International Journal of Agriculture Innovations and Research
Volume 9, Issue 5, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 19/02/2021 | Accepted on: 10/03/2021 | Published: 23/03/2021

# Sunflower Research: Current Status and Future Prospects in Ethiopia

**Misteru Tesfaye*** **and Birhanu Mengistu**
Holetta Agricultural Research Center, P.O. Box. 31, Holetta, Ethiopia.
*Corresponding author email id: misterutesfaye@yahoo.com

***Abstract*** **– Sunflower is one of the four most important oilseeds in the world. Because of its high quality of oil about 90% of the total production of oil is used for human consumption. In Ethiopia noug, linseed, Ethiopian mustard and cotton are the primary source for oil millers. Although sunflower is not widely grown in Ethiopia, the country has immense potential for its production. Furthermore, it has a wide adaptability and high yielder than major oilseeds in the country. Currently some private farmers has started to grow due to high demand of raw material for oil-millers and thus its coverage is started to increase from time to time; the country possesses large agricultural land suitable for sunflower production. In Ethiopia, research on sunflower was started in the late 1960's; however the research comes to a halt for over one decade. But because of the growing interest from private sector to produce sunflower the Ethiopian Institute of Agricultural Research (EIAR) have been started to revive the research starting from 2004. This paper tries to review sunflower improvement research effort in Ethiopia along with its production status and research accomplishments and finally suggest future research prospects.**

***Keywords*** **– Edible Oil, Ethiopia, Hybrid Variety, Open Pollinated Variety, Sunflower.**

## I. INTRODUCTION

Sunflower is one of the major sources of oil in the world and assumed to be originated from southern United States where its progenitor or wild *H. annuus* was found (Heiser 1978). Sunflower is a wide spread oilseed crop of the world and it is almost grown in all continents. Europe, America and Australia accounts for 80% of the total production of the world whereas Asia contributes to 18% and the rest 2% from Africa (Damodaran and Hege, 2010). The domesticated sunflower was introduced from North America into Europe in the sixteenth century by the early Spanish explorer (Putt, 1977) where the crop utilized as a garden ornamental. Evidences suggested that sunflower was introduced to the North Horn of Africa including Ethiopia by the Italians some 160 years ago.

Cultivated sunflower can be grouped into three categories based on its use: i) Oil types: those used for oil extraction ii) confectionary types: - those used as ornamental purpose and iii) Ornamental types: those used for ornamental purpose. The oil from sunflower is a healthful with great acceptance from consumers and it is considered premium oil for salad, cooking and margarine production. The seeds of confectionary sunflower used as a snack food as well as for feeding birds and small animals. The main difference between the oil and confectionary type sunflower are the oil content and seed size. Oil type of sunflower relatively have small black seed with low hull content and high oil content up to 50% while confectionary sunflower varieties have large seeds, which are usually black with white stripes, with lower oil content (about 30%) and higher hull percentage. The last group of sunflower varieties includes those grown for ornamental purpose. Such sunflower cultivars are used in gardens, home landscape or as cut flowers. The majority of sunflower production is oil type and most of the cultivars produced are hybrids varieties of high productivity and oil content (Seiler and Jan, 2010 and Skoric, et al., 2012).

In Ethiopia, the major oilseeds which are currently used by the oil - millers as raw materials are noug, linseed

and Ethiopian mustard and cotton especially by large oil-millers. Although noug and linseed are dominantly used for edible oil, their productivity and oil content is lower than sunflower and their oil especially for linseed sensitive to autoxidation makes the oil rancid. The oil from sunflower, however, is a premium due to its light color, bland flavor, high smoke point and good nutritional quality (Fowleri, 2006, Bashiri. et al. 2015 and Alagawanyi, 2015). Moreover, sunflower has a wide adaptability, photoperiod insensitivity, high yield and easy for cultivation (kaleem *et al.* 2011). Because of the above advantages of the crop, sunflower has been demanded by the consumers and studies or research on the crop has been stated since then. This paper tries to review sunflower improvement research effort in Ethiopia along with its production status and research accomplishments and finally suggest future research prospects.

## II. PRODUCTION STATUS

Although sunflower is not widely grown in Ethiopia, the country has immense potential for sunflower production. According to the previous cropping history of the crop, warmer areas with altitude of 1400-2400 m a.s.l. with well drained clay/sandy loam soil in the Hawassa, Bako, Birr and Dedessa valley, Debrezeit (Bishoftu) to Nazret (Adama) and Ziway to Arsi-Negele were suitable production areas. Those state farms that produce maize used to grow sunflower as one of the break crops in their rotation plan. During those days, the late maturing cultivar "*Russian black*" was recommended for wide-scale production, as it was relatively adapted. Despite the fact that sunflower production was not significant in the country, currently some private farmers has started to grow due to high demand for raw material for oil-millers and thus its coverage is started to increase time to time.

According to Central Statistical Authority (CSA 2008/9- 2017/18) of the country, sunflower production is increased by two fold between years of 2010/11 and 2012/13 with slight increase in area of production (Fig.1). Despite small area of coverage of the crop, the country possesses large agricultural land suitable for sunflower production.

