



EVALUATING SEED YIELD AND YIELD RELATED TRAITS IN SOYBEAN (*Glycine max* L. Merrill) GENOTYPES AS INFLUENCED BY PLANTING ENVIRONMENTS IN SOUTH WESTERN NIGERIA

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Received 19th January, 2026; Accepted 29th January, 2026

ABSTRACT: Climate change is altering the ecosystems, affecting crop production, posing challenges on food security. Hence, the need to identify suitable environment for crop adaptation and production. Twenty-four soybean genotypes sourced from International Institute of Tropical Agriculture (IITA), Ibadan were planted using randomized complete block design (RCBD) with three replicates at three locations (Abeokuta, Lagos and Ibadan) to determine the responses of seed yield parameters across the environments. Data collected on number of days to 50% flowering, plant height at flowering, number of pods per plant, number of seeds per plant, 100 seed weight and yield per plant were subjected to analysis of variance (ANOVA), significant means were separated using Duncan Multiple Range Test (DMRT) at 5% probability level. Principal component analysis and genotypic correlation were done. The result showed that the three environments differed with respect to agrometeorological data collected, hence, affected the response of soybean yield traits evaluated. In terms of yield, Lagos and Ibadan are the ideal environments for soybean production. TGx 2004-10F remains a stable genotype with high yield, thus recommended for soybean improvement programme. Also, number of pods and seeds per plant contributed to yield observed. However, yield being a complex trait; further studies should be conducted to determine other characters contributing to soybean yield improvement.

Keywords: climate change, environment, seed yield, soybean, Genotype × Environment (G × E) interaction

INTRODUCTION

In the phase of unpredictable weather condition, it is becoming more difficult for plant breeders to predict

the performance of a cultivar from year to year and location to location. This climatic variation possesses a serious issue with respect to seed yield in crop production as agriculture in developing countries depends majorly on rainfall. Observations of the effects of climate trends on crop production indicate that climate change has already negatively affected crop yields in many regions, as well as globally. Field

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et al. (2012) and Stocker et al. (2013), reported that negative impacts are more commonly found than positive ones.

The selection of high seed yielding genotypes with wider adaptation performance in targeted agro-ecology remains an important goal in plant breeding programme. This is often preceded by multi environmental testing, in which the relative performance of the test genotype is determined from one environment to another. When genotypes are grown in multi-environmental trials, significant differences are usually observed in yield performance over the tested environments. The observed differential yield response of genotypes from one environment to another is called Genotype $\times$ Environment ($G \times E$) interaction (Allard, 1964).

The presence of $G \times E$ interactions make it difficult for breeders to decide which genotype(s) should be selected (Ojo, 2000). Thus, the estimation of yield stability performance becomes important to identify consistent performing and high yielding genotypes whenever such interactions assume a practical importance in a testing programme (Kang, 1998).

Yield being a complex character, is influenced by number of yields contributing characters controlled by polygenes and also highly influenced by environment (Aravind *et al.*, 2006). Characters such as yield performance and its stability must be considered when selecting varieties for a production area (William, 2016). Since the performance of any variety varies from year to year and from environment to environment depending on factors such as weather, management practices and variety adaptation, it is therefore important to consider the performance of a variety in more than one environment. Hence, this study was conducted to assess the effects of planting environments on seed yield and yield related parameters among selected soybean genotypes.

MATERIALS AND METHODS

Twenty-four soybean genotypes were sourced from International Institute of Tropical Agriculture (IITA), Ibadan and planted over three environments; Lagos, Ibadan and Abeokuta. The experimental fields were ploughed and harrowed. Planting was done in Abeokuta in May, 2017 while planting was done in

Lagos and Ibadan in May and June, 2018, respectively. The fields were laid out in a randomized complete block design (RCBD) with three replicates. Sixty (60) seeds of each genotype were sown on a single row plot of 3m long, with 0.05m by 0.75m; intra and inter row spacing. Cultural practices such as weeding was done manually at three weeks interval, while 40ml of Cypermethrin in 15 liters of water was sprayed to control insect pest as at when necessary. Harvesting was done manually at maturity across the three locations.

