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Performance evaluation of Medium maturing soybean (G*lycine max* (L) Merrill) varieties under irrigation in north wester Ethiopia

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Abstract

This experiment was conducted in 2018 and 2019off seasonsat Pawe Agricultural Research Center irrigation site of Duhuans Baguna substation, to select high yielder and best performing soybean varieties under irrigation, to generate information about the varietal performance and widen the production options to investors and smallholder farmers in addition to rainfed. The experiment consisting eight medium maturing soybean varieties and was done using randomized complete block design with three replications. The result revealed that there was highly significant difference in days to flowering, and 100 seed weight among the tested varieties. The variety was significantly interacted with year in days to flowering, and numbers of branches plant^{-1}.Two-year combined results of grain yield were ranged from 1909.6 to 2615 kg ha^{-1}. The highest grain yield was obtained by Cheri(2615) followed by Wello (2607.4 kg ha^{-1}) where as Davies (1909.6 kg ha^{-1}) and Crawford (2026.4kg ha^{-1}) were recorded the lowest grain yield, respectively. Therefore, the variety Cheri, and Wello are recommended for production under irrigation in northwestern Ethiopia and similar agricultural ecologies.

Key words: Evaluation**,** Irrigation**,** Production, Soybean Variety, Yield Performance

Introduction

Soybean (Glycine max L.) positions first among oilseed crops on the planet and it contributes almost 25 percent of universes all out oil and fat production (Basediya et al., 2018). The world soybean yearly production is represented 362.87 million metric tons. Top five world soybean delivering nations are USA, Brazil, Argentina, China and India, which represent 89.31% of world supply (USDA, 2019).

According to CSA, 2019 report, In the past 10 years the total area of land under soybean production increased from 5678.69 to 64,720.12 ha, while the total volume of soybean production during the same period has increased from 7205 to 149454.6 tons and productivity increased from 12.7 to 23.1 quintalha^{-1} which mean 81.8% of increment. The expansion of soybean production area was largely in order to meet local demand of edible oil, soybean meal for livestock feed and used as rotation crop on some of government owned sugarcane plantations (USDA, 2016). In Ethiopia, Soybeans is delivered on more than 64,720.12 ha yearly with national normal yield of 2.31 tons ha^{-1}

(CSA, 2019). The significant soybean delivering zones are North Western and South Western parts of the nation, Amhara, Benishangul Gumuz, and pieces of Oromia region which account 99.6% of production.

Irrigation has been tremendously refreshing for its noteworthy commitment to worldwide farming production and food security in the course of recent years. Now a day, greater than 40 percent of worldwide agricultural products are created on irrigated land (FAO, 2018). The ultimate goal of irrigation is to utilize added water efficiently on soybean hectarage that can give the greatest seed yield increase from added water (Pejic B et al.., 2012). Several studies conducted for a wide range of environments have demonstrated that soybean yield increases with irrigation (Dogan et al. 2007, Sincik et al. 2008, Bajaj et al. 2008, Gerçek et al. 2009).Irrigation improved overall yield of soybean by an average of, 21.93% (Pejic B et al.., 2012), 26.1% (Berger-Doyle et al., 2014).

The area and production of soybean in Ethiopia has steadily increased over the years. However, the national average productivity in Ethiopia is 2.31 tons ha $^{-1}$(CSA, 2019) which is far below the genetic potential of the crop when compared to countries like Brazil (3.33), USA (3.16), and Argentina (3.02 tons ha $^{-1}$) (USDA, 2020). The major reasons for low productivity of the crop includes: limited availability of seed, poor crop management and extension service, lack of mechanization, biotic and abiotic factors, limited seed sector involvement, limited financial support and low soil fertility (Tesfaye *et al*., 2018).

so far, a large portion of the released soybean varieties by the national and regional research institute were tested fundamentally for rainfed environmental conditions. Therefore, the present study was designed to select high yielder and best performing soybean varieties under irrigation condition, to generate information about the varietal performance and enlarge the production options to investors and smallholder farmers in addition to rainfed agriculture.