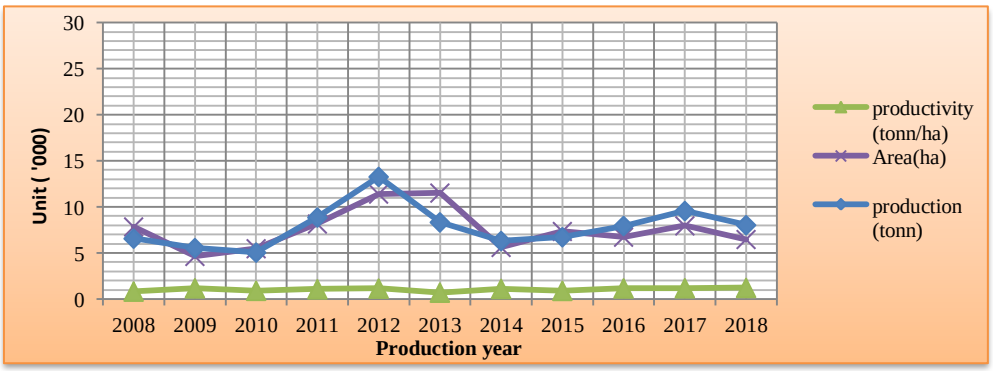


Fig. 1. Sunflower Area coverage, production and productivity trend in Ethiopia for the period 2008 to 2018.

According to the personal observation during the field visit in northern, central and western part of the country, sunflower can be grown in a wide range of agro-ecology in Ethiopia. Currently, the crop is grown as a boarder crop and sometimes as sole crop in Central Highlands of Shewa (eg. Bishoftu and Adama), West Gojam (eg. Fenotselam and Achefer), East Wellega (eg. Anger Guti) and some districts of Arsi Zone.

Recent findings of adaption trials also indicated that the crop performed best in warmer areas where other major crops fail to grow. For large scale production of sunflower in Ethiopia, there are potential districts in

Benishangul Gumuz region and there are some potential zones around Amhara region. The altitude and area location in term of latitude and longitude is presented in table 1.

Table 1. Geographic position of potential districts for sunflower production in Benishangul Gumuz, Metekel Zone and the surrounding districts of Amhara region, Ethiopia.

| Districts | Altitude | Latitude | Longitude |
|---|---|---|---|
| Pawe | 1050 | $11^0$ 35' 22.4" | $36^0$ 42' 59.6" |
| Dangur | 933 | $11^0$ 26' 98.7" | $35^0$ 72' 16.0" |
| Bullen | 1382 | $10^0$ 32' 18.3" | $35^0$ 56' 24.1" |
| Dibate | 1453 | $10^0$ 35' 22.4" | $35^0$ 70' 59.6" |
| Bambassie | 1300-1470 | - | - |
| Asossa | 1500-2000 | $10^0$ 19' 60.00" | $35^0$ 39' 59.99" |
| Guangua | 1489 | $10^0$ 35' 22.4" | $36^0$ 42' 59.6" |

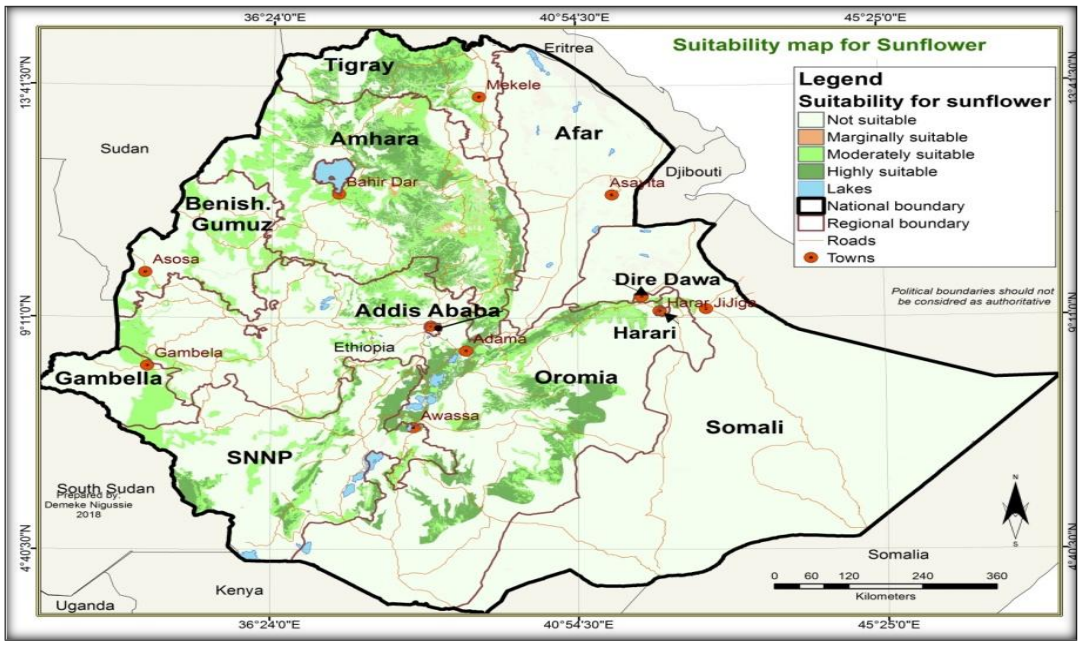


Fig. 2. Suitability map of sunflower production in Ethiopia.

