Ethiop. J. Agric. Sci. 33(3) 19-28 (2023)

Performance of Andinet Soybean [*Glycine max* (L.) Merrill] Variety

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Abstract

Several soybean genotypes that have been introduced in 2015 from the Institute of International Tropical Agriculture (IITA), Nigeria, by the Pawe Agricultural Research Center of the Ethiopian Institute of Agricultural Research were evaluated for yield and other desirable agronomic traits, aiming to identify genotypes that have better yields than the existing varieties cultivated in the country. The combined mean square of genotype plus genotype × environment interaction (GEI) analysis showed highly significant ($P < 0.01$) difference for grain yield among the tested genotypes. Genotype Tgx-1989-75F has showed best performance for grain yield, hundred seed weight, number of branches per plant and number of seed per pod based on the combined mean results. In addition, the genotype exceeded the standard check (Pawe-03) and local check (Gishama) varieties by 35.6% and 19.7%, respectively. And also, it has showed additional merits such as; resistance to frog eye leaf spot and tolerance to bacterial blight, brown leaf spot, red leaf blotch, and rust, and has been shown to be stable across test locations and seasons. Genotype Tgx-1989-75F has released as a variety with name "Andinet" and can be widely used for commercial farming in Pawe, Asosa, Bako, Sirinka, Areka, Jimma, Gonder, and similar areas, resulting in increased revenue for smallholder farmers.

Keywords: Andinet, Genotypes, Soybean, Stable, Standard check, Variety

Introduction

Soybean [*Glycine max* (L.) Merrill] is a multipurpose crop that can be used for a variety of purposes, including the preparation of different kinds of foods and animal feed, alleviating malnutrition, improving soil fertility status, and as a raw material for the processing industry. Ethiopia has a huge potential for soybean production and the crop has been found to be the best crop for intercropping with maize and sorghum, as well as rotational crops in irrigated production environments with cotton and wheat. In addition to its economic advantage, the crop has a significant contribution to sustainable crop production by replenishing soil fertility (Hailegiorgis, 2010; FAO, 2020).

In Ethiopia, soybean is well adapted to the lowland to mid-altitude agro-ecologies of the country (Fentahun, 2019). During the 2020-2021 cropping season, soybean

was produced on 108,665.6 hectares of land, and the national average productivity was 2.5 tons ha^{-1} (Central Statistics Agency, 2021). Soybean is grown predominantly by smallholder farmers and has shown an increasing trend to be grown by medium-scale and commercial farmers because of the growing demand from the industry. In the past twelve years, the total area under soybean production has increased from 5,679 to 108,665.6 hectares of land, and the total volume of production during the same period has increased from 7205 to 208,676 tons, and productivity has increased from 1.3 to 2.5 tons ha^{-1} (Central Statistics Agency, 2021).

However, the average productivity of the crop is lower than the world average, which is greater than 3 tons ha^{-1} (USDA, 2020), due to biotic and abiotic stresses (Mulugeta Atnaf *et al*., 2015), lack of diversified soybean materials, and reduction of the genetic potential of released varieties (Mesfin Hailemariam and Abush Tesfaye, 2018). Therefore, the Pawe Agriculture Research Center has strived to develop varieties with higher yield, disease resistance, high seed oil content, and other desirable agronomic traits than the previously released varieties to increase crop production and productivity in the country. Though, several soybean genotypes have been introduced in 2015 from the Institute of International Tropical Agriculture (IITA), Nigeria, by the Pawe Agricultural Research Center of the Ethiopian Institute of Agricultural Research and tested for their disease rection, quality and yield performances through successive trial stages, about fourteen of them were selected and passed for further two consecutive years national variety trail with the aim of identifying genotypes that have better yields than the existing varieties and cultivars cultivated in the country. Therefore, genotype Tgx-1989-75F has showed superior performance in disease resistance, grain yield and quality traits than the checks (standard check variety Pawe-03 and the local check variety Gishama) (Table 5 & 6) and, hence, has released as a variety with name "Andinet" and it is under production in its suitable agro-ecological areas of Pawe, Asossa, Bako, Sirinka, Areka, Jimma, Gonder, and similar areas.

Materials and Methods

Experimental materials and test locations

Only fourteen soybean genotypes (Table 1) have advanced to variety verification trial based on their grain yield and other quality (oil and protein parameter) after two consecutive years (2016-2017) of national variety trial at five testing locations (Pawe, Asosa, Bako, Areka, and Sirinka) across the country.