MATERIALS AND METHODS

Experimental site and conditions

The present study was conducted during the2018 and 2019winter seasons at Pawe Agricultural Research Center irrigation site, Duhuans Baguna substation which is located in Benishangul Gumuz Regional State in Metekel Zone. Experiment location was 1195 m above sea level and it was situated within 11°, 02.34´ N latitude and 36°, 20.264´ E longitude. The soil textural class was a clay loam with 38% clay, 24% silt and 38% sand at 30cm soil depth.

Experimental material

Eight medium maturing released soybean varieties were used for this study. These materials were released by federal and regional agricultural research institute in our country. The lists of materials used for this experiment are preset in Table 1below.

Experimental design

The experiment was arranged in a randomized completely block design with three replicates. Each variety was planted using 2.4 m × 4m plot area and 100kg ha^{-1} DAP which applied at sowing. The two-year experiments were sown on 15 and 11th of December in 2018 and 2019, respectively.

The experiment was performed by furrow irrigation with spacing of 60cm between rows and 15cm raising bed. Soybean seeds were planted in spaced 5cm between plants on the one shady sides of the ridge, to protect them from the sun. The plots were irrigated using a conventional furrow irrigation method at 100% FC (field capacity) and subsequent irrigations were applied every 9 days during plant vegetative development stage, and every 7 days during reproductive stages up (R7 = Beginning maturity) one normal pod on the main stem that has reached its mature pod color.

Table 1: List of released soybean varieties, year of released and released institute

S.no.	Variety	Maturity group	Year of Released	Released Center
1	Gizo	Medium set	2010	Pawe ARC/EIAR
2	Afgat	Medium set	2007	Awassa ARC/SARI
3	Cheri	Medium set	2003	Bako ARC/OARI
4	Wello	Medium set	2012	Sirinqa ARC/ARARI
5	Davies	Medium set	1982	Awassa ARC/SARI
6	Clark-63k	Medium set	1982	Awassa ARC/SARI
7	Crawford	Medium set	------	Awassa ARC/SARI
8	Gishama	Medium set	2010	Pawe ARC/EIAR

Where ARC= Agricultural Research Center, AwARC= Awassa Agricultural Research Center, EIAR = Ethiopian Institute of Agricultural Research, ARARI=Amhara Regional Agriculture Research Institute, OARI= Oromia Agriculture Research Institute and SARI= Southern Agriculture Research Institute

Data collection

The phenological, yield and yield contributed trite data were recorded. At maturity, five plants were randomly selected from the two central rows of each plot and the following traits were measured; plant height (cm), number of branches plant^{-1}, number of pods plant^{-1},number of seeds plant^{-1} and number of seeds pod^{-1}. Seed yield kg ha^{-1} was calculated over all plants in the two central rows of the plot.

Statistical analyses

The two consecutive years, phenological, yield and yield contributing traits data were recorded. The results of those data were subjected to Analysis of Variance test using the general linear model (GLM) in SAS 9.4software. The least significant difference (LSD) test at 5% of probability was performed to compared the differences among the varieties. Data for the two years was tested for homogeneity of variance using Levene'stest of homogeneity and it was found to be homogeneous, so the data were combined for further analysis.

RESULTS AND DISCUSSION

Combined analysis of variance (ANOVA)

Leven's test result revealed that error variance was homogeneous for grain yield, pod plant^{-1}, seed pod$^{-1,}$days to maturity and flowering, and numbers of branches plant $^{-1}$(appendix Table 1) and allowed to proceed for further analysis of variance across two years.

The mean square values are presented in (Table 2). The analysis of variance revealed that there was statistically high significant difference in years for traits, days to flowering and maturity, numbers of seeds pod^{-1}, plant height and hundred seed weight. This may indicate, those variety was significantly influenced by the environment. Similar findings reported on plan height (Perez Arocho, 2017; Ibrahim *et al*., 2017), days to flowering and maturity(Ibrahim *et al*., 2017). Similarly, there was significant difference among tested varieties in days to flowering and 100 seed weight. The variety significantly interacted with year only on trait days to flowering and numbers of branches. Previously, on traits grain yield, days to 50% flowering highly significant and, plant height, number of branch and hundred seed weight significant variety with year interaction was reported (Molla Malede *et al.,* 2020).

