Performance of Newly Released Early Maturing Soybean (*Glycine max* (L.) Merr.) Variety, 'Guda' in the Major Growing Agro-ecologies of Ethiopia

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Abstract

Soybean is an affordable and valuable source of protein, oil, and other important nutrients. The current national average yield is 2.49 t ha-1, which is low as compared to its potential due mainly to lack of varieties with wider adaptability to major agro-ecologies. Most of the released soybean varieties are medium to late maturity groups, and early maturing varieties are generally limited. Efforts have been underway to fill the gap through developing early maturing varieties. Jimma Research Center conducted a multi-location National Variety Trial (NVT) followed by a Variety Verification Trial (VVT) where candidate varieties were evaluated for release. Prior to release, the candidate was evaluated on a series of variety performance trails, including the NVT where 10 genotypes including the checks were tested in a randomized complete block design with four replications for two seasons across five locations. Combined data analysis revealed that the variety 'Guda' outperformed all the test genotypes including the checks. 'Guda' exhibited a 17 and 26% yield advantages over the recently released standard check, 'Gazelle' and the other check, 'Nova', respectively. In addition, the variety showed better tolerance to diseases. After a thorough evaluation of the NVT data and verification plots, the candidate genotype, HAR/PR142-15-SB, was officially released by the name "Guda" in the 2021 cropping season. Popularization of the new variety for farmers and fast inclusion of the new variety seed in the production system will play a significant role in increasing production and productivity of soybean in moisture deficit growing areas.

Keywords; - Soybean, early-maturing, performance trial, 'Guda', moisture stress

Introduction

The soybean is an important legume crop for food, feed, and soil fertility enhancement. Due to the seed composition of this crop, it is the most highly demanded crop at the global level. Seeds of soybeans contain 38-42 percent protein, and 18-20 percent oil, and are rich in essential amino acids and unsaturated fatty acids (Zhang *et al*., 2018). There is the potential for the crop to increase farmers' incomes and be used in various foods and feed

products as a protein source (Garrett *et al*., 2013). Soybean was first introduced to the Sub-Saharan Africa (SSA) in the 19th century (Khojely *et al*., 2018).

Production and utilization of soybean in Ethiopia is increasing since its introduction in the country. During the past seven years, soybean production have exponentially increased in terms of area of cultivation from about 31,854 ha and grain volume of 636,531 quintals in 2005/06 to 38,073 ha and 1,256,232 quintals in 2018/19 (CSA, 2005/06; CSA, 2018/19). In Ethiopia, soybean is gaining high importance in recent years. The current area under soybean cultivation is expected to increase in years to come due to the ever-increasing demand from domestic processing industries and export. Soybean productivity in Ethiopia average 2.49 metric tons per hectare (CSA, 2021), which is lower than the global average of 2.7 metric tons per hectare (FAO, 2021).One of the reasons for the low yield might be the lack of high-yielding varieties for specific agro-ecologies.

Since the inception of soybean research in Ethiopia, 36 soybean varieties have been developed and released for different agro-ecologies. However, most of the released varieties so far are medium to late-maturing groups. Although there are few early-maturing varieties like Nova and Williams, these varieties were found to give low grain yield and biomass production. This necessitates the development of high-yielding early maturing varieties adaptable to the different agro-ecologies of the country. Despite the ever-increasing importance of soybean in Ethiopia, most of the area expansion, however, was in high rainfall areas, and soybean growing in moisture stress areas remains limited. Moreover, impacts of the global climate change has resulted in prolonged dry spell periods in most soybean-producing areas which in turn lower grain yield of popular varieties in the country. The aforementioned challenges and gaps call for continuous improvement and targeted breeding for early maturity varieties. As part of addressing the existing soybean production gaps and to widen soybean variety choices of early maturing varieties, a new soybean variety, ‘Guda’ was released from Jimma Agricultural Research Center in the year 2021.

Materials and Methods

Variety Guda was evaluated at various stages of variety testing, i.e. starting from observation nurseries, Preliminary Variety Trials (PVT), National Variety Trial (NVT), and verification trial. The national variety release procedure/system requires results of the NVT data for application and verification plots of the candidate varieties to evaluate candidate varieties against the standard checks.

Experimental locations and trail design

National variety trial

In this study, NVT trial was conducted at five locations representing the major soybean agro-ecologies in Ethiopia (Table 1) between 2018 and 2019 cropping seasons. The trial was planted in a 40cms by 5cms between row and within row spacing's respectively. The design used was RCB with four replications. NPS fertilizer was applied at the rate of 121kg per hectare at planting. All other cultural practices were carried out as recommended for soybean. A brief geographical and weather description of each test location is shown in the following Table1.

