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Evaluation of soybean varieties at Arbaminch zuria district of Gamo zone in southern Ethiopia

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Abstract

The study was conducted using sixteen soybean varieties gained from Pawe Agricultural Research Center. The varieties were tested for yield and yield-related traits at Arbaminch zuria district during the 2017 and 2018 main production periods. The study was conducted by using a randomized complete block design with three replications. Variance analysis for the individual year on yield and yield component showed significant differences (p<0.05) among genotypes except for seeds per pod in the year 2018. During the 2017 cropping season, the highest yield was obtained from Gazale (1948 kgha-1) and Niyala (1922 kgha-1 whereas the lowest grain yield was obtained from AFGAT (956 kgh-1). While in 2018 Nova (1110 kgha-1), Dhedessaa (1050.9kgha-1) and Nyala (988.9 kgha-1) showed better yield than other tested varieties while the lowest grain yield was observed on Korme (504.6 kgh-1). The combined test for analysis of variance showed a significant differences among genotypes for grain yield and components of yeild exculding the number of seeds per pod. The highest plant height was recorded for AFGAT (107.7m) whereas the highest number of pods per plant was obtained from Jalale (61.03) followed by Dhedessaa (60.23). The maximum hundred seed weight was gained from Nyala (15.67g while the highest branch number was obtained from Jalale (4.2) and Gishima (4.1). Nyala and Gazale had the highest grain yield of 1455 kgha-1 and 1445 kgha-1, respectively, while AFGAT (819Kgha-1 had the lowest grain yield. The result obtained from Niyala (1455 kgh-1) and Gazale (1445kgh-1) gave better yields than other tested varieties. Therefore, varieties Nyala and Gazale can be recommended for the study area and areas with similar agro-ecologies for demonstration.

Keywords: Adaption; Correlation; Soybean; Varieties; Yield

1. Introduction

Since the 1960s, soybean (*Glycine max (*L.*)* Merrill.) Is one of the world's dominant oilseeds and most vital legumes in terms of production and trade (Smith and Huyser, 1987). The crop is originated in Asia and later introduced into North America, Europe, then into South and Central America (Hymowitz, 2004). The United States of America and Brazil were the biggest producers of soybean in the world with an output of 73 million metric tons (33 %) and 42 million metric tons (28 %) respectively in 2008. Nigeria is the largest of Africa's soybean producers (39%), closely followed by South Africa (35 %) (Kolapo, 2011). It is the prominent oil and protein crop of the world, which is used as a source of high-quality edible oil, protein, and livestock feed (Rajcan et al., 2005). It contains a maximum amount of protein and other essential vitamins that play important role in our daily life (Hartman *et al*, 2011). The grain contains 40% protein, 26% carbohydrate and 20% oil that is rich in vitamins, fibre and minerals (Wasike et al. 2009). Soybean contains highly nutritious protein with all essential amino acids (Ali, 2010). It offers numerous advantages in sustainable cropping systems including the ability to fix atmospheric nitrogen (N2) via symbiotic N2 fixation (Sinclair and Vadez, 2012). Therefore, to alleviate the need to apply large amounts of nitrogen fertilizer (Herridge *et al*. 2008).

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In Ethiopia, soybean grows over wider agro-ecologies that have moderate annual rainfall (500-1500mm) (Besufikad, 2019). It performs well between 1300 and 1700 m.a.s.l. Soybean requires temperature ranging from 23- 25°C and medium relative humidity for optimum yield production (Mesfin and Abush, 2019). In the 2017/18 production season in Ethiopia, a total of 8,646.79 tons of soybean was produced from 38072.70 ha. Productivity of 2.27 ton ha^{-1} (CSA, 2017/18).

