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Performance Evaluation of Sunflower (Helianthus annuus) Varieties under Irrigation Condition in Land Areas of South Omo Zone, South Ethiopia

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Abstract Sunflower (Helianthus annuus L.) is the most important oilseed crop in the world together with oil palm, soybean, and rapeseed. However, in south Omo Zone areas, the yield of this crop is limited mainly due to a lack of evaluated improved sunflower varieties. This field experiment was conducted during the 2021/22 and 2022/23 main cropping seasons to evaluate and recommend high-yielder sunflower varieties for yield production at Bena-Tesiemay and Selamago Districts in South Omo Zone. The experiment involves three improved varieties (Russian Black, Oissa, and Ayehu) and localcultivars. The experiment was conducted in a randomized complete block design with four replications. The varieties were planted in rows with 4 m width and 4m length (16m2) along five rows per plot, 75cm between rows and 25cm between plants.The basic important data were collected on plant height, head diameter, head per plant, primary branches per plant, grain yield, thousand seed weight, and days to maturity, and the collected data were analyzed using SAS software. The combined analysis of variance was done after a homogeneity test for yield and yield-related traits for locations. From the evaluated varieties, the maximum grain yield was recorded from varieties, Russian Black (2110.8kg ha-1) and Oissa (1861.8 kg ha-1) while the minimum combined mean grain yield was recorded for local variety (1290.4kg ha-1). It could be concluded that varieties Russian Black (2110.8kg ha-1) and Oisa (1861.8 kg ha-1) can be demonstrated and popularized as well as important for the target area and similar agroecologies.

Keywords Grain yield, location, Sunflower, varieties

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1. Introduction

Sunflower (Helianthus annuus L.) is one of the most important oil seed crops in the world (Bakht et al., 2010). It is a widespread oilseed crop of the world and it is almost grown in all continents. America, Australia, and Europe produce up to 80% of the total production of the world while, Asia produces up to 18% and Africa produces the rest 2% (Damodaran and Hege, 2010). The domesticated and introduced sunflower variety was moved from America into Europe in the 16 (sixteenth) centuries by the Spanish explorers at the early and was utilized as a garden ornamental. Some evidence shows that the crop was introduced to the North Horn of Africa including Ethiopia by the Italians some 160 years ago (Putt, 1977). It is the most important oil crop and is used as a source of edible oil in our world including Ethiopia and other countries. Besides its primary advantage in human consumption, its oil can be used as a supplement in the industry chemical as well as in the medicinal industry. Sunflower meal, a side product (byproduct), and the oil is rich in protein and it is utilized when blended with a meal of soybean for use in livestock feeding (Seiler and Jan 2010). Its oil is also a rich source of linoleic acid (up to 64%), which helps in washing out cholesterol deposition in the coronary arteries of the heart and is good for heart disease (MOANR, 2016). Sunflower is categorized as a low to medium drought-sensitive crop (drought tolerance). The drought-tolerant nature can be attributed to its extensive root system, which can extract water and nutrients to a depth of 3m. Sunflower is grown in many semi-arid regions of the world. It is tolerant of both low and high temperatures but more tolerant to low temperatures (Demirer et al., 2004). Optimum temperatures for growing were from 21.3 to 26°c, but a wider range of temperatures (18 to 35°c) showed little effect on productivity. The crop is grown on land coverage of 6,738.00 ha in Ethiopia and the production was about 7,953.72 tons produced in the year 2017 and the average regional per hectare yield of 1.18t ha-1 (CSA, 2017).

However, in Ethiopia, the grain yield is low in the attainable yield (2.5 to 3.5 t ha-1) under good management conditions at farmers' fields (MOANR, 2016). The yield reduction of sunflower is attributed to different production problems these includes lack of improved varieties, diseases and insect pests, poor crop management practices, and other factors (Farahvash et al., 2011). Sunflower is becoming a high-potential crop in the South Ethiopia region and the South Omo Zone. Therefore, to increase the production and productivity of the crop in the target area, evaluating, recommending, and promoting high-yield varietiesis crucial work. So, this study is crucial to select and recommend the best high-yielding sunflower varieties for the area and small-scale holder pastoralists, agro-pastoralists, farmers, and privet inverters to produce this crop in the future which will support food security and income generation in their lives.