Table2: Combined analysis of variance for 9 agronomic traits of 8 medium maturingsoybean varieties evaluatedunder irrigation intwo consecutive seasons of 2018 and 2019

Parameter	Year -1	Rep(year) -4	Trt -7	Year*trt -7	Error (28)	CV%
YLD	43649.96^{ns}	196779.21^{ns}	399462.56^{ns}	290008.68^{ns}	265043	22.16
HSW	27.15**	10.77*	7.55*	4.88^{ns}	2.65	10.99
NB	0.01^{ns}	0.734^{ns}	0.89^{ns}	2.01*	0.6	21.52
SdP	2.13**	0.12^{ns}	0.24^{ns}	0.15^{ns}	0.18	23.96
PPP	318.79^{ns}	65.03^{ns}	222.71^{ns}	162.24^{ns}	168.88	27.23
PH	5334.08**	183.25^{ns}	510.78^{ns}	377.43^{ns}	415.52	28.42
DM	11470.08**	22.71^{ns}	42.13^{ns}	12.42^{ns}	41.76	5.44
DF	1419.19**	10.98^{ns}	137.16**	73.95*	27.43	8.73

Where DF= days to 50% flowering,DM= days to maturity, PH= plant height(cm),PPP= number of pods plant^{-1},SdP= number of seeds pod^{-1}, NB= number of branch plant^{-1}, HSW= 100 seed weight(gm), and GY = grain yield (kg ha^{-1})

Yield and Agronomic performance

In 2018, Grain yield performance was ranged from 1361.7 to 2820.6 kg ha^{-1} and 1992.4 to 2657.2kg ha^{-1} in 2019, respectively (Table 3 and 4).In 2018, the highest grain yield was recorded on variety clarck-63K(2820.6 kg ha^{-1}),followed by Wello(2713.9) and Cheri(2572.8kg ha^{-1}) whereas the lowest grain yield was obtained on variety Crawford and Davies, which performed under the mean (Table 3).

In 2019,the highest grain yield performance was found on variety Cheri (2657.2) and Wello(2500.8 kg ha^{-1}), whereas Gizo and Clarck-63K was performed under the mean (Table 4). The overall yield performance in this season was low in comparison with the previous season, because of security problem irrigation application stop earlier as per the proposed.

The combined result confirmed that statistically was none significant variation in grain yield among the tested varieties, year and variety year interaction (Table 2). These might be happened due to the same genetic background of those varieties and their response to irrigation environment. Two consecutive year combined grain yield was ranged from 1909.6 to 2615 kg ha^{-1}(Table 5). The highest grain yield was found on variety Cheri (2615)followed by Wello (2607.4)and Clark-63k (2498.2 kg ha^{-1})whereas the lowest grain yield was recorded on variety Davies (1909.4) and Crawford (2026.4kg ha^{-1}), respectively (Table 5). The varieties Cheri, Wello, Clark-63K and Afgat were performed above the mean and Davies, Crawford, Gizo and Gishama performed under the combined mean among the tested varieties. Even if, statistically none significant the variety Cheri and Wello were performed well under irrigation environment.

In 2018, Days to flowering were ranged from 53 to 73 days. Davies, Crawford, Clarck-63K and Cheri were flowered early, while Gishama, Gizo, Wello and Afgat were flowered late(Table 3).In 2019, days to flowering were ranged from 50 to 60.33 days. Davies, Cheri, Gizoand Clarck-63Kwere flowered early, while Afgat, Craw ford and Gishama were lately flowered (Table 4).There was ranking difference in days to flowering on Crawford and Gizo in 2018 and 2019 experimental seasons (Table 3 and 4). This implies, these varieties were significantly interacted with environments (season). The overall combined analysis of variance revealed that the year, variety and their interaction significantly varied in days to flowering (Table 2).Days to 50% flowering was ranged from 51.5 to 65.2 days. The variety Davies, and Crawford

were flowered early among the tested varieties while Afgat, Gishama, Wello and Gizo were flower lately (Table 5).

Statistically there is no significant difference among the tested varieties in Days to maturity in both 2018 and 2019 experimental seasons. Days to maturity was ranged from 128.67 to 140.67 days in 2018.Cheri, Davies and Crawford were matured early, while Clarck-63K was matured late (Table 3). In 2019, days to maturity of genotypes were ranged from 98.67 to 106.33 days. Relatively the varieties Gizo, was matured early, whereas Wello, Afgat, and Clarck-63K were matured late (Table 4). The combined result revealed that days to maturity ranged from 115.5 to 122.5 days (Table 5). The variety Chari, Davies and Crawford were matured early while Clarck-63K, Afgat, and Wello were relatively matured late.