In Ethiopia research on soybean most probably have focused on the evaluation of different maturity groups, rhizobial inoculation response, the genetic variability for agronomic traits and intercropping it with cereals (Bekere *et al*. 2013; Dilnesaw and Getahun 2013; Zerihun *et al*. 2014; Abebe *et al*. 2014). Recently, soybean production has rapidly increased in Ethiopia, to meet industry demands and overcome nutrition deficiency (Mutegi and Zingore, 2014). However, the varieties released so far in Ethiopia are not popular among smallholder farmers. Therefore, it is necessary to identify soybean genotypes that are high-yielding and perform better in the study area.

2. Material and methods

2.1. Description of the Study Area

The experiment was conducted at Arba Minch Zuria district, Chano Mille and Derashe district, Gato sub-stations. The mean monthly maximum and minimum temperatures of the study area ranges from 33.8 °C (February) to 28.1 °C (July) and 18.2 °C (April) to 15.3 °C (December), respectively with the average monthly temperature of 26.1°C. The dominant soil type of the area is sandy loam. The elevation of the study site is 1216 meters above sea level. The area is categorized under bimodal rain type; the *belg* and *meher*. The first cropping season, *Belg*, extends from March to June with an average rainfall of 150.74mm, whereas the second cropping season *Meher*, extends from the last week of August to November having average rainfall of 129.825mm.

2.2. Experimental Materials and Design

The study was composed of sixteen improved soybean varieties (Table 1) organized in a randomized completed block design with three replications. The size of plots used for this experiment was 2.4mx4m (9.6m²). The spacing between rows and plants was 60cm and 5cm, in the given order.

Table 1 List of genotypes used for the experiment with their characteristics

Varieties	Year of release	Center of release	Altitude(masl)	Maturity group
Belesa-95	2003	ARARCSRARI	520-1800	Late
Wegayen	2010	PARC	520-1800	Late
Kata	2011	BARC	1200-1900	Medium
Korme	2011	BARC	1200-1900	Medium
Gizo	2010	PARC	520-1800	Medium
Gishama	2010	PARC	520-1800	Medium
Afgat	2007	AwARC/SARI	520-1800	Medium
Dhidhessa	2008	BARC/OARI	1200-1900	Medium
Boshe	2008	BARC/OARI	1200-1900	Medium
Jalale	2003	BARC/OARI	1300-1850	Midum
Awasa-04	2012	HWARC	1200-1700	early
Nyala	2014	HwRC/SARI and Pawe ARC/EIAR	520-1800	Early
Gazale	2015	HwARC/SARI andPawe/EIAR	800-1700	Early
Nova	2012	HWARC	1200-1700	Midium
Cheri	2003	BARC/OARI	1300-1850	Midium
Pawe-03	2016	Pawe ARC/EIAR	#	#

2.3. Data Collection

Data were recorded on both a plant and plot basis. Grain yield and hundred seed weight were recorded on plot base. For data recorded on plant base, five sampled plants from the central rows were randomly were used. The average value of the five plants in each experimental plot was used for statistical analysis for parameters such as plant height, number of pods per plant, branch numbers per plant and number of seeds per pod. The data for grain yield was recorded from the two central rows then converted to a hectare base. Hundred seeds weight was recorded from randomly picked hundred seeds harvested from two central rows of each plot.

2.4. Data analysis

The data were analyzed using the general linear model (GLM) procedures using the SAS statistical software. For the mean separation test, Dunken's Multiple Range Test at P<0.05 was used.

3. Results and discussion

3.1. Analysis of Variance

A combined analysis of variance was executed to determine the effects of genotypes, year and genotype by year interaction on grain yield and yield-related traits of soybean genotypes following the homogeneity test. The variance analysis for genotypes showed that all parameters were significant except seed per pod (P0.05). The analysis of variance also for year and genotype by year interaction show significant differences for all parameters except plant height and seeds per pod. The existence of significant interaction for the studied traits between years indicated no consistency of the varieties over two years (Table 2).