2. Methodology

2.1. Description of the study areas

The experiment was conducted in two Districts at Bena- Tesiemay and Selamgo District during the main cropping seasons from 2021 to 2022/23 under irrigation conditions. Bena-Tesiemay (Woyito) was located South Omo Zone in the South Ethiopia Regional State. It is situated between 5°01' and 5°73' North latitude & 36°38' and 37°07' East longitude with an altitude of 588 meters above sea level. The rainfall distribution of the area is bimodal with the main rainy season extending from January to May and the second cropping season, from July to October. It receives annual average rainfall of 876.3 mm and the monthly average minimum and maximum temperatures of 18.2 and 37.3°C, respectively. Selamago District was located South Omo Zone in the South Ethiopia Regional State. It is situated between 5°32′–6°46′ N and 35°89′–36°45′ E with an altitude of 565 meters above sea level. The rainfall distribution of the area is bimodal, with a primary rainy season between April to June and a secondary small rain between August and September to October. The monthly minimum and maximum temperatures of 24.4 and 37.8°C, respectively

2.2. Experimental Design and Treatments

The experiment involves (includes) three improved varieties (Russian Black, Oissa, Ayehu), and one local cultivar was used for this experimental study. The experiment was conducted using a randomized complete block design (RCBD) with four replications. The varieties were planted in rows with 4 m width and 4m length (16m2) along five rows per plot, 75cm between rows and 25cm between plants. Important agronomic practices were applied equally to all the treatments at their proper time of application.

2.3. Data Collection

The most important growth, yield, and yield-related traits such as days to maturity, plant height, head diameter, head per plant, productive primary branches per plant, grain yield, and thousand seed weights were collected.

2.4. Data analysis

The collected data were subjected to analysis of variance in a randomized complete block design (RCBD) using SAS software version 9.2 (SAS, 2008) with a generalized linear model (GLM) procedure. Means were separated using the least significant differences (LSD) test at a 5% level of significance. The homogeneity of error mean square between the two sites was tested by the F-test on variance ratio.

3. Results and Discussions

3.1. Analysis of variance (ANOVA)

The Combined analysis of variance for both locations was carried out after the homogeneity of error variances was tested and all of the traits showed homogeneous error variances (Table 3). Knowing this result, a combined analysis of variance was done and presented in Table 3. The mean squares obtained in a combined analysis of variance were used to separate varieties' effects, locations, and interactions. The mean squares from the combined analysis of variance over the two locations for varieties showed statistically significant ($P \leq 0.05$) for days to maturity, productive primary branches per plant, number of heads per plant, head diameter, and grain yield. While none is significant for plant height and thousand seed weight (Table 3). The mean squares from the combined analysis of variance over the two locations for locations showed statistically significant ($P \leq 0.05$) for plant height, grain yield, and thousand seed weight, while no significance for days to maturity, productive primary branches per plant, head per plant, and head diameter. Main effects of varieties and location as well as their interactions had a significant effect on head per plant and thousand seed weight and none significantly ($P>0.05$) effects on days to physiological maturity, plant height productive primary branches per plant head diameter, and grain yield.

The presence of significant differences among the tested varieties might be due to the existence of dissimilarity in genetic composition among them, for that fact, characters may be differ in their genetic properties. Besides, environmental influences might be the possible causes of their significant differences or both. This research finding result was similar to the research finding of Awoke and Anteneh (2022) who reported that there were presences of significant differences among the evaluated sunflower varieties.

3.2. The mean performance of Growth, Yield, and yield components

3.2.1. Growth parameters

The combined analysis of variance as shown in Table 3, indicates the main effects of varieties and location as well as their interactions had no significant ($P>0.05$) effects on days to maturity, plant height, productive primary branches per plant, head diameter and grain yield. However, the main effects of varieties and location as well as their interactions had significant ($P <0.05$) on the number of heads per plant and thousand seed weight. Days to maturity: The analysis of variance as shown in Table 3, indicates the main effects of varieties had a significant effect and locations had no significant effect while location and variety and their interactions had no significant ($P >0.05$) effects on the days of maturity duration. From the evaluated varieties the combined mean performance on days to maturity was statistically significant but numerically they have no significant difference to physiological maturity. Plant height: The analysis of variance as shown in Table 3 indicates the main effects of varieties had no significant effect and location had a significant effect while location and variety interactions had no significant ($P >0.05$) effects on the plant height length. From the combined mean value, Russian black had the tallest plant height (216.67 cm) and Oissa had the shortest height (193.10cm). This result was similar to the research finding of Awoke and Anteneh (2022) who reported that the main effects of varieties and location as well as their interactions had no significant ($P>0.05$) effects on days to physiological maturity and plant height.