Verification plot

Verification plots are tested in a 10m x 10m plot at TiroAfeta Jima zone, Gofa, and Sirinka research testing sites and at two farmer's fields near each site. A variety release technical committee composed of breeder and pathologist experts evaluated the varieties. The technical committee thoroughly evaluated the application data of the NVT and visually evaluated the field performance of the candidate variety under verification plot along with checks. The technical committee makes its own decision about the candidate variety and presented its final decision to National variety release committee. And, the national variety release committee finally gave decision based on its assessment.

Table1. Description of the experimental locations.

Test location	Altitude (m.a.s.l)	Annual rainfall (mm)	Temperature (°C) Min	Max
Mehoni	1571	600	18.0	25.0
Tiro-afeta	1768	1829	18.0	26.0
Gofa	1774	1298	13.1	28.0
Sirinka	1749	876	18.0	27.0
Humera	585	620	20.4	37.6

Plant materials

The trail involved 10 soybean genotypes of different genetic background and originated from different sources. As indicated in Table 2, four of the test genotypes were introductions from USA while the other four including the new variety, 'Guda' (HAR/PR142-15-SB) are recombinant inbred lines(RIL) developed by the breeding program of the Jimma Agricultural Research Center. The rest two genotypes, Gazelle and Nova were released early maturing varieties included as checks (Table 2). Guda is homozygous line developed from a cross between Hardee an early maturing variety recommended in 1970 with promising line PR 142 through successive selection from segregating generations using a modified single seed descent method.

Table 2. Soybean genotypes and the corresponding seed sources used in the study.

No.	Genotype	Origin/ Source
1	Gazale	Early maturing check variety
2	PI200488	USA
3	JM-HAR/G99-15-SD-2	RIL-JARC
4	PI417116	USA
5	JM-PR142/G99-15-SB	RIL-JARC
6	PI506764	USA
7	JM-HAR/PR142-15-SB	RIL-JARC
8	Nova	Early maturing check variety
9	JM-DAV/PR142-15D	RIL-JARC
10	Delsoy 4710	USA

Results and Discussion

Based on the combined data analysis, the maximum grain yield (2.11 t/ha) was recorded from the newly released variety, Guda followed by the other two genotypes (JM-HAR/G99-15-SD-2 and JM-PR142/G99-15-SB) (Table 3). Results showed that the new variety, 'Guda' exhibited 17 and 26% yield advantages over the standard checks, Gazela and Nova, respectively (Table 3).

Days to maturity of the genotypes ranged from 86-102 days from sowing. Result showed that the days to maturity of the promising genotypes among the group including Guda(98) JM-HAR/G99-15-SD-2 (97 days), and JM-PR142/G99-15-SB (101days were found to be earlier in maturity than the standard check Gazelle (102 days).The finding indicate as there was , a positive trait in breeding for earliness. In most of the environments tested, the early maturing genotypes had also better grain yield. The maximum number of seeds per plant was obtained from the candidate genotype, 'Guda' followed by the check variety Nova. The least number of seed per plant was recorded from the genotype PI506764. Furthermore, the two promising genotypes showed better tolerance reaction against soybean rust and bacterial blight (Table 3). In addition, the new variety Guda was better than the check (Nova) in hundred seed weight (Table 3).

In addition to the significant yield advantage of the new variety, Guda has comparable seed protein and oil content with the standard checks Gazale (Table 4).

The national variety release committee after thorough evaluation of the NVT data and verification plot finally accepted the candidate variety JM-HAR/PR142-15-SB and released by the name Guda since June 2021. The name Guda in Afaan Oromo language means big. This name was given tracing the big seed size of the variety main morphological characteristics of the candidate variety listed below (Table 4).

Table 3. Combined mean yield and related parameters of the test genotypes in the national variety trials.

Genotype	DTF	DTM	PH (cm)	NP	NSP	SH	RUST	CBB	HSW (g)	Yield (t/ha)	% Yield increase over check varieties	
											Gazella	Nova
Gazale	47.5	102	53.9	43.4	113.0	1.4	1.2	1.5	18.3	1.81	-	8
PI200488	42.6	86.6	38.4	31.5	80.0	2.5	1.3	2.1	18.2	1.41	-22	-16
JM-HAR/G99-15-SD-2	45.0	97.0	45.4	34.0	94.1	1.6	1.1	2.1	18.2	1.98	9	19
PI417116	41.9	85.5	30.8	26.2	57.2	2.8	1.0	1.4	19.1	1.11	-39	-34
JM-PR142/G99-15-SB	47.9	101.3	54.5	38.8	104.5	1.2	1.2	2.2	17.3	1.97	9	18
PI506764	41.1	88.8	29.6	23.5	56.8	2.2	1.3	1.9	18.4	1.30	-28	-22
Guda	45.0	97.5	56.5	43.5	113.4	1.4	1.3	1.7	15.7	2.11	17	26
Nova	43.6	86.3	54.5	50.2	129.2	2.1	1.4	1.7	12.9	1.67	-8	-
JM-DAV/PR142-15D	45.9	96.2	41.3	40.7	100.2	1.7	1.0	2.0	17.3	1.79	-1	7
Delsoy 4710	40.8	86.7	41.7	34.9	95.2	1.7	1.0	1.5	16.0	1.43	-21	-14
Mean	44.1	92.8	44.7	36.7	94.4	1.9	1.2	1.8	17.1	1.66		
CV	6.4	5.3	14.0	31.6	38.7	53.0	34.9	60.4	16.8	24.36		
LSD	5.5	9.6	12.2	22.7	71.5	1.5	0.8	NS	5.7	0.78		