Table 1. Number of tested Soybean genotypes and their code for graphical representation

No.	Genotype	Gen.code	No	Genotype	Gen.code
1	TGX 1989-11F	G1	10	TGX 1990-114F	G10
2	TGX 1989-42F	G2	11	TGX 1990-87F	G11
3	TGX 1989-45F	G3	12	TGX 1990-80F	G12
4	TGX 1989-53F	G4	13	TGX 1990-95F	G13
5	TGX 1989-75F	G5	14	TGX 1993-4F	G14
6	TGX 1990-106F	G6	15	Pawe-03 (st. check)	G15
7	TGX 1990-107F	G7	16	Gishama (loc. check)	G16
8	TGX 1990-110F	G8			
9	TGX 1990-111F	G9			

Where, No. = Number and Gen.code = Genotype code, st. check = standard check and loc. check = local check.

Data collection

Days to 50% flowering, days to 95% maturity, protein content (%), oil content (%), grain yield (kg) were recorded on plot bases. The grain yield per plot was measured from the middle two rows and converted to hectare bases. All other parameters were recorded on plant basis by taking ten plants randomly from each experimental plot according to Malek *et al*. (2014). However, main yield contributor traits (number of seed per plant, hundred seed weight) and grain yield data were considered for this paper analysis and interpretation.

Analysis of Variance

The mean squares for genotype and genotype × environment interaction (GEI) was highly significant ($P < 0.01$) in the analysis of variance for grain yield of the tested soybean genotypes (Table 2). This revealed that the GEI resulted in various yield ranks for the cultivars (Kang, 2002). In such cases, a cross-environment evaluation of varieties for mean yield and stability is required to select varieties that perform consistently well under all conditions or to identify particular varieties for each environment (Gauch, 2006).

Table 2. The analyses of variance of grain yield of 16 soybean genotypes tested at the five locations

Source	DF	Variance explained (%)	Mean squares
Environment	4	77.45	20610239.47
Genotype	15	7.03	2487140.5***
G*EI	63	15.47	208222.9**

Where, G*EI = Genotype by Environment Interaction and DF = Degrees of freedom.

Results and Discussion

Grain yield and yield related agronomic trait performances

The combined mean yield and agronomic traits performances of 16 Soybean genotypes tested in five environments are presented in Table 3. Genotype 5 (TGX 1989-75F) showed the highest grain yield and medium to late days to maturity comparable to genotype 8 (TGX 1990-110Fn), which showed medium grain size. This indicates that, the released variety, "Andinet", showed best performance in terms of grain yield, hundred seed weight, number of branches and seed per pod based on the combined mean results.

Variety "Andinet" outperformed the local and standard checks of Gishama and Pawe-03 in both seasons, with grain yield of 2276.7, 1951.9, and 1698.3 kgha^{-1}, respectively (Table 4). The Andinet variety exceeded the standard and local checks by 35.6% and 19.7%, respectively (Table 5). The observed yield advantage of the new variety over the checks was quite high, indicating a successful attempt in the country's variety yield enhancement breeding program.

Table 3. The combined mean yield and agronomic traits performances of 16 Soybean (genotypes and checks) at 5 locations in 2016-2017

No.	Genotypes	DF 50%	DM 95%	NSPP	HSW (g)	AdjYld (kgha^{-1})
1	TGX 1989-11F	64.8	122.2	2.4	12.9	1741.8
2	TGX 1989-42F	63.6	122.3	2.3	12.7	1808.3
3	TGX 1989-45F	61.9	121.6	2.4	12.7	1686.9
4	TGX 1989-53F	63.7	121.9	2.4	12.6	1746.7
5	TGX 1989-75F	62.8	122.5	2.4	13	2276.7
6	TGX 1990-106F	64.7	122.2	2.3	12.7	1686.2
7	TGX 1990-107F	64.2	122.8	2.3	13.3	1801
8	TGX 1990-110Fn	61.4	121.8	2.4	12.9	2188.2
9	TGX 1990-111F	64.5	121.4	2.4	12.7	1811.5
10	TGX 1990-114F	65.1	122.2	2.3	13	1742.6
11	TGX 1990-87F	62.4	122.6	2.4	13.1	1910.5
12	TGX 1990-80F	64.9	156.4	2.2	13.4	1620.3
13	TGX 1990-95F	67	122.3	2.3	12.6	1689.8
14	TGX 1993-4F	63.9	122.9	2.4	12.8	1726.6
15	Pawe-3	65	123	2.4	12.7	1698.3
16	Gishama	64.4	121.9	2.3	12.5	1951.9
	Mean	64	124.3	2.4	12.9	1817.9
	CV (%)	8.2	2.2	16	10	24
	LSD	2.7**	1.6**	0.2**	0.64**	226.2**