Table 2 Analysis of variance of 16 soybean genotypes grown in 2017-2018 cropping season, Chano mille, Ethiopia

Source of variation	DF	PH	BN	PPp	SPp	HAW	GY/ha
Treatment	15	1177.1*	2.0511**	547.40**	0.06^{NS}	12.87**	287627**
Block within year	4	225.3	2.307	125.23	0.09	2.70	174000
Year	1	106.5^{NS}	41.54**	10535.8**	0.03^{NS}	23.01*	9304387**
Treatment*Year	15	346.2^{NS}	2.75**	175.14*	0.03^{NS}	6.61*	131401**
Error	60	423.1	0.91	83.48	0.04	3.72	61542

"*" shows significant difference among treatment. "**" shows highly significant difference among treatments."NS" shows non-significant. PH= plant height in centimetres, BN = branch number per plant, SPP=number of seeds per pod, PPP=number of pods per plant, GY=grain yield in kilogram per hectare, HSW=hundred seed weight

3.2. The mean value of the Soybean Varieties for Individual Years

The mean value of the yield of grain and yield-related attributes of the 16 soybean varieties in 2017 and 2018 are presented below in Table 2. In 2017 the highest plant height was recorded in AFGAT (130.8cm) while the lowest plant height was recorded on Nyala(54.8cm). The highest number of pods per plant was observed on Jalale (79.6) followed by Nyala (73.0). The lowest number of pods per plant was obtained from the variety Cheri (9.47). The same variety Jalale (5.87) gave the highest branch numbers per plant while the lowest branch numbers per plant were observed on variety Cheri(2.6). In the case of a hundred seed weights, the weight was recorded from Nyala (17.3g) and Gazale (16.67g). Gazale and Nyala had the highest grain yield of (1948 kgh^{-1}) and (1922 kgh^{-1}), respectively, while AFGAT (956 kgh^{-1}) had the lowest grain yield. During 2018, the highest plant height was recorded in Korme (97.87m) and Kata (92.33cm) whereas the lowest plant height was recorded for Nyala variety (47.27) in the same year. The highest number of pods per plant was gained from Dhedessaa (58.33) followed by Korme (48.03), while the lowest number of pods per plant was observed from Wegayen variety (2.07). The highest branch number was obtained from Gishima(4.00) whereas the lowest one was obtained from Gazale(1.73). The highest hundred seed weight was recorded from Jalale (15.33g). Nova, Dhedessaa and Nyala had a better grain yield of (1110.2 kgh^{-1}), (1050 kgh^{-1}) and (988.9 kgh^{-1}) respectively than other tested varieties.

Variation in grain yield for soybean genotypes was observed across the years. The grain yield in the year 2017 was higher compared to the year 2018. The reason behind this yield variation was there was a shortage of moisture during the 2018 cropping season, especially at the flowering stage and pod-filing stage. Water stress reduces soybean yield by about 40% (Pathan et al., 2007). According to Soheil et al. (2011), insufficient water, especially during emergence, flowering and pod-filling stages lowers the yield of soybean. The yield per hectare was reduced by 622.6 kg ha-1 (43.5%) in 2018 when compared to 2017 (Table 3). Study by Abebe *et al*, (2014) reported the variation in genotypes for yield across the year. In addition, environmental variation and even management differences may cause the yield and yield trait variations (Abebe *et al*., 2014). According to Wiatrak (2012), unfavourable environmental conditions such as high temperature disturb soybean growth, development and yield. A study by Mesfin and Abush (2019) reported that varietal adaptability to environmental fluctuations is important for the stabilization of crop production over regions and years. Some of the information on GEI leads to the successful evaluation of stable genotype, which could be used for general cultivation. Yield has a complex quantitative appeal that is greatly influenced by environmental fluctuations. Hence, it may be very effective when the selection of genotypes is based on yield based on a single location across year.