DTF = days to 50% flowering, DTM = days to 95% maturity, PH = plant height, NPP = Number of pods per plant, NSP = Number of seeds per plant, HSW=hundred seeds weight (g)

Table 4. Mean seed protein and oil contents of the candidate variety compared with the two standard checks.

Seed composition	Nova	Gazale	Guda (JM-HAR/PR142-15-SB)
Protein	36.81	38.84	36.92
Oil	21.09	20.73	21.44

Table 5. Main morphological characteristics of the candidate variety

No.	Candidates	Seed coat Color	Leaf Shape	Hilum color of the seed	Flower color	Morphological characteristics			
						Pubescence color	Pod color	Seed luster	Pubescence density
1.	JM-HAR/PR142-15-SB(Guda)	Yellow	Intermediate	Black	Purple	Tawny	Light brown	1	Semi dense

Note; Seed luster scoring system was used a 1-5 scale (1=luster or attractive, and 5= unattractive).

The new variety, Guda can be adoptable from low to mid altitude soybean growing agro-ecologies, in areas with moisture deficit with annual rainfall rang of 300-620mm (Table 2). The variety could also be used for double cropping practices owing to its early maturing characters. Moreover, in high rainfall areas farmers plant soybean late due to overlap of other farm activities, mainly maize planting and weeding. Under such circumstances, farmers can harvest reasonable yield if they plant early maturing soybean varieties like Guda late in the season, which otherwise is hardly possible for medium and late maturing varieties to cope under such practices.

Conclusion and Recommendation

The newly released soybean variety Guda is an early maturing variety having mean days to maturity of 98 days, higher seed yield, better tolerance to major foliar diseases of soybean, and seed quality attributes as compared to the standard varieties studied. Hence, the variety has the potential to increase productivity and production in its current adaptation zones and similar moisture-deficit growing agro-ecologies. It's, therefore, worth to recommend the new variety for demonstration and popularization under small-scale farmers and for commercial production. Importantly, the impact of variety development can be realized if enough quantity of seed is multiplied and distributed to users in both quality and quantity. Towards that end, all actors and stakeholders in the soybean value chain should be engage in seed production and supply. Likewise, as owner of the variety, the breeding program of JARC need to regularly maintain the true-to-typness of the variety and continuously produce initial (breeder and pre-basic) seeds in a required quality and quantity.

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References

Central Statistical Authorit Agricultural samples survey., 2005/2006. Report on Area and Production of Crops, Addis Ababa, Ethiopia

Central Statistical Authorit Agricultural samples survey., 2020/2021. Report on Area and Production of Crops, Addis Ababa, Ethiopia

FAO, 2021. FAOstat .http://www.fao.org/faostat/en/#home.accessed 20.9.2021

Garrett, R.D., Rueda, X. and Lambin, E.F., 2013. Globalization's unexpected impact on soybean production in South America: linkages between preferences for non-genetically modified crops, eco-certifications, and land use. *Environmental Research Letters*, *8*(4), p.044055.

Khojely, D.M., Ibrahim, S.E., Sapey, E. and Han, T., 2018. History, current status, and prospects of soybean production and research in sub-Saharan Africa. *The Crop Journal*, *6*(3), pp.226-235.

Ministry of Agriculture.,2018. Plant Variety Release, Protection and Seed Quality Control Directorate, Crop Variety Register, Issue No. 17, Addis Ababa, Ethiopia

Singh, P., Kumar, R., Sabapathy, S.N. and Bawa, A.S., 2008. Functional and edible uses of soy protein products. *Comprehensive reviews in food science and food safety*, *7*(1), pp.14-28.

Shurtleff, W. and Aoyagi, A., 2009. *History of soybeans and soyfoods in Africa (1857-2009): extensively annotated bibliography and sourcebook*. Soyinfo Center.

Zhang, J., Wang, X., Lu, Y., Bhusal, S.J., Song, Q, Cregan, P.B., Yen, Y., Brown, M. and Jiang, G.L., 2018. Genome-wide scan for seed composition provides insights into soybean quality improvement and the impacts of domestication and breeding. *Molecular Plant*, *11*(3), pp.460-472.