## III. SUNFLOWER RESEARCH IN ETHIOPIA

### *Historical Background*

In Ethiopia, sunflower improvement started in the late 1960's and during that time three varieties namely *Russian black, Hesa and Pop* -158 were recommended for production at national level. These varieties were late maturing, tall type and are less uniform and thus systematic research on sunflower has been conducted since 1980s at Hawassa Agricultural Research Center which was a coordinating center till 2004 to release open-pollinated varieties with desirable agronomic traits. Later in the 1990s two early and shorter candidate varieties namely "*NSH-2 and NSH-25*" for lower-rainfall and warmer areas and another full-season type variety "*Argentario*" were in pipelines for release from synthetic variety development program. None of these varieties, however, were not successful for release and the state farms also lost interest in producing the crop due partly to

i) the severity of bird damage in the production areas ii) disease occurrence such as downy mildew and sclerotinia and ii) lack of strong research program and follow up. Due to the above challenges the then IAR-management decided to cease the research program all together and all the germplasm materials had been kept in safe at the PGRC/E (now Ethiopian Biodiversity Institute-EBI). In Ethiopia, research on sunflower was, therefore, come to a halt for over one decade.

*Research Accomplishments (2004- 2018/19)*

Since the last few years it seems that there is a growing interest from private sector to produce sunflower and thus Ethiopian Institute of Agricultural Research (EIAR) have been started to revive the research on sunflower shifting the research program from Hawassa to Holetta Agricultural Research Center (HARC). Some of the research accomplishments conducted so far is discussed hereunder.

*Variety Development Efforts*

The first variety development attempt by Highland Oilseeds Research team was introduction of improved varieties from abroad and conducting adaption trial. In 2004, two varieties of sunflower namely *Indam*-6 and *Aditya* was introduced from India and grown at Debrezeit both on the main research center and sub-center (Dembi). Although these varieties relatively shown better uniformity, early maturing and shorter in height and gave comparable yield and oil content with the standard check Russian black, they had not been registered as a variety since the adaption trial was conducted in limited location and it was not possible to find the history of the variety form the country of origin. It was, however, possible to develop the first open-pollinated sunflower variety namely *Oissa* in 2005 from previously stated variety development research efforts by Hawassa Agricultural Research Center.

*Germplasm Acquisition and Characterization*

In order to exploit the existing germplasm for sunflower improvement, the oilseeds research team at HARC acquired 52 germplasm from Ethiopian Biodiversity Institute (EBI) and characterize along with the existing varieties and lines maintained for breeding in 2012. Most of the accessions collected were from Oromiya region followed by South Nation and Nationalities People (SNNP) regions (Fig. 2). Few collections were also acquired from Amhara and Tigray region.

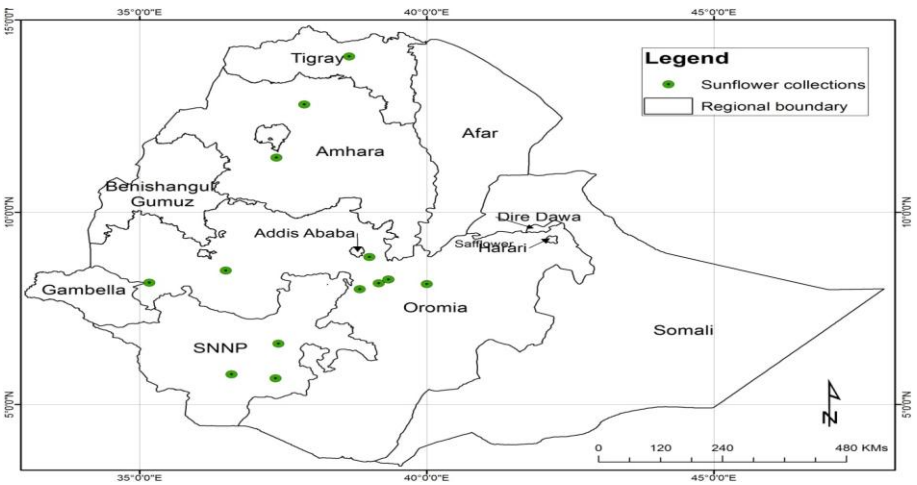


Fig. 3. Sunflower collection areas in collaboration with Ethiopian Biodiversity Institute.

Characterization was made for these accessions along with standard checks (*Oissa and Russian black*) and pipeline sunflower populations (*Adadi-1, Adadi-2 and Adadi-3*) for major agro-morphological traits. The experiment was done with simple lattice design and each entries was planted in two rows of 30 cm and 3m length and each entries was apart each other with 75 cm space. Each entries was evaluated with major traits (date of flowering and maturity, plant height, stem diameter and yield per plot) and the value of each traits was analyzed and its output is presented in Table 2 below.

Table 2. Sunflower accessions and germplasm evaluated for seed yield and agro-morphological traits at Holetta and Ghinchi, Ethiopia.