3.2.2. Yield and yield components

Number of productive primary branches per plant: The analysis of variance as shown in Table 3, indicates the main effects of varieties had significant effects and locations had no significant effect while locations and varieties and their interactions had no significant ($P >0.05$) effects on the number of productive primary branches per plant (Table

3). From the combined mean value, the maximum number of productive primary branches per plant was recorded for the local cultivar (12.75) and the improved varieties had only a mother plant (having no branches) they have no productive primary branches (Table 4). Number of heads per plant: The analysis of variance as shown in Table 3, indicates the main effects of varieties and locations as well as their interactions had significant (P <0.05) effects on heads per plant (Table 3). From the combined mean value, the maximum number of heads per plant was recorded for the local cultivar (12.85) (Table 4). Head diameter (cm): In this study, the analysis of variance showed that the main effects of varieties and location as well as their interactions had no significant (P >0.05) effects on head diameter (Table 3). From the combined mean result improved varieties had statistically similar head diameters, the longest diameter was recorded for Oissa variety (23.72 cm) and the local cultivar had the shortest head diameter (19.05 cm) (Table 4). This result was in agreement withthe research findings of Awoke and Anteneh (2022) who reported that Oissa variety had a maximum head diameter at the Woito and Dasench locations also similar results research reported by Eman (2015) who found a significant difference among sunflower varieties. Grain yield (kg ha-1) Results combined analysis of variance of the current research study showed the main effects of varieties and locations had significant (P<0.05) effect while their interactions had no significant effects on grain yield. The maximum grain yield (2110.8kg ha-1) and (1861.8 kg ha-1) were recorded for the Russian Black and Oissavarieties, respectively and the lowest grain yield (1290.4 kg ha-1) was recorded for the local cultivar. Significant differences among the evaluated varieties might be due to the existence of dissimilarity in genetic composition among them, for that case, variety characters may be differ in their genetic properties from variety to variety. Moreover, environmental influences and weather conditions might be the possible causes of their significant differences to the varieties. This current work was similar result with the research result finding of Awoke and Anteneh (2022) who reported that Russian Black and Oissa varieties had a maximum grain yield than local cultivars. Similarly, this research finding results agree with the research finding of Eman (2015) who observed and reported a significant difference among sunflower varieties. Similarly, Milan et al. (2019) who studied and reported on evaluated sunflower varieties found that, a significant difference in grain yield of different sunflower varieties tested in different locations. The weight of thousand seeds (g): analysis of variance showed that the main effects of varieties had no significant effect and locations had a significant effect while varieties and locations, as well as their interaction, had a significant (P<0.05) effects on thousand seeds weights but there was no statistically different among tested varieties on the weight of thousand seeds. The maximum thousand seed weight (62.43g) was recorded for the Russian Black variety and the minimum thousand seed weight (53.90) was recorded for the local cultivar (Table 4).

This research result is in line with the research finding result of Natalija et al, (2015) who obtained minimum and maximum values for thousand seed weight on different sunflower varieties, and a similar finding was reported by Awoke and Anteneh (2022) who reported that Russian Black and Oissa varieties had maximum thousand seeds weight yield than local cultivar.

4. Conclusion and Recommendation

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 and in the target areas this was mainly due to shortage of improved varieties. This field experiment was conducted to evaluate and recommend sunflower varieties for grain yield production at Benna- –Tesiemay and Selamago District in South Omo Zone, South Ethiopia. The experiment contains three improved varieties namely Russian

Black, Oissa, Ahyehu, and local cultivars. This research experiment was in a randomized complete block design with four replications. Important data were collected on days to maturity, plant height, head per plant, productive primary branches per plant, head diameter, grain yield, and thousand seed weight and the collected data were subjected to analysis of variance using the SAS software program. From the combined results of this research study, the maximum grain yield (2110.8kg ha-1) and (1861.8 kg ha-1) were recorded for Russian Black and Oissa varieties, respectively and the lowest grain yield (1290.4 kg ha-1) was recorded for local cultivar respectively. Therefore, it can be concluded that the variety of Russian Black followed by the Oissa variety is well performed and could be recommended for the pastoralists, agro-pastoralists, farmers, and private investors growers in the study areas and similar agro-ecologies.