Data collected on the following agronomic yield characters: number of days to 50% flowering, plant height at flowering, number of pods per plant, number of seeds per plant, 100 seed weight and yield per plant were subjected to analysis of variance (ANOVA), significant means were separated using Duncan Multiple Range Test (DMRT) at 5% probability level, Principal component analysis (PCA) and genotypic correlation coefficients were done.

RESULTS AND DISCUSSION

The main objective of a breeding programme is crop improvement, to produce seed of highest quality in terms of yield attributes. However, in attaining this, several factors such as climatic conditions and the genetic material among others must be given due considerations. The result (Table 1) showed that all soybean genotypes evaluated differed significantly ($p < 0.01$) from one another with respect to the tested seed yield traits across the three environments (Lagos, Ibadan and Abeokuta) except for plant height. Though, 100 seed weight was only significant at Abeokuta. The significant differences observed gives room to plant breeders for appropriate selection in soybean improvement. This result is in consonance with earlier findings of the following authors (Ojo, 2000; Goksoy *et al.*, 2009 and Lawal *et al.*, 2023) in soybean breeding programme.

The mean performance of twenty-four soybean genotypes tested across three environments (Table 2) showed that genotype TGx 2004-10F had the shortest day to flowering at Abeokuta (56.33), genotype TGx 1989-45F recorded the shortest day to flowering at Ibadan and Lagos with 55.83 and 58.00, respectively.

Table 1: Mean square values for seed yield attributes of soybean genotypes evaluated in three environments

ABEOKUTA

Sources of Variation	df	Days to flowering	Plant height (cm)	Number of pods/plant	No of seeds/plant	100-Seed weight (g)	Yield/plant (g)
Block	2	1.26	281.62*	1563.04*	15479.17**	5.32	246.05*
Genotype	23	13.74**	120.98	1304.14**	9066.13**	5.71*	139.75**
Error	46	0.96	70.37	453.75	2983.97	2.95	58.76

IBADAN

Sources of Variation	df	Days to flowering	Plant height (cm)	Number of pods/plant	No of seeds/plant	100-Seed weight (g)	Yield/plant (g)
Block	2	0.18	175.92**	2046.60*	3786.13	1.27	102.56*
Genotype	23	11.29**	42.08	1707.61**	7281.22**	7.37	151.01**
Error	46	0.73	29.04	594.13	2579.87	4.84	26.11

LAGOS

Sources of Variation	df	Days to flowering	Plant height (cm)	Number of pods/plant	No of seeds/plant	100-Seed weight (g)	Yield/plant (g)
Block	2	1.06	164.19	185.27	1214.64	8.77	49.49
Genotype	23	20.54**	98.95	1845.88**	14693.62**	14.88	439.64**
Error	46	1.30	68.58	618.97	5933.41	12.31	51.6

*, ** Significant differences at 0.05 and 0.01 levels of probability, respectively.

Table 2: Mean performance of twenty-four soybean genotypes tested across three environments