| Accessions | Date of Flowering | | Date of Maturity | | Plant Height (cm) | | Stem Diameter (cm) | | Yield (Q/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| ACC.202490 | 94 | 1.4 | 139 | 1.4 | 207.0 | 66.5 | 1.5 | 0.0 | 9.9 | 0.2 |
| ACC.202491 | 93 | 0.7 | 160 | 2.1 | 165.5 | 14.8 | 1.2 | 0.0 | 8.5 | 4.5 |
| ACC.202492 | 99 | 4.2 | 163 | 2.8 | 169.5 | 23.3 | 1.8 | 0.2 | 10.4 | 0.8 |
| ACC.202493 | 89 | 1.4 | 138 | 0.0 | 169.5 | 10.6 | 1.6 | 0.1 | 9.8 | 1.8 |
| ACC.202494 | 96 | 0.0 | 150 | 15.6 | 175.5 | 19.1 | 1.5 | 0.0 | 7.0 | 4.5 |
| ACC.202495 | 91 | 2.8 | 138 | 2.1 | 182.0 | 19.8 | 1.7 | 0.0 | 9.3 | 1.9 |
| ACC.202496 | 91 | 2.8 | 151 | 21.2 | 213.5 | 40.3 | 1.5 | 0.1 | 5.9 | 7.5 |
| ACC.202497 | 94 | 1.4 | 163 | 0.0 | 234.0 | 53.7 | 1.6 | 0.3 | 6.1 | 0.1 |
| ACC.202498 | 93 | 1.4 | 158 | 2.8 | 172.5 | 7.8 | 1.5 | 0.0 | 6.9 | 0.8 |
| ACC.207989 | 120 | 5.7 | 164 | 2.8 | 174.0 | 76.4 | 1.7 | 0.1 | 3.2 | 1.2 |
| ACC.208122 | 117 | 9.2 | 162 | 1.4 | 176.0 | 2.8 | 1.7 | 0.1 | 14.4 | 0.1 |
| ACC.208123 | 115 | 6.4 | 161 | 0.7 | 170.0 | 15.6 | 1.6 | 0.1 | 12.0 | 4.9 |
| ACC.208124 | 116 | 8.5 | 163 | 0.7 | 183.0 | 8.5 | 1.6 | 0.0 | 15.7 | 0.2 |
| ACC.208461 | 121 | 4.9 | 165 | 2.1 | 207.0 | 11.3 | 1.6 | 0.2 | 12.2 | 1.9 |
| ACC.208768 | 106 | 18.4 | 171 | 3.5 | 214.5 | 4.9 | 1.6 | 0.3 | 11.5 | 1.2 |
| ACC.208902 | 120 | 1.4 | 164 | 0.7 | 170.5 | 14.8 | 1.5 | 0.3 | 8.5 | 3.6 |
| ACC.212935 | 114 | 6.4 | 164 | 0.7 | 180.0 | 19.8 | 1.7 | 0.4 | 8.1 | 0.2 |
| ACC.212936 | 121 | 3.5 | 166 | 4.2 | 199.5 | 14.8 | 1.4 | 0.3 | 11.2 | 4.8 |
| ACC.229783 | 104 | 21.9 | 165 | 2.1 | 171.0 | 11.3 | 1.5 | 0.1 | 1.7 | 0.2 |
| ACC.231342 | 99 | 4.2 | 163 | 0.7 | 170.5 | 7.8 | 1.6 | 0.3 | 5.7 | 6.8 |
| ACC.231343 | 106 | 26.2 | 166 | 2.8 | 202.5 | 9.2 | 1.4 | 0.0 | 10.8 | 2.5 |
| ACC.231344 | 89 | 1.4 | 137 | 0.7 | 153.0 | 22.6 | 1.7 | 0.1 | 9.7 | 2.9 |
| ACC.231345 | 89 | 6.4 | 162 | 2.1 | 192.0 | 62.2 | 1.5 | 0.0 | 4.2 | 1.0 |
| ACC.231346 | 96 | 0.0 | 162 | 0.0 | 130.0 | 21.2 | 1.6 | 0.1 | 3.9 | 0.9 |
| ACC.231348 | 116 | 10.6 | 163 | 1.4 | 159.0 | 11.3 | 1.4 | 0.2 | 19.1 | 13.6 |
| ACC.231352 | 89 | 0.0 | 139 | 0.7 | 159.5 | 0.7 | 1.6 | 0.1 | 9.5 | 1.2 |