Where, DF 50%=50% Days to flowering, DM95%=95% Days to maturity, NSPP=Number of seeds per pod, HSW= hundred-seed weight in grams, AdjYld(kgha^{-1}) = Adjusted Yield per hectare in kilogram, CV (%) = coefficient of variation in percent (%)., and LSD= Least Significance Difference at 5% probability level.

Table 4. Mean grain yield (kgha^{-1}) performance of Soybean genotypes evaluated in the National Variety Trial across locations and over years (2016-2017)

		2016						2017						
No.	**Genotypes**	**Bako**	**Areka**	**Asosa**	**Pawe**	**Sirinka**	**Mean**	**Bako**	**Areka**	**Asosa**	**Pawe**	**Sirinka**	**Mean**	**Over all mean**
1	TGX 1989-11F	1760.8	1262.7	1550.9	1337.4	1913.4	1565	1372.3	1491.7	1393.1	2563.8	2771.5	1918.5	1741.8
2	TGX 1989-42F	1969.4	1312.5	1105.9	1590	1753.8	1546.3	1994.1	1618.4	1676.1	2830	2233.3	2070.4	1808.3
3	TGX 1989-45F	1810.7	1454	927	1035.9	1782.7	1402.1	1696.9	1661.4	1512.3	2545.3	2442.7	1971.7	1686.9
4	TGX 1989-53F	2076.7	1567.5	1582.1	980.6	1771.1	1595.6	1437.3	1588.5	1860.6	1981.3	2621.8	1897.9	1746.7
5	TGX 1989-75F	2374	2275.4	1605.7	2473.9	2403	2226.4	1958.1	2184.4	2415	2570.5	2506.7	2326.9	2276.7
6	TGX 1990-106F	1545.5	1391.2	1449.9	963.6	1727.1	1415.5	1148.1	2283	1289	2479.5	2585.3	1957	1686.2
7	TGX 1990-107F	1778	1682	1411.6	1441	1870.4	1636.6	1395.6	1748	1902.3	2320.2	2460.9	1965.4	1801
8	TGX 1990-110Fn	2142.6	1743.6	1961.5	1966.7	2497.3	2062.3	1475.4	1984.4	2371	2665	3074.7	2314.1	2188.2
9	TGX 1990-111F	1474	1320.4	1600.8	1231.3	2432.5	1611.8	1859.9	1689.2	1531.8	2314.4	2660.7	2011.2	1811.5
10	TGX 1990-114F	2008.9	1246.8	1388.5	1385.3	2050.8	1616	1630.4	1466.5	1055.1	2461.8	2732	1869.2	1742.6
11	TGX 1990-87F	1921	1858.2	1517.5	1486.2	1861.1	1728.8	2258.2	1565.8	1829	2319.2	2489.3	2092.3	1910.5
12	TGX 1990-80F	1688.4	1220.2	1326.2	1297.5	1646.4	1435.7	1564	1711	1058.1	1674.9	3016.7	1804.9	1620.3
13	TGX 1990-95F	1707.9	1396.2	1338.5	1486.2	2051.6	1596.1	2006.5	1084.7	1394.8	1839.9	2591.9	1783.6	1689.8
14	TGX 1993-4F	2009.5	1129.2	1341.1	1353.8	1646.8	1496.1	1713.5	1695.2	1328.4	2392.3	2655.7	1957	1726.6
15	Pawe-03	1626.4	1184.8	1346	1551.3	1785.3	1498.8	1455.4	1518.4	1710.3	2195.7	2609.1	1897.8	1698.3
16	Gishama	1928.4	1918.7	1650.4	1556.5	1925.2	1795.9	2637.9	1752.4	1572.5	2051.3	2525.4	2107.9	1951.9
	Grand mean	**1858.1**	**1489**	**1432.4**	**1446.2**	**1932.9**	**1631.7**	**1833.2**	**1683.3**	**1632**	**2317.7**	**2621.2**	**1997.7**	**1814.7**
	LSD	620*	800*	700*	978**	557**		700*	988*	870*	600**	657**		
	CV (%)	16	20.3	19.7	15.7	19		11.8	13	14.2	18	10.6		