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Appendix:

Table1 The mean value of growth, yield, and yield-related traits in Benna- Tsemay District in 2021/22

Varieties	DM	PH (cm)	PB	HD (cm)	H/P	YD (kg/ha)	TSW (g)
Ayehu	102^{ab}	202.25	0^{b}	24.25^{a}	0^{b}	1571.6^{c}	47.17^{a}
Oissa	106^{a}	188.25	0^{b}	22.9^{ab}	0^{b}	1841.5^{b}	51.87^{a}
R.balack	105^{ab}	210.75	0^{b}	23.35^{a}	0^{b}	2001.3^{a}	49.87^{a}
Local	103^{b}	190.65	12.0^{a}	19.6^{b}	12^{a}	1205.5^{d}	29.55^{b}
CV (%)	2	8.1	7	10.4	3.5	5.92	14.82
LSD 5%	3.65	NS	2.79	3.74	2.39	156.69	10.576

Note: Means with the same letters within the columns are not significantly different at p<0.05. DM =days to maturity, PH =plant height, PB= Primary branches, HD= head diameter, H/P number of head per plant, GY =Grain yield, TSW =Thousand seed weight, Variety = Variety and Ns = none significance

Table 2. The mean value of growth, yield, and yield-related traits in Selamago District in 2022/23

Varieties	DM	PH (cm)	PB	HD (cm)	H/P	YD (kg/ha)	TSW (g)
Ayehu	108.50^{b}	222.90	0^{b}	24.20	1.60^{b}	1726.7^{b}	63.00
Oissa	107.00^{b}	197.95	0^{b}	24.55	1.00^{a}	1882.0^{b}	69.63
R.balack	109.75^{b}	222.60	0^{b}	24.0	1.00^{b}	2220.4^{a}	75.00
Local	123.75^{a}	221.55	13^{a}	18.50	11.70^{a}	1375.32^{c}	78.25
CV (%)	4.47	11.95	5.09	17.59	28.84	7.92	12.74
LSD 5%	8.03	Ns	3.57	Ns	41.33	170.65	Ns

Note: Means with the same letters within the columns are not significantly different at p<0.05. DM =days to maturity, PH =plant height, PB= Primary branches, HD= head diameter, H/P number of head per plant, GY =Grain yield, TSW =Thousand seed weight, Trt = treatment and ns = none significance

Table 3. Mean square values of traits of sunflower varieties over location during 2021/22 and 2022/23

SV	DF	DM	PH	PB/P	H/P	HD	GY	TSW
Rep	3	19.66 ^{ns}	550.31^{ns}	1.46^{ns}	0.695^{ns} 0.695 0.695 0.695 0.695	3.34^{ns}	8390^{ns}	31.53^{ns}
loc	1	1.26^{ns}	2671.80 *	1.12^{ns}	1.44ns	0.72^{ns}	170833*	5768.72*
Variety	3	19.91*	849.75^{ns}	321.00 *	276.28*	47.190*	965689*	140.19^{ns}
Var*Loc	3	4.25^{ns}	186.56^{ns}	0.458^{ns}	3.28*	2.71^{ns}	11411^{ns}	456.35*
Mean square of Errors (MES)								
BenaTesmay	-	5.2222	257.40	3.056	2.247	5.4944	9595	43.718
Selamgo	-	6.83333	667.596	5.007	1.217	6.1256	11381	64.077
F= max	-	1.3 ^{ns}	2.6 ^{ns}	1.64 ^{ns}	1.85 ^{ns}	1.11 ^{ns}	1.18 ^{ns}	1.47 ^{ns}

Note: DM =days to maturity, PH =plant height, PB= Primary branches, HD= head diameter, H/P number of head per plant, GY =Grain yield, TSW =Thousand seed weight, Var= varieties, SV= source of variance, Loc= location, *= significance and ns = none significance

Table 4. The combined mean value of growth, yield, and yield-related traits in Bena-Tesemay and Selamago District

Varieties	DM	PH (cm)	PB	HD (cm)	H/P	YD (kg/ha)	TSW(g)
Ayehu	102.62^{b}	212.58^{ab}	0.25^{b}	24.22^{a}	1.30^{b}	1649.1^{c}	55.08
Oissa	106.13^{a} A	193.10^{b}	0.00^{b}	23.72^{a}	1.00^{b}	1861.8^{b}	60.75
R.balack	104.25^{ab}	216.67^{a}	0.00^{b}	23.70^{a}	1.0^{b}	2110.8^{a}	62.43
Local	103.00^{b}	206.10^{ab}	12.75^{a}	19.05^{b}	12.85^{a}	1290.4^{d}	53.90
CV (%)	2.19	10.68	3.71	14.96	3.75	5.62	20.63
LSD 5%	2.31	21.93	3.57	3.32	41.33	101.57	NS

Note: Means with the same letters within the columns are not significantly different at p<0.05. DM =days to maturity, PH =plant height, PB= Primary branches, HD= head diameter, H/P number of head per plant, GY =Grain yield, TSW =Thousand seed weight, Trt = treatment and ns = none significance

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