| Accessions | Date of Flowering | | Date of Maturity | | Plant Height (cm) | | Stem Diameter (cm) | | Yield (Q/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| ACC.231354 | 105 | 0.0 | 163 | 2.8 | 118.5 | 3.5 | 1.6 | 0.1 | 4.5 | 4.0 |
| ACC.231359 | 107 | 2.8 | 165 | 0.0 | 149.0 | 7.1 | 1.5 | 0.1 | 4.7 | 0.3 |
| ACC.231361 | 109 | 2.8 | 164 | 1.4 | 188.5 | 33.2 | 1.4 | 0.4 | 6.7 | 0.2 |
| ACC.231362 | 109 | 10.6 | 166 | 3.5 | 226.5 | 53.0 | 2.0 | 0.2 | 8.9 | 3.4 |
| ACC.231363 | 88 | 0.0 | 136 | 1.4 | 119.0 | 4.2 | 1.6 | 0.0 | 1.8 | 0.7 |
| ACC.231364 | 105 | 4.9 | 163 | 0.7 | 155.0 | 0.0 | 1.5 | 0.0 | 1.0 | 0.3 |
| ACC.231365 | 113 | 8.5 | 164 | 1.4 | 185.0 | 8.5 | 1.6 | 0.1 | 8.7 | 3.6 |
| ACC.231366 | 99 | 4.9 | 162 | 1.4 | 151.5 | 17.7 | 1.5 | 0.1 | 7.3 | 0.8 |
| ACC.231367 | 95 | 2.1 | 163 | 2.8 | 150.5 | 7.8 | 1.8 | 0.1 | 10.5 | 4.2 |
| ACC.231370 | 99 | 3.5 | 163 | 2.8 | 176.5 | 13.4 | 1.5 | 0.3 | 6.9 | 0.3 |
| ACC.231371 | 94 | 1.4 | 147 | 23.3 | 147.5 | 6.4 | 1.6 | 0.2 | 7.1 | 5.0 |
| ACC.231372 | 88 | 0.0 | 137 | 0.7 | 149.5 | 3.5 | 1.6 | 0.1 | 6.6 | 1.0 |
| ACC.231374 | 91 | 3.5 | 137 | 0.7 | 135.0 | 2.8 | 1.3 | 0.1 | 4.3 | 0.8 |
| ACC.231375 | 108 | 21.2 | 170 | 4.9 | 223.5 | 14.8 | 1.4 | 0.1 | 10.5 | 3.5 |
| ACC.231378 | 93 | 0.0 | 140 | 2.8 | 185.5 | 20.5 | 1.4 | 0.1 | 5.1 | 1.0 |
| ACC.231379 | 94 | 0.0 | 163 | 2.1 | 180.0 | 17.0 | 1.7 | 0.4 | 6.4 | 0.4 |
| ACC.231380 | 94 | 0.7 | 164 | 2.1 | 157.5 | 6.4 | 1.7 | 0.1 | 4.9 | 2.1 |
| ACC.231381 | 97 | 1.4 | 165 | 3.5 | 252.5 | 27.6 | 1.5 | 0.1 | 5.0 | 0.8 |
| ACC.231382 | 93 | 0.7 | 163 | 0.7 | 160.0 | 24.0 | 1.6 | 0.1 | 6.6 | 4.0 |
| ACC.231383 | 91 | 2.8 | 151 | 17.0 | 159.0 | 8.5 | 1.6 | 0.1 | 7.6 | 0.5 |
| ACC.231384 | 89 | 5.7 | 169 | 2.8 | 196.0 | 2.8 | 1.5 | 0.1 | 6.9 | 1.9 |
| ACC.235586 | 123 | 0.7 | 165 | 2.8 | 210.5 | 12.0 | 1.4 | 0.0 | 13.4 | 5.1 |
| ACC.236937 | 109 | 21.9 | 166 | 4.2 | 235.0 | 24.0 | 1.5 | 0.0 | 9.8 | 0.2 |
| ACC.236938 | 124 | 0.0 | 171 | 2.8 | 225.5 | 2.1 | 1.5 | 0.2 | 9.8 | 1.4 |
| ACC.236939 | 117 | 3.5 | 171 | 2.8 | 260.0 | 1.4 | 1.5 | 0.1 | 8.9 | 2.8 |
| ACC.92002 | 94 | 1.4 | 155 | 13.4 | 203.0 | 65.1 | 1.5 | 0.1 | 5.1 | 1.0 |
| Adadi-1 | 119 | 5.7 | 163 | 0.7 | 189.5 | 21.9 | 1.6 | 0.1 | 11.4 | 3.9 |
| Adadi-2 | 96 | 8.5 | 152 | 19.1 | 144.5 | 23.3 | 1.6 | 0.1 | 4.4 | 0.3 |
| Adadi-3 | 106 | 20.5 | 138 | 3.5 | 143.0 | 38.2 | 1.5 | 0.1 | 3.6 | 0.4 |
| Adadi-4 | 111 | 6.4 | 165 | 2.8 | 198.5 | 17.7 | 1.6 | 0.2 | 9.1 | 1.1 |
| NS-H-45 | 107 | 0.7 | 162 | 0.7 | 223.0 | 46.7 | 1.4 | 0.2 | 8.9 | 0.0 |
| Oissa | 109 | 7.5 | 164 | 1.7 | 184.8 | 14.8 | 1.5 | 0.1 | 10.5 | 4.3 |

| Accessions | Date of Flowering | | Date of Maturity | | Plant Height (cm) | | Stem Diameter (cm) | | Yield (Q/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Russian black | 110 | 15.2 | 167 | 5.0 | 216.5 | 14.2 | 1.4 | 0.1 | 9.9 | 4.0 |
| SPS-1 | 110 | 0.7 | 164 | 0.0 | 169.5 | 6.4 | 1.4 | 0.1 | 5.8 | 0.7 |
| CV | 8.5 | | 3.5 | | 13.7 | | 10.04 | | 40.7 | |

According to analysis of variance made for each trait, the date of maturity of the accessions and testing lines ranges from 136 to 171 days almost one month gap between the early and late accession. The plant height and stem diameter ranges from 119 to 260 cm and 1.4- 2cm, respectively. Based on yield taken in plot bases, nine accessions including Adadi-1 was found to be better in yield as compared to the latest open-pollinated variety (OPV), *Oissa* (Table 2).

From the breeding point of view, plants having short maturity regime, shorter to medium high, uniform and single head are preferred which could be sources of early maturing varieties suitable for harvesting at one time intervals. Among the above accession, Acc. 231363 and Acc. 231374 was found to be early maturing with short height although the first one was less productive. Adadi-3 was early maturing with shorter height while Adadi-2 was shorter height and productive but medium maturing type (Table 2).

### *Registration of Hybrid Varieties*

Since 2010 a number of hybrid sunflower varieties have been registered through conducting adaptation trial at various locations in collaboration of different private companies. The adaption trials have been conducted at different research centers such as Holetta, Debrezeit, Kulumsa, Pawe and Asossa. So far 14 hybrid sunflower varieties were registered (MoA, 2015) and such varieties were found to be adaptable in a wide agro-ecology and gave better productivity and oil content which ranges from 1.7-3.1 t/ha and 37-51 %, respectively (Table 3). The hybrid varieties were uniform in head maturity, shorter in height and usually single headed as compared to OPV variety Oissa.