Grain yield stability performance

The yield performance and yield stability of the evaluated soybean genotypes were visually represented using a GGE biplot (Figure 1). The Average Environment Coordination (AEC) abscissa is a straight line passing through the AEC with a biplot origin, and the AEC ordinate is a straight line passing through the origin and perpendicular biplot (Yan, 2002; Yan and Kang, 2003). Based on the AEC coordinates, the genotypes were split into two groups: below and above the average overall yield. Figure 1 displays how the four high-yielding soybean genotypes (G16, G15, G8, and G5) outperform the average yield. Genotype 5 (Tgx-1989-75F) provided the maximum yield and was suited to the three test areas of Ethiopia that are, Pawe, Asosa, and Sirinka, which could be cultivated in places up to 1650 m above sea level.

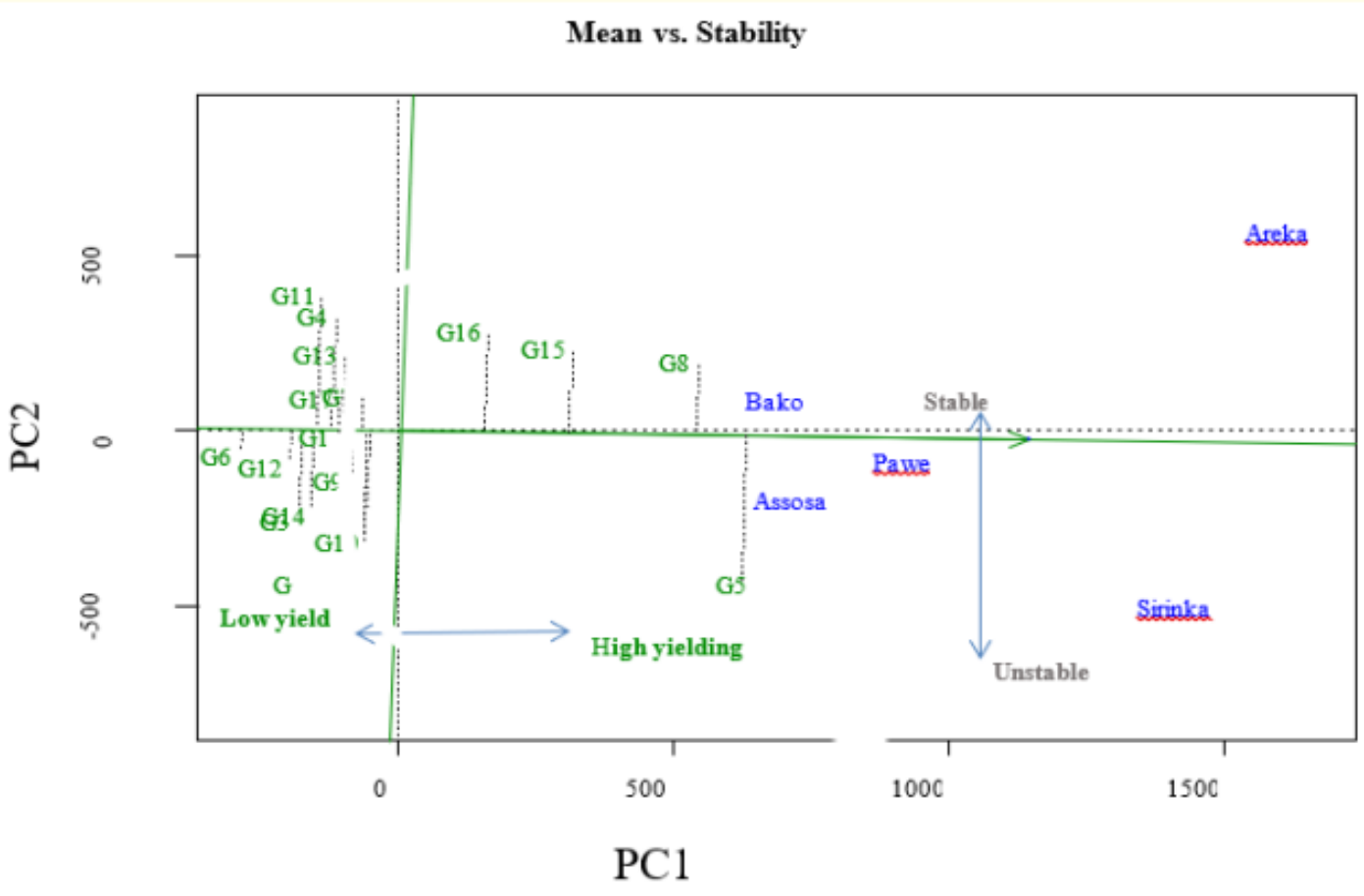

Figure 1: Average environment coordinate (AEC) of the GGE biplot. Where, GGE: Genotypes, Genotypes by Environment interaction, PC1: = the first Principal Components and PC2: = the second Principal components.

Table 5. The yield advantage (%) of the Andinet variety over the standard and local checks

		Yield (kgha^{-1})			Yield advantage (%) of candidate over checks	
Test year	No. of test loc	Candidate (Tgx -1989-75F)	St. check (Pawe-03)	Loc.check (Gishama)	St. check (Pawe-03)	Loc. check (Gishama)
2016	5	2226.4	1498.8	1795.9	48.55	23.97
2017	5	2326.9	1897.8	2014.9	22.61	15.48
Overall mean		2276.65	1698.3	1905.4	35.58	19.73

Table 6. Oil and protein contents of the Andinet variety and the checks

Oil content (%)			Protein content (%)		
Candidate (Tgx-1989-75F)	Standard check (Pawe-03)	Local check (Gishama)	Candidate (Tgx-1989-75F)	Standard check (Pawe-03)	Local check (Gishama)
23.5	23	20	35.4	-	31.4

Where, St. check= standard check and Loc. Check = local check

Table 7. Agronomical and Morphological characteristics

No.	Characteristics	Description	No.	Characteristics	Description
1	Adaptation area	Pawe, Asosa, Bako, Srinka, Areka, Jimma, Gonder and similar areas	19	Maturity group	Medium to late
			20	Branching ability (number)	High
2	Altitude (m.a.s.l.)	700-1860	21	Pod attachment(number)	High
3	Rainfall (mm)	500-1586	22	Oil content (%)	High
