses in Africa: an Ethiopian case study, DOI: 10.19103/AS.2016.0004.18.
73. Tadessa Daba, 2017. Nutritional and Soio-Cultural Values of Teff (Eragrostis tef) in Ethiopia, International Journal of Food Science and Nutrition Volume 2; Issue 3, P. 50-57 www.foodsciencejournal.com.
74. Tafa Jobie, Bayeh Mulatu, (2011). Research achievements in barley shoot fly in Ethiopia, Ethiopian Institute of Agricultural Research, International Center for Agricultural Research in the Dry Areas, p. 157-172.
75. Taffesse As, Dorosh P, Asrat S, (2011). Crop production in Ethiopia: Regional patterns and trend, International Food Policy Research Institute, Washington DC.
76. Tamene Mideksa, KasahunTadese and Hiwot Sabsibe. (2016). Registration of "Singitan" a newly Released Malt Barley (Hordeum vulgare L.) Variety for Highland Areas of Bale, Academic Research Journal of Agricultural Science and Research,Vol. 4(6), pp.241-244.
77. Tamirat Belayneh, Jember Tekle, (2017). "Review on Adoption, Trend, Potential, and Constraints of Rice Production to Livelihood in Ethiopia." International Journal of Research - Granthaalayah, 5(6), 644-658. https://doi.org/10.5281/zenodo.824116.
78. Regasa, T., Mekbib, F., & Eticha, F. (2016). Effect of seed source and seed age on yield and yield related traits of malt barley (Hordium vulgare L.) varieties at Central Arsi Highlands Ethiopia. Journal of Plant Breeding and Crop Science, 8(10), 223-227.
79. Tekle Yoseph, Zemach Sorsa, (2014). Evaluation of Sorghum (Sorghum bicolor (L.) Moench) Varieties, for Yield and Yield Components at Kako, Southern Ethiopia, Journal of Plant Sciences, Vol. 2, No. 4, 2014, pp. 129-133.
80. Tesfaye Amare, (2014). Effect of weed management methods on weeds and Wheat (Triticum aestivum L.) Yield, African Journal of Agricultural Research, Vol. 9(42), pp 1914-1920. DOI: 10.5897/AGAR2003.8288
81. Tesfay A, Amin M, Mulugeta N (2014) Management of Weeds in Maize (Zea mays L.) through Various Pre and Post Emergency Herbicides. Adv Crop Sci Tech 2: 151. doi:10.4172/2329-8863.1000151.
82. Tesfaye Amare, Amin Mohammed, Mulugeta Negeri, Firehiwot Sileshi, (2015). Effect of Weed Control Methods on weed Density and Maize (Zea mays L.) yield in West Shoa Oromia, Ethiopia; African Journal of Plant Science. Vol. 9(1), pp. 8-12. DOI: 10.5897/AJPS 2014. 244.
83. Tesfay Amare, J.J. Sharma, and Kassahun Zewdie, (2014). "Effect of Weed Control Methods on Weeds and Wheat (Triticum Aestivum L.) Yield, World Journal of Agricultural Research, vol. 2, no. 3, p. 124-128. doi: 10.12691/wjar-2-3-7.
84. Tesfaye Geleta, (2015). Seed Rate and Sowing Method Effects on Seed Quality of Bread Wheat (triticum aestivum L.) Varieties in Horo District, Western Ethiopia, Malaysian Journal of Medical and Biological Research, Vo. 2, P. 273-283. ISSN 2313-0008 (Print); ISSN 2313-0016 (Online); Prefix I0.18034.
85. Tilahun Mola, Kifle Belachew. (2015). Effect of Weeding Time on Rice (Oryza sativa Linn) Yield and Yield Components at Kaffa, Southwest Ethiopia, Journal of Biology, Agriculture and Health care, Vol.5, No.1.
86. Tsedeke Abate, Bekele Shiferaw, Abebe Menkir, DagneWegary, Yilma Kebede, Kindie Tesfaye, Menale Kassie, Gezahegn Bogale, Berhanu Tadesse, Tolera Keno, (2015). Factors that transformed maize productivity in Ethiopia.
87. Tewodros Ayalew, Bereket Abebe Tarekegn Yoseph, (2017). Response of Wheat (Tritium aestivum L.) to Variable Seed Rates: the Case of Hawassa Area, Southern Ethiopia; African Journal of Agricultural Research, Vol. 12(14), pp. 1177-1181. DOI: 10.5897/AJAR2017.12196.
88. Tura Kaso, Gashaw Guben. (2015). Review of Barley Value Chain Management in Ethiopia, Journal of Biology, Agriculture and Health care, Vol. 5, No. 10, P. 84-97.
89. Waktole Sori, Amsalu Ayana, (2012). Storage pests of maize and their status in Jimma Zone, Ethiopia; African Journal of Agricultural Research, Vol. 7(28), pp. 4056-4060, Available online at http://www.academicjournals.org/AJAR.
90. Wasihun Yaregal Wubneh, Flagote Alemu Bayu, (2016). Assessment of diseases on rice (Oriza sativa L.) in major growing fields of Pawe district, Northwestern Ethiopia, World Scientific News (WSN). Ethiopian Institute of Agricultural Research (EIAR), Pawe Research Center, Ethiopia, Vol. 42, p. 13-3.
91. Zahara Mohammed, Shugute Addisu, (2016). Evaluation of Sequential Application of Herbicides for Broad and Grass Weed Management in Durum Wheat, Ethiopia, American Journal of Environmental and Resource Economics, Vol. 1, No. 1, 2016, pp. 32-36. doi: 10.11648/j.ajere.20160101.14.
92. USDA (United States Department of Agriculture), (2018). World Agricultural Supply and Demand Estimates, WASDE-573.