Table 3. Hybrid varieties registered in Ethiopia and their yield and oil content potential.

| S. No | Varieties | Year of Registration | Average Seed Yield (t/ha) | Oil Content (%) | Sources of varieties | |
|---|---|---|---|---|---|---|
| | | | | | Country of Origin | Collaborative company |
| 1 | PR63A98 | 2015 | 1.7 - 1.8 | 45 | France | Pioneer Seed Co. |
| 2 | PR63LL06 | 2015 | 1.8 - 1.9 | 40 | France | Pioneer Seed Co. |
| 3 | Camara II | 2014 | 2.0 - 2.5 | 42.5 | America | Minerva PLC |
| 4 | NLN11037 | 2014 | 1.7 - 2.0 | 40.4 | Serbia | Minerva PLC |
| 5 | Vicenzo | 2014 | 1.8 - 2.2 | 38.7 | Serbia | Minerva PLC |
| 6 | X6859 | 2014 | 2.1 - 2.5 | 38.0 | America | Minerva PLC |
| 7 | Hysun 33 | 2013 | 2.5 - 3.0 | 45.0 | Australia | General Chemicals and Trading Company |
| 8 | NK-Delfi | 2012 | 1.76 | 44.0 | France | Red Speckled Global Trading PLC |
| 9 | Neoma | 2012 | 1.94 | 46.0 | France | Red Speckled Global Trading PLC |

| S. No | Varieties | Year of Registration | Average Seed Yield (t/ha) | Oil Content (%) | Sources of varieties | |
|---|---|---|---|---|---|---|
| | | | | | Country of Origin | Collaborative company |
| 10 | VSFH-2074 | 2012 | 1.8 | 37-40 | India | Vibha Seeds, India |
| 11 | VSFH-1006 | 2012 | 2.1 | 37-40 | India | Vibha Seeds, India |
| 12 | Kazanova | 2011 | 3.1 | 48-51 | Serbia | Ashiraf Agricultural and Industrial PLC |
| 13 | NS-H-45 | 2011 | 1.8 | 45-50 | Serbia | Ashiraf Agricultural and Industrial PLC |
| 14 | NS-H-111 | 2011 | 1.9 | 48-50 | Serbia | Ashiraf Agricultural and Industrial PLC |

*Open Pollinated Variety Development Efforts*

Despite the fact that hybrid varieties are more productive with high oil content as well as suitable for mechanized farming system, the cost of the seed could not be affordable by small scale farmers. It is thus necessary to develop open pollinated sunflower varieties which should be early maturing, uniform and productive in terms of seed yield and oil content. The oilseeds research team of HARC have been strive to release OPV sunflower varieties better than the existing the OPV variety, *Oissa*. The breeding work have been started in enhancement of Germplasm using head to row selection bases as illustrated in the following figure 3.

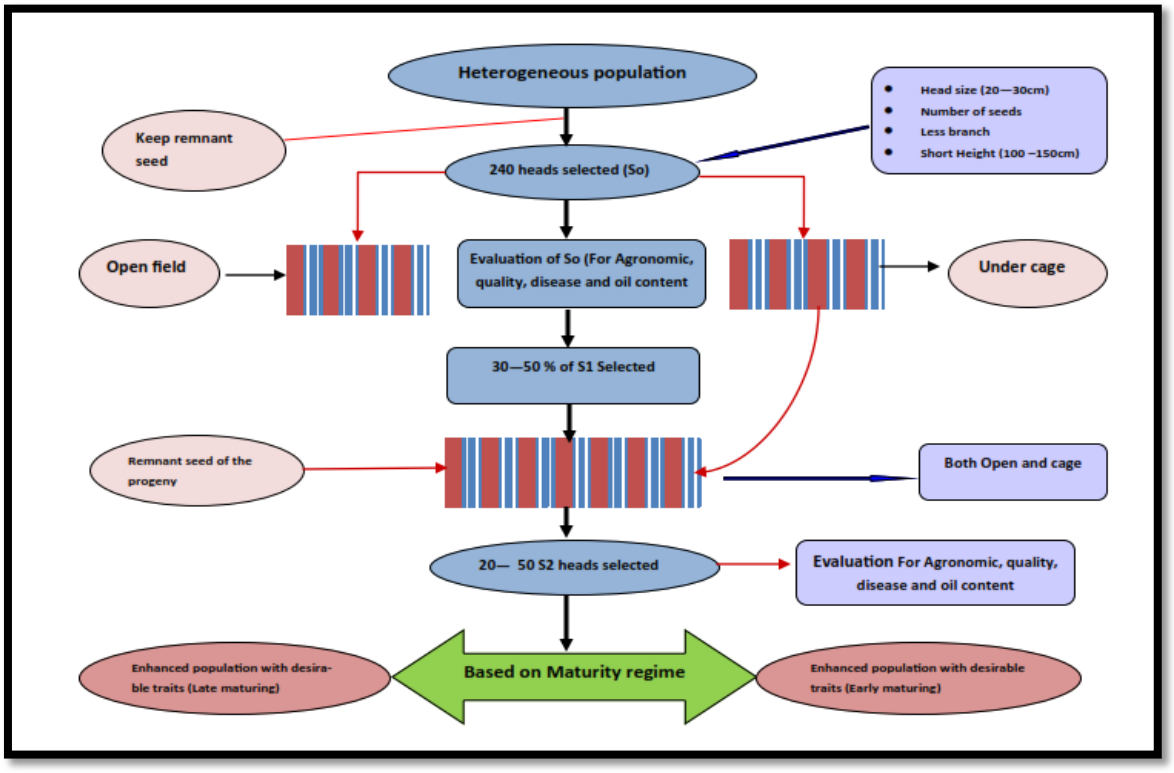


Fig. 4. Diagrammatical representation of head to row selection in sunflower.