4	Seed rate (kgha^{-1})	60-70	23	Yield (kgha^{-1}) at:	
5	Fertilizer rate(kgha^{-1}) DAP	100		Research field	1960-2550
6	Spacing (cm) between:			Farmers field	1700-2300
	Row	60	24	Year of release	2019
	Plants	5	25	Maintainer	Pawe ARC
7	Date of Planting	3rd June-1st week of July			
8	Days to 50% flowering	62.8			
9	Days to 95% maturity	122			
10	Plant height(cm)	69.1			
11	Growth type	Semi-determinate			
12	Seed coat color	Yellow			
13	Helium color	Brown			
14	Pubescence color	Brown			
15	Flower color	Purple			
16	Hundred seed weight (g)	13			
17	Oil content (%)	23.5			
18	Protein content (%)	35.4			

Abbreviations: m.a.s. l = meter above sea level, mm= Mili meter, kgha^{-1} = kilogram per hectare, DAP = Di ammonium phosphate, cm = cent meter, g = gram,

Other merits and reactions to major disease

The Andinet variety can produce a high number of branches and pod attachments. Moreover, the variety is resistance to frog eye leaf spot and tolerance to bacterial blight, brown leaf spot, red leaf blotch, and rust.

Conclusion

The findings of this study have shown that in terms of seed production and seed oil content, the released Andinet variety is superior to the standard check (Pawe-03) and local check and (Gishama) varieties. The new variety has additional advantageous characteristics such as, resistance to frog eye leaf spot and tolerance to bacterial blight, brown leaf spot, red leaf blotch, and rust, and has shown to be stable across test locations and seasons. Finally, the newly released Andinet variety can be widely used for commercial farming in Pawe, Asosa, Bako, Sirinka, Areka, Jimma, Gonder, and similar areas, resulting in increased revenue for smallholder farmers.

Acknowledgements

The authors are grateful to the Ethiopian Institute of Agricultural Research for financial support. We would also like to thank the Pawe Agricultural Research Center for delivering all the necessary materials, starting from material screening up to the variety released. Finally, special thanks to all the collaborative research centers for their smooth and continuous participation in the performance evaluation trial and variety development.

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