Gen	Days to flowering			Plant height (cm)			Number of pods/plant		
	Abeokuta	Ibadan	Lagos	Abeokuta	Ibadan	Lagos	Abeokuta	Ibadan	Lagos
1	49.00d	50.17fgh	51.00fg	57.27ab	59.18abc	58.80abc	40.33e	46.15e	45.37e
2	49.00d	51.50d-g	54.00cde	62.07a	62.95a	61.53ab	55.30cde	63.28cde	50.40de
3	53.67bc	54.83ab	56.00abc	62.33a	59.68ab	54.73a-d	43.40de	49.66de	127.17ab
4	49.00d	49.67gh	50.67fg	41.47bc	47.43d	51.10a-d	43.80de	50.12de	70.00cde
5	49.00d	50.00fgh	51.00fg	51.27abc	52.68a-d	51.80a-d	50.87cde	58.21cde	102.27abc
6	52.67bc	53.83bc	55.00bcd	61.80a	57.07a-d	50.03a-d	74.47a-e	85.21a-e	64.87cde
7	54.00b	55.83a	58.00a	46.87abc	53.25a-d	57.33a-d	69.70b-e	79.76b-e	81.40b-e
8	49.00d	52.50cd	56.00abc	58.80a	57.55a-d	54.00a-d	114.60a	131.13a	91.43a-e
9	49.00d	50.00fgh	51.00fg	61.53a	52.85a-d	41.87d	84.23a-d	96.39a-d	105.67abc
10	49.00d	49.00h	49.00gh	54.73ab	55.22a-d	53.40a-d	60.23cde	68.92cde	88.00a-e
11	49.00d	50.67e-h	52.33ef	51.10abc	55.97a-d	58.53abc	91.53abc	104.74abc	78.93b-e
12	49.00d	49.83fgh	51.00fg	51.80abc	56.97a-d	59.83abc	53.90cde	61.68cde	56.83cde
13	49.00d	50.17fgh	51.00fg	54.13ab	55.15a-d	53.87a-d	50.03cde	57.25cde	132.33a
14	49.00d	50.00fgh	51.00fg	58.67a	53.02a-d	45.07bcd	74.33a-e	85.06a-e	131.13a
15	49.00d	52.00de	55.00bcd	54.27ab	56.38a-d	56.20a-d	73.80a-e	84.45a-e	80.13b-e
16	49.00d	50.00fgh	51.00fg	56.57ab	54.48a-d	50.10a-d	110.43ab	126.37ab	92.27a-e
17	56.33a	55.17ab	53.67de	54.33ab	52.97a-d	49.30a-d	47.33de	54.16de	127.17ab
18	49.00d	50.00fgh	51.00fg	63.67a	61.83ab	57.70a-d	42.10de	48.17de	74.83cde
19	52.00c	52.83cd	53.67de	56.67ab	53.47a-d	47.97a-d	63.57cde	72.74cde	101.10abc
20	52.67bc	50.33fgh	48.00h	50.93abc	48.78cd	44.33cd	74.50a-e	85.25a-e	69.07cde
21	49.00d	51.33d-g	53.67de	56.23ab	52.83a-d	47.13a-d	61.00cde	69.80cde	66.20cde
22	49.00d	52.50cd	56.00abc	57.33ab	56.82a-d	54.00a-d	76.17a-e	87.16a-e	97.67a-d
23	49.00d	49.83fgh	51.00fg	54.00ab	58.92abc	61.53ab	68.40cde	78.27cde	81.90b-e
24	49.00d	52.83cd	56.67ab	37.47c	51.18bcd	62.60a	35.77e	40.93e	74.90cde

Means followed by the same alphabets along the column are not significantly different from one another at 5% probability level according to DMRT.

Table 2. Cont;d

Gen	Number of seeds/plant			100-Seed weight (g)			Yield/plant (g)		
	Abeokuta	Ibadan	Lagos	Abeokuta	Ibadan	Lagos	Abeokuta	Ibadan	Lagos
1	101.36efg	108.73g	96.53d	13.21ab	18.59a	19.13a	15.62b-e	27.82efg	27.63e-h
2	120.33c-g	120.70fg	99.33d	12.49a-d	15.72abc	14.87ab	17.64a-e	21.76g	15.40h
3	105.87d-g	272.64ab	390.33a	10.04b-e	14.20abc	14.67ab	12.00de	30.67c-g	39.87b-e
4	101.92efg	152.47c-g	175.57cd	13.42ab	16.83abc	15.87ab	13.57cde	22.88fg	20.97gh
5	122.55c-g	159.82c-g	168.33cd	11.12a-e	12.65c	10.90b	13.75cde	23.34fg	24.50fgh
6	184.19b-g	193.60b-g	168.17cd	12.07a-e	18.01ab	19.27a	25.53a-d	40.38abc	43.23bc
7	162.59b-g	218.64a-e	235.33bcd	9.50de	13.60bc	14.17ab	20.77a-e	25.62fg	21.40gh
8	304.29a	274.25abab	194.83cd	8.70e	15.25abc	17.83ab	30.49ab	38.61bcd	36.57c-f
9	205.50a-e	252.29abc	253.67abc	9.22de	12.81c	13.07ab	22.06a-e	29.87d-g	29.13d-h
10	127.85c-g	216.40a-f	266.00abc	13.03abc	16.86abc	16.30ab	25.84a-d	36.49b-e	35.90c-f
11	219.43abc	227.16a-e	194.00cd	11.50a-e	17.34ab	18.67a	31.23a	37.59b-e	32.40c-g
12	125.85c-g	168.36c-g	180.57cd	10.98a-e	17.40ab	19.30a	17.30a-e	36.53b-e	44.17bc
13	113.45c-g	206.84a-g	263.00abc	9.74cde	15.52abc	17.27ab	12.28de	30.96c-g	39.30b-e
14	185.14b-g	295.86a	353.33ab	11.31a-e	16.38abc	17.20ab	25.97a-d	43.93ab	50.97b
15	211.57a-d	248.48a-d	240.67bcd	11.69a-e	14.48abc	13.50ab	27.56abc	32.57c-f	27.93d-h
16	247.17ab	229.89a-e	171.23cd	11.73a-e	17.20ab	18.20a	31.81a	31.32c-g	19.37gh
17	105.77d-g	218.59a-f	292.07abc	12.17a-d	17.22ab	17.80ab	15.29b-e	47.92a	69.07a
18	93.31fg	147.70d-g	175.50cd	10.72b-e	15.72abc	16.63ab	12.17de	23.63fg	24.60fgh
19	156.01b-g	236.91a-d	275.17abc	11.40a-e	15.11abc	14.90ab	19.15a-e	23.71fg	18.20h
20	194.75b-f	196.99a-g	163.77cd	14.23a	17.30ab	15.87ab	28.65abc	32.56c-f	24.93
21	153.20b-g	183.06b-g	179.97cd	11.73a-e	15.53abc	15.30ab	25.82a-d	35.84be	35.50c-f
22	166.16b-g	201.74a-g	201.00cd	10.45b-e	16.54abc	18.33a	20.43a-e	32.06c-f	32.67c-g
23	172.87b-g	209.54a-f	208.50bcd	10.71b-e	16.64abc	18.23a	19.89a-e	36.92b-e	42.87bcd
24	83.24g	134.20efg	161.00cd	10.38b-e	16.70abc	18.67a	9.38e	23.71fg	26.90fgh