In 2018, there is non significant difference in Plant height at maturity among tested soybean varieties. Wello was produced tallest plants of 71.87 cm followed by Gishama and Crawford (66.93 and 65.93cm respectively), while Afgat, Davies, and Cheri were short in plant height (Table 3). In 2019, longest plant height was obtained on varieties Afgat (102.9), Gishama (94.4) Wello (92.6), and Clark-63K (83.33cm), while shortest plant height found on varieties Davies (53.3cm), followed by Crawford (68.53cm) (Table 4).In this trait, there is significant variation seasonally. These indicates, plant height was significantly interacted with the environment. The two-year combined result revealed that there is non significant difference among the varieties in plant height (Table 5). Wello and Gishama were tallest whereas Davies was shortest varieties in plant height. In this trial plant height ranges from 53.72 to 82.23cm long.

Table 3. Mean performance of released medium maturing soybean variety evaluated under irrigation in 2018

S No.	Variety	GY	DF	DM	PH	PPP	HSW	SdP	NB
1	Gizo	2547.2	71	135.67	60.67	44.17	14.83	1.64	3
2	Afgat	2526.2	70	137	52.07	60.47	13.5	1.17	3.27
3	Cheri	2572.8	67	128.67	55.17	44.93	12.17	1.66	3.43
4	Wello	2713.9	70.33	135.33	71.87	48.2	14.33	1.38	3.8
5	Davies	1720.4	53	131	54.13	42.13	16	1.71	4.47
6	Clarck-63K	2820.6	65.33	140.67	62.67	31.6	14.17	2.04	3.53
7	Crawford	1361.7	54	132	65.93	41.13	14.83	1.71	3.67
8	Gishama	2206.2	73	133	66.93	48.73	12.67	1.23	3.8
	MEAN	2308.62	65.46	134.17	61.18	45.17	14.06	1.57	3.62
	CV%	23.45	2.12	4.53	17.61	26.73	4.48	27.44	15.78
	LSD	948.09	2.43*	10.65	18.87	21.15	1.1*	0.75	1

Table 4. Mean performance of released medium maturing soybean variety evaluated under irrigation in 2019 under irrigation

S. No	Variety	GY	DF	DM	PH	PPP	HSW	SdP	NB
1	Gizo	1992.40	53.00	98.67	73.40	51.93	14.03	2.23	3.87
2	Afgat	2256.00	60.33	105.33	102.90	47.07	14.67	2.13	3.40
3	Cheri	2657.20	52.00	102.33	78.23	55.00	17.33	2.09	5.60
4	Wello	2500.80	55.33	106.33	92.60	64.60	14.17	1.63	3.20
5	Davies	2098.70	50.00	101.33	53.30	37.07	18.17	1.95	2.67
6	Clarck-63K	2175.70	53.33	104.33	83.33	46.67	16.33	2.18	3.07
7	Crawford	2332.40	56.00	101.33	68.53	51.47	15.83	1.75	3.47
8	Gishama	2332.00	56.67	101.33	94.40	48.80	14.00	1.93	3.53
	Mean	2293.16	54.58	102.63	80.84	50.33	15.57	1.99	3.60
	CV%	23.54	13.33	6.71	34.20	27.53	14.24	21.21	26.07
	LSD	945.29	12.74	12.06	48.43	24.26	3.88	0.74	1.64

Where DF= days to 50% flowering,DM= days to maturity, PH= plant height(cm),PPP= number of pods plant^{-1},SdP= number of seeds pod^{-1}, NB= number of branch plant^{-1}, HSW= 100 seed weight(gm), and GY = grain yield (kg ha^{-1})

The mean performance of pods number plant^{-1} in 2018 and 2019 is presented in Table 3 and 4 respectively. The number of pods plant^{-1} of varieties was ranged from 31.6 for variety Clarck-63K to 60.47 for Afgat in 2018 (Table 3), while from 37.07 for variety Davies to 64.6 for variety Wello in 2019 experimental season (Table 4). The combined result showed that, the lowest number of pods plant^{-1} was found on varieties Clarck-63K and Davies 39.13 and 39.6, respectively while, relative highest pod numbers were recorded on varieties Wello and Afgat 56.4, 53.77, respectively (Table 5).