3.3. The Combined mean performance of Soybean Varieties for the two years

Table 3 The mean values of 16 soybean varieties for yield and yield components at Arbaminch zuria district in the 2017-2018 cropping season, SNNPR, Ethiopia

	The year 2017						The year 2018					
Varieties	**PH**	**Brno**	**PPP**	**SPP**	**HSW**	**GY (kgha^{-1})**	**PH**	**BR.no**	**PPP**	**SPP**	**HSW**	**GY (kgha^{-1})**
Belesa-95	83.13^{b}	2.73^{ef}	45.27^{def}	2.63abc	13.33^{bcde}	1502 ^{bcd}	75.33^{abc}	2.47^{cde}	35.77^{ef}	2.547	11.00^{cd}	935.2^{bcd}
Wegayen	88.80^{b}	3.07^{de}	42.07^{ef}	2.65^{abc}	12.33^{def}	1227 ^{cde}	74.87^{abc}	2.00^{defg}	23.07^{i}	2.680	11.33^{bcd}	779.6^{cdef}
Kata	78.13^{c}	2.53^{f}	46.93^{def}	2.60^{abc}	13.33^{bcde}	1819^{b}	92.33^{a}	3.00^{bc}	29.40^{gh}	2.733	10.00^{d}	505.6^{f}
Korme	85.67^{b}	3.60^{bcde}	58.87^{bcde}	2.67^{ab}	12.67^{cdef}	1367^{bcde}	97.87^{a}	3.5^{ab}	48.03^{b}	2.587	11.33^{bcd}	504.6^{f}
Gizo	83.40^{bc}	3.93^{bcde}	47.67^{def}	2.39^{de}	11.00^{fg}	961^{e}	87.33^{a}	3.31^{b}.	32.67^{fg}	2.600	12.00^{bcd}	705.6^{cdef}
Gishama	82.67^{bc}	4.87^{bcd}	46.67^{def}	2.52^{bcd}	12.67^{cdef}	1014de	81.93^{ab}	4.00^{a}	28.00^{h}	2.660	11.33^{bcd}	662.0^{def}
Afgat	130.80^{a}	4.60^{bcde}	47.53^{def}	2.40^{cde}	11.33^{ef}	956^{e}	84.60 ^{a}	2.53^{cd}	27.73^{h}	2.613	12.67^{abcd}	681.5^{cdef}
Dhedessaa	80.53^{bc}	3.50^{cde}	62.13^{bcde}	2.60^{abc}	15.00^{abc}	1562^{bc}	77.53 ^{abc}	3.53^{ab}	58.33^{a}	2.640	11.67^{bcd}	1050.9^{ab}
Boshe	64.53^{d}	5.20^{ab}	59.87^{bcde}	2.76^{a}	14.00^{bcd}	1620^{bc}	77.73^{abc}	2.32^{cdef}	38.53^{de}	2.600	13.33^{abc}	852.8^{bcd}
Jalale	57.07^{e}	5.87^{a}	79.60^{a}	2.17^{e}	13.67^{bcde}	1397^{bcde}	54.60^{cd}	2.47 ^{cde}	42.47^{cd}	2.413	15.33^{a}	967.6^{bcd}
Awasa-04	76.40^{b}	5.13^{ab}	54.60^{cdef}	2.49^{bcd}	15.67^{ab}	1573^{bc}	80.30^{ab}	1.86^{defg}	29.27^{gh}	2.567	12.67^{abcd}	846.3^{bcd}
Nyala	54.80^{e}	5.40^{ab}	73.00^{abc}	2.69^{ab}	17.33^{a}	1922^{a}	47.27^{d}	2.10^{defg}	41.57^{cd}	2.433	14.00^{ab}	988.9^{abc}
Gazale	67.00^{b}	4.27^{bcde}	65.47^{bcd}	2.41^{cde}	16.67^{a}	1948^{a}	59.67^{bcd}	1.73^{eg}	43.73^{bc}	2.520	13.67^{abc}	942.6^{bcd}
Nova	55.40^{de}	3.53^{bcde}	76.27^{ab}	2.68^{ab}	13.33^{bcde}	1540^{bc}	74.60^{abc}	2.47 ^{cde}	31.13^{gh}	2.633	12.33	1110.2^{a}
Cheri	86.67^{b}	2.60^{f}	39.47^{f}	2.59^{bcd}	11.67^{def}	1024de	77.20^{abc}	2.00^{defg}	29.60^{gh}	2.493	12.00^{bcd}	625.0^{ef}
Pawe-03	86.93^{b}	2.53^{f}	56.73^{bcde}	2.55^{bcd}	8.67^{g}	1465^{bcd}	85.07^{a}	2.47 ^{cde}	27.60^{h}	2.667	12.33^{bcd}	775.9^{cdef}
CV(%)	31.1	28.3	22.4	5.9	11.3	20.5	19.2	14.5	7.4	9.0	12.0	22.9
Mean	78.87	3.96	56.38	2.55	13.29	1431	76.76	2.48	35.43	2.587	12.31	808.4