Means followed by the same alphabets along the column are not significantly different from one another at 5% probability level according to DMRT.

1=TGx 2006-3F, 2=TGx 2008-4F, 3=TGx 2010-12F, 4=TGx2004-13F, 5=TGx 1448-2E, 6=TGx 2010-11F,
7=TGx 1989-45F, 8=TGx1987-62F, 9=TGx 2010-3F, 10=TGx 1990-3F, 11=TGx 1989-20F, 12=TGx 1989-21F,
13=TGx 1990-95F, 14=TGx 1987-10F, 15=TGx 1835-10E, 16=TGx 1990-21F, 17=TGx 2004-10F, 18=TGx 1989-40F,
19=TGx 2007-8F, 20=TGx 1989-49FN, 21=TGx 1990-80F, 22=TGx 1991-10F, 23=TGx 1951-3F, 24=TGx 1993-4FN

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In terms of plant height, genotypes TGx 2008-4F, TGx 2010-12F, TGx 2010-11F, TGx1987-62F, TGx 2010-3F, TGx 1987-10F and TGx 1989-40F had statistically tallest heights at Abeokuta ranging from 58.67 to 63.67(cm). However, genotype TGx 2008-4F recorded the tallest plant height (62.95cm) in Ibadan while the tallest plant in Lagos (62.60cm) was genotype TGx 1993-4FN. For number of pods per plant, genotype TGx1987-62F had the largest number of pods per plant in Abeokuta (114.60) and Ibadan (131.13), while genotypes TGx 1990-95F and TGx 1987-10F both had the highest statistically similar values of 132.33 and 131.13, respectively in Lagos. Similarly, the highest number of seeds per plant in Abeokuta was observed in genotype TGx1987-62F (304.29), Ibadan in genotype TGx 1987-10F (295.86) and genotype TGx 2010-12F in Lagos (390.33). More so, Abeokuta had it highest 100 seed weight (14.23g) in genotype TGx 1989-49FN, Ibadan (18.59) in genotype TGx 2006-3F while Lagos (19.30) in genotype TGx 1989-21F which is statistically similar to other genotypes. Lastly, yield per plant had its highest mean value in Abeokuta with genotypes TGx 1990-21F and TGx 1989-20F (31.81 and 31.23g) respectively. Genotype TGx 2004-10F recorded the highest yield (49.92g) in Ibadan and Lagos with values 49.92 and 69.07g, respectively. The distinct performances observed among the twenty-four soybean genotypes across the three environments could be attributed to variation in the genetic makeup of those materials (Adebisi 2004; Lawal *et al.*, 2018) or the climatic condition of the growing period (Okelola *et al.*, 2022).