Hundred seed weight (g): hundred seed weight ranged from 12.17g to 16g in 2018, from 14g to 18.17g in 2019 and from 13.33 to 17.08g two-year combined means, respectively (Table 3, 4, and 5).Mean performance indicated that greater hundred seed weight was recorded onDavies16, 18.17, and 17.17g, in 2018.2019 and combined performance respectively. The lowest 100 seed weight was obtained on variety Cheri 12.17g, and Gishama 12.67g in 2018, Gishama 14g, and Gizo 14.03g in 2019, and Gishama 13.33g and Afgat 14.08g in two years combined performance. In this trait, there is a cross over interaction between varieties and the seasons.

Table 5. Combined Mean Performance of 8 medium maturing soybean varieties evaluated at Duhuans Baguna substation irrigation site in two consecutive years 2018 and 2019.

S No.	Variety	GY	DF	DM	PH	PPP	HSW	NB	SdP
1	Gizo	2269.8	62	119.7	72.73	48.05	14.43	3.43	1.94
2	Afgat	2391.1	65.17	121.2	77.48	53.77	14.08	3.33	1.65
3	Cheri	2615	59.5	115.5	66.7	49.97	14.75	4.52	1.88
4	Wello	2607.4	62.83	120.8	82.23	56.4	14.25	3.5	1.51
5	Davies	1909.6	51.5	116.2	53.72	39.6	17.08	3.57	1.83
6	Clark-63k	2498.2	59.33	122.5	73	39.13	15.25	3.3	2.11
7	Crawford	2026.4	55	116.7	67.23	46.3	15.33	3.57	1.73
8	Gishama	2269.1	64.83	117.2	80.67	48.77	13.33	3.67	1.58
	MEAN	2323.32	60.02	118.71	71.72	47.75	14.82	3.61	1.78
	CV	22.159	8.73	5.44	28.42	27.22	10.99	21.52	23.96
	LSD	608.86	6.19*	7.64	24.11	15.37	1.93	0.92	0.5

Where DF= days to 50% flowering,DM= days to maturity, PH= plant height(cm),PPP= number of pods plant^{-1},SdP= number of seeds pod^{-1}, NB= number of branch plant^{-1}, HSW= 100 seed weight(gm), and GY = grain yield(kg ha^{-1}).

Conclusion and recommendation

This study was done in 2018 and 2019 two consecutive off-seasons under furrow irrigation systems. The experimental result revealed that the year had highly significant influence on traits 100 seed weight, seed pod^{-1}, plant height, days maturity and flowering. The variety was significantly interacted with year in days to flowering and number of branches plant^{-1}.

In this study, statistically there is non significant difference in grain yield among the tested varieties. Relatively the highest grain yield performance was found on variety Cheri and Wello 2615, 2607.4kgha^{-1} respectively. So, we are recommended these varieties for production under irrigation environmental conditions in north western and similar areas of Ethiopia.

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Appendix

Appendix Table 1: - Levene's Test for Homogeneity Variance for yield and yield related traits of medium set released soybean varieties

	Sum of Squares		Mean Square			
Traits	**Year (1)**	**Error (46)**	**Year (1)**	**Error (46)**	**F Value**	**Pr > F**
YLD	30948.5	4090033	88913.8	30948.5	0.35	0.56
HSW	18.8021	61.1491	18.8021	1.3293	14.14	0.001
NB	1.325	18.521	1.325	0.4035	3.28	0.08
SdP	0.04	2.95	0.04	0.06	0.63	0.43
PPP	23.58	2932.5	23.58	63.75	0.37	0.55
PH	1900	4551.4	1900	98.94	19.2	<.0001
DM	1.39	675.9	1.39	14.69	0.09	0.76
DF	13.11	786.9	13.11	17.11	0.77	0.39

Where DF= days to 50% flowering,DM= days to maturity, PH= plant height(cm),PPP= number of pods plant^{-1}, SdP= number of seeds pod^{-1}, NB= number of branch plant^{-1}, HSW= 100 seed weight(gm), and GY = grain yield(kg ha^{-1})