Different letters in the superscript shows significant difference among treatments; PH= plant height in centimeters, BRNO = branch number per plant, SPP=number of seeds per pod, PPP=number of pods per plant, GY=grain yield in kilogram per hectare, HSW=hundred seed weight in gram and CV=coefficient of variation

The combined mean value of the grain yield and yield-related characters of the 16 soybean varieties is presented below in Table 4. The highest plant height was observed in AFGAT (107.7m) whereas the lowest plant height was recorded from Nyala (51.03m). The pods per plant were ranged from 32.57 to 61.03. The highest number of pods per plant was gotten from Jalale (61.03) followed by Dhedessaa (60.23), while the lowest number of pods per plant was obtained from Wagayen (32.57). The highest branch number was obtained from Jalale(4.2) and Gishima(4.1) while the lowest was obtained from Cheri (2.3). In the case of a hundred seed weight, the highest hundred seed weight was gained from Nyala(15.67g) whereas the lowest seed weight was gained from Pawe-03 variety (10.5g). Based on the combined data over the two year wide ranges of mean values between the minimum (819kg/ha) for AFGAT and maximum (1455kg/ha) for Nyala were observed (table 4). Nyala and Gazale had the highest grain yield of (1455 kgh^{-1}) and (1445 kgh^{-1}), respectively, while AFGAT (819 kgh^{-1}) had the lowest grain yield. This finding disagrees with the finding of Mesfin and Abush (2019) who reported mean grain yield ranged from 1426 to 2973 kgh^{-1} but the finding agrees with Abush et al.,(2017) who reported that a 1234 kgh-1 of mean grain yield, 13.24 hundred seed weight and 2.6 number of seed per pods.

Table 4 The combined mean value of 16 soybean varieties for yield and yield related components at Arbaminch zuria district from 2017-2018