Selection from heterogeneous population started by selecting of lines with big head size (20-30 cm), shorter and moderate height, less branch. These lines were evaluated both under cage and field condition to protect contamination from bees and to evaluate the genotypes under natural condition, respectively.

The selection of sunflower lines classified based on maturity regime (early and late/medium maturing) and three cycle of selection was made till uniform sunflower population to be obtained. From the first head to row

selection conducted (2012/13 till 2016/15), 10 sunflower populations were selected and promoted to national variety trial for the year 2015/16. The oilseeds research team expected at least one OPV varieties from these materials. In other cycle head to row selection conducted for three years from 2014/15 to 2016/17 eight promising lines were promoted to national variety trial for the year 2018/19. In the other cycle conducted from 2016/17 to 2019 36 promising lines promoted to preliminary variety trial. In the near future OPV varieties with better seed yield, uniform, high oil content with desirable agronomic performance and disease resistance will be released for production.

## IV. Crop Management and Recommendations

Limited agronomic and crop protection research conducted in sunflower. Some of such research limited to specific locations such as Debrezeit and Hawassa. Summary of some recommendations generated during previous studies are discussed here under.

Planting sunflower from early-to late-June at inter- and intra-row spacing of 75 and 25 cm resulted in a higher seed yield. Fertilizer application did not have significant effect on sunflower yield. Assessments on yield losses from weed competition indicated that one hand weeding at 25 days after emergence is enough to reduce full-season weed competition effect of 58% yield loss to economically negligible level. This experiment was carried out at two locations Adadi and Holetta research stations for two successive years (From 2017 to 2018 ) to study the fertilizer requirement of sun flower varieties at the study locations. Based on both statistical analysis and partial budget analysis, application of 34.5 kg N/ha and 34.5 kg $P_2O_5$ /ha fertilizer rate can be recommended for sunflower varieties.

In Ethiopia, downy mildew, sclerotinia head and stem rot, leaf spot and rust were identified as important diseases of sunflower. Higher incidence of downy mildew was noted with excessive delays in sowing dates beyond the established-optimum for a particular region. The disease can be controlled by dressing the seeds of sunflower with metalaxyl at the rate of 120 g a.i per 100 kg of seed. Sclerotinia causes tremendous yield losses as noted in the state farms. Despite limited research on the sunflower diseases, crop rotations with sufficiently long enough periods are perceived to be better preventive measure. Surveys made in the South and South Eastern parts of the country enabled to identify more than 28 species of insect pests on sunflower.

## V. Quality Analysis of Sunflower Varieties

So far the only quality parameters analyzed for sunflower was oil content. Recently, it was possible to analyze fatty acid and proximate analysis of sunflower in collaboration with Agricultural Laboratories and Nutrition Research Department of HARC. The proximate and fatty acid profile of the old variety Russian black and Oissa is presented in Table 4 below. According to the proximate analysis, the variety Russian black contained more fat and protein relative to Oissa (Kefale B. and Sisay A., 2017).

Table 4. Proximate and fatty acid profile of sunflower varieties.

| Types of Analysis | Parameter | Name of Varieties | |
|---|---|---|---|
| | | Oissa | Russian Black |
| Proximate analysis | Fat | 20.5% ± 0.07 | 23.9 ± 0.00 |
| | Protein | 14.9 ± 0.01 | 16.5 ± 0.14 |

| Types of Analysis | Parameter | Name of Varieties | |
|---|---|---|---|
| | | Oissa | Russian Black |
| | Moisture | 4.4 ± 0.01 | 3.9 ± 0.01 |
| | Ash | 3.6 ± 0.07 | 2.4 ± 0.07 |
| Fatty acid profile | Palmitic acid (C:16:0) | 6.8 ± 0.01 | 6.6 ± 0.07 |
| | Stearic acid (18:0) | - | 4 ± 0.07 |
| | Oleic acid (18:1) | 31.9 ± 0.07 | 56.9 ± 0.00 |
| | Linoleic acid (18:2) | 54.3 ± 0.01 | 32.2 ± 0.00 |
| | Margaric acid (17:0) | 6.7 ± 0.07- | 1.8 ± 0.01 |

Fatty acid profile is the major parameter for oil quality from health and nutritional point of view. In general, saturated fatty acids with the exception of stearic acid have hypercholestromic effect and should be reduced in edible oil (Mensink et.al., 1994). Although polyunsaturated fatty acids such as linoleic and linolenic acid are essential fatty acids useful for our body to reduce serum cholesterol and other health benefit, they might be harmful in causing tissue injury or aging due to their susceptibility of autoxidation (Shahidi, 1996). Thus, oilseeds with high oleic acid are preferred due to their oxidative stability and avoid the above complications. Therefore besides its late maturing and low uniformity Russian black produced high oleic acid which is the most desirable quality for oil and the future quality breeding of sunflower targeted to increase its oleic acid by using Russian black and other genotypes as a source material.