Varieties	PH	BN	PPP	SPP	HSW	GY(kg ha^{-1})
Belesa-95	79.23^{bc}	2.6^{bc}	40.52^{cd}	2.587	12.33^{cdef}	1219^{abc}
Wegayen	81.83^{abc}	2.5^{bc}	32.57^{d}	2.664	11.83^{def}	1003^{bcd}
Kata	85.23^{ab}	3.0^{abc}	38.17^{d}	2.667	11.67^{def}	1162^{abc}
Korme	91.77^{ab}	3.7^{ab}	$53.4\ 5^{ab}$	2.627	12.00^{cdef}	936^{cd}
Gizo	85.37^{ab}	3.2^{abc}	40.17^{cd}	2.493	11.50^{ef}	833^{d}
Gishama	82.30^{abc}	4.1^{a}	37.33^{d}	2.590	11.83^{def}	838^{d}
AFGAT	107.70^{a}	3.567	37.63^{d}	2.507	12.00^{cdef}	819^{d}
Dhedessaa	79.03^{bc}	3.57^{abc}	60.23^{a}	2.620	13.33^{abcde}	1306^{ab}
Boshe	71.13^{bcd}	3.52^{abc}	49.20^{bc}	2.680	13.67^{abcde}	1236^{abc}
Jalale	55.83^{cd}	4.2^{a}	61.03^{a}	2.293	14.50^{abc}	1182^{abc}
Awasa-04	78.35^{bc}	3.49^{abc}	41.93^{cd}	2.530	14.17^{abcd}	1210^{abc}
Nyala	51.03^{d}	3.75^{ab}	57.28^{ab}	2.563	15.67^{a}	1455^{a}
Gazale	63.33^{bcd}	3.0^{abc}	54.60^{ab}	2.467	15.17^{ab}	1445^{a}
Nova	65.00^{bcd}	3.0^{abc}	53.70^{ab}	2.657	12.83^{bcdef}	1325^{abc}
Cheri	81.93^{abc}	2.3^{c}	34.53^{d}	2.540	11.83^{def}	825^{d}
Pawe-03	86.00^{ab}	2.5^{bc}	42.17^{cd}	2.607	10.50^{f}	1121^{abcd}
CV (%)	26.4	29.2	19.9	7.6	3.15	22.2
Mean	77.82	3.221	45.91	2.568	12.80	1120

Different letters in the superscript shows significant difference among treatments; PH= plant height in centimetres, BN= branch number per plant, SPP=number of seeds per pod, PPP=number of pods per plant, GY=grain yield in kilogram per hectare, HSW=hundred seed weight in gram and CV=coefficient of variation.

3.3.1. Correlation of grain yield with other traits

A phenotypic correlation among the various traits is presented in Table 4. Grain yield had a significant and positive correlation with branch numbers per plant, pods number per plant, and hundred seed weight. This indicates that the improvement of these characters would result in a considerable increment in grain yield. Positive and significant association of branch numbers per plant, pods number per plant and 100 seed weight with grain yield shows the importance of these characteristics in determining grain yield. Generally, these highly correlated variables contributed to greater variation in grain yield. A study by Aditya *et al*. (2011) reported a significant and positive correlation of these characters with grain yield. A finding by Rajanna *et al.* (200) also reported similar findings for different parameters in soybean.

Table 5 The phenotypic correlation coefficients in sixteen soybean varieties tested at Arbaminch zuria district from 2017 to 2018

Variable	GY	BN	PH	PPP	SPP	HSW
GY	1.00	0.46***	-0.12	0.64***	-0.04	0.49***
		1.00	-0.01	0.61***	-0.12	0.29*
			1.00	-0.12	-0.00	-0.38**
				1.00	-0.18	0.34***
					1.00	-0.064
						1.00

"***" shows highly significant difference among treatments; PH= plant height in centimetres, BN = branch number per plant, SPP=number of seeds per pod, PPP=number of pods per plant, GY=grain yield in kilogram per hectare and HSW=hundred seed weight in gram

4. Conclusion

In the present study, sixteen soybean genotypes were evaluated in the 2017 and 2018 crop growing seasons to select high-yielding varieties for further promotion in soybean producing areas. The highest yield obtained in the present study is below the national average yield (2217 kg h^{-1}). This is due to low moisture stress occurring in the 2018 cropping season. Even if the yield obtained is below the national yield, Niyala with a yield of 1455 kg h^{-1} and Gazale with 1445 kg h^{-1} gave better yield than the other tested varieties.

Recommendations

Therefore, the two varieties, Nyala and Gazale, were recommended for further demonstration and promotion for the study area and areas with similar agro-ecology in the Gamo zone of SNNPR. Further research will be done using more soybean genotypes, over more locations and years to come up with better highly adapted and stable genotypes.

Compliance with ethical standards

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Dedication

This study is a dedication to former researcher Mr. Ashenafi Dana who was eager to see the success of this activity but passed without seeing the success.

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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