## VI. Future Prospects

Sunflower production area coverage is very small in Ethiopia and popularization of the crop is rare. The growing interest of the crop, however, is increasing by private farmers as well as some small scale farmers due to the demand of the crops for oil mill factories. Nowadays, consumers especially higher and middle classes prefer to use introduced sunflower oil despite its price is relatively high with palm oil. This indicates that production of sunflower will be profitable as we produced the seed and oil locally. In another words, the country can save foreign currency through import substitution. In addition to oil, there is a possibility to grow confectionary sunflower seed for food and utilizing its stem for fuel. Despite its diverse relevance of the crop, the available technologies of sunflower are very limited and thus the improvement of sunflower should proceed at the same pace with its demand. Enhancement of the existing germplasm through recurrent selection, hybridization and introductions is necessary for the improvement effort of the crop. The current effort of developing high yielding open-pollinated varieties should be strengthen including other quality parameters such as improvement of oil content and oleic acid. In the near future the oilseeds team of HARC is planned to develop hybrid varieties and the use of modern tools of plant breeding with the hope that all necessary conditions such as trained man power and facilities provided or availed for the research.

## Acknowledgements

The authors acknowledge collaborative research centers in management of national and adaption trials. We appreciate research technicians of HARC in handling and managing the trials. We would like to also acknowledge private companies such as Pioneer Hi-breed seed Ethiopia, Minerva PLC, General Chemicals and

Trading Company, Red Speckled Global Trading PLC, Vibha Seeds, India and Ashiraf Agricultural and Industrial PLC in supplying seeds and financing the hybrid adaption trials.

*Conflict of Interest:*

The authors declare there is no potential conflict of interest.

## REFERENCES

[1] Alagawany M, Farag MR, Abdi EI-Hack ME, Dhama K. 2015. The practical application of sunflower in poultary njutration. Adv, Anim. Vet. Sci. 3:634-648.
[2] Bashir T., Mashwani ZR, ZaharaiK, Haider S, Mudrikah TS (2015) Chemistry, pharmacology and ethnomedicinal uses of Helianthus annuus (sunfower): a review.Pure Appl Biol 4(2):226–235
[3] Central Statistical Authority (CSA), the Federal Democratic Republic of Ethiopia. Agricultural Sample Surveys Report on area and production of Major crops for *Meher* season crops from the year 2008/09 to 2018/19.
[4] Damodaram, T. and Hegde, D.M., 2010. Oilseeds situation, a statistical compendium, Directorate of Oilseed Research Hydrabad.
[5] Fowler MW (2006) Plants, medicines and man. J.Sci. Food Agric. 86(12):1797–1804.
[6] Heiser, C.B. 1978. Taxonomy of Helianthus and origin of domesticated sunflower. In: *Sunflower Science and Technology*, J.F. Carter (Ed.), Agronomy Monograoh 19, ASA-CSSA-SSsA, Madison, WI, USA, pp. 31-53.
[7] Kaleem, S., Hassan, F.-u., Ahmad, M., Mahmood, I., Wasaya, A., Randhawa, M.A., Khaliq, P., 2011a. Effect of growing degree days on autumn planted sunflower. African Journal of Biotechnology 10: 8840–8846.
[8] Kefale Biyadg and Sisay Aleminesh, 2017. Evaluation of basic quality parameters with in sunflower and saff flower varieties from Holeta, Ethiopia. MOJ Bioorganic & Organic Chemistry. 1(2), 50–52. DOI: 10.15406/mojboc.2017.01.00010
[9] Mensik R.P., Temme E.H.M., Hornstra G. 1994. Dietry saturated and trans fatty acids and lipoprotein metabolism. *Annals of Medicine* 56:461-464.
[10] Minsitry of Agriculture and Natural Resource. 2015. Plant Variety Release. Protection and Seed Quality Control Directorate, Bulleting No. 15.
[11] Putt, E.D. 1997 Sunflower early history. In: A.A. Schneiter (Ed.), Sunflower Production and Technology. Agronomy Monograph 35. ASA-CSSA-SSSA, Madison, WI, USA, pp. 1–21.
[12] Seiler GJ and Jan CC (2010). Basic sunflower information. In: Hu J, Seiler G, and Kole C (eds.) Genetics, Genomics, and Breeding of Sunflower, pp. 1–50. Enfield, NH: Science Publishers Chapter 1, 335 pp.
[13] Shahidi F. 1996. Natural anti-oxidant. An overview. Im: Natural antioxidant. Chemistry, Health effects and Applications, ed. F. Shahidi, Champaign, IL, USA: AOCS Press. pp. 1-11.
[14] Skoric D., Seiler GJ, Zhao L, Jan CC, Miller JF, and Charlet L (eds.) (2012) Sunflower Genetics and Breeding. Novi Sad, Serbia: Serbian Academy of Science and Arts, 520 pp.

## AUTHOR'S PROFILE

**First Author**
**Misteru Tesfaye W/Yohannes,** Male, Employment: Permanent Employ of Ethiopian Institute of Agricultural Research. Senior researcher and Oilseeds breeder at Ethiopian Institute of Agricultural Research. Education: MSc in Genetics from Addis Abeba University. Now PhD Fellow at SIDA AAU-SLU Project. Mobile:+251-911-319-994, Ethiopia.
email id: misterutm@gmail.com

**Second Author**
**Birhanu Mengistu Aboye,** Male, Employment: Permanent Employ of Ethiopian Institute of Agricultural Research. Researcher and Oilseeds Breeder Based at Holetta Agricultural Research Center and National High and Midland Oilseeds Research Program Coordinator in Ethiopia. Education: MSc. In plant Biotechnology. Mobile: +251-967-00-90-44, Ethiopia. email id: yesilase07@gmail.com