Table 3 and Figure 1a, b and c present the responses of seed yield characters across the three tested environments. Earliest days to 50% flowering was observed in Abeokuta (50.14), while the genotypes flower late in Lagos (52.78). However, soybean planted in Ibadan had the tallest plant height (55.28cm) meanwhile the shortest plant height (53.45cm) was recorded in Lagos. Conversely, Lagos environment produced soybean with the highest number of pods per plant (87.13) and number of seeds per plant (212.83) while Abeokuta environment had the least number of pods per plant and seeds per plant, 64.99 and 156.85, respectively.

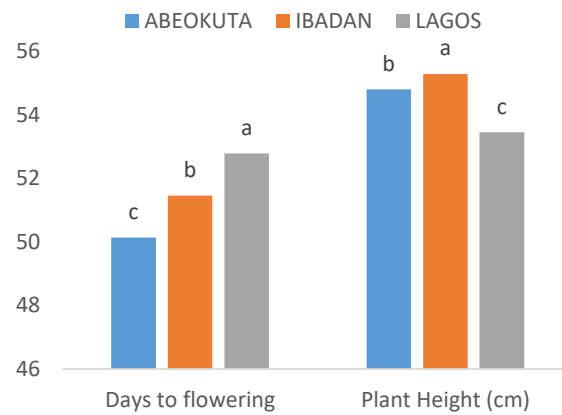


Figure 1a: Responses of number of days to flowering and plant height in three environments

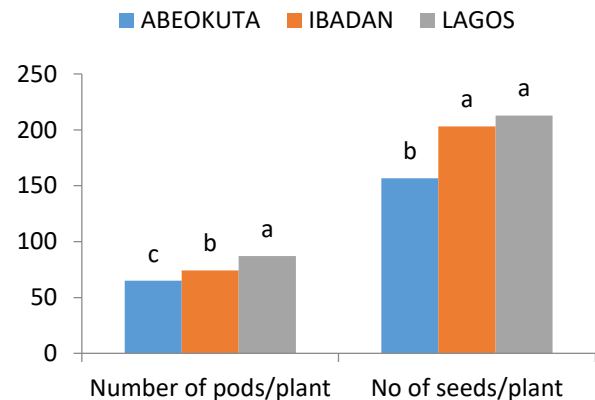


Figure 1b: Responses of number of pods per plant and number of seeds per plant in three environments

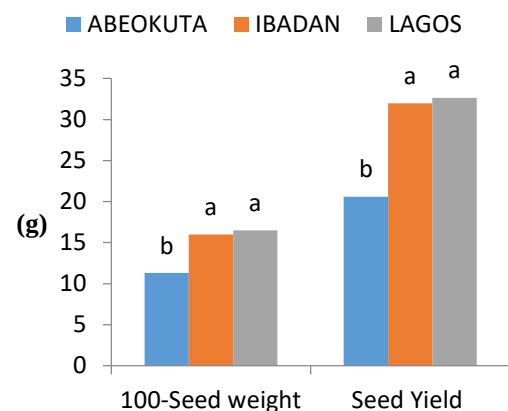


Figure 1c: Responses of 100-Seed weight and Seed yield in three environments

Similar pattern was observed for 100 seed weight and seed yield per plant, where soybean grown in Lagos recorded the highest value of 16.50g and 32.64g, respectively, the performance was followed by that of

Ibadan environment with values 15.98 and 31.95g, respectively, while Abeokuta produced the least performing genotypes with respect to 100 seed weight (11.31g) and seed yield per plant (20.59g).

Table 3: Responses of seed yield character across the tested environments.

Environments	Days to flowering	Plant height (cm)	Number of pods/plant	No of seeds/plant	100-Seed weight (g)	Yield/plant (g)
Abeokuta	50.14	54.8	64.99	156.85	11.31	20.59
Ibadan	51.45	55.28	74.37	203.12	15.98	31.95
Lagos	52.78	53.45	87.13	212.83	16.5	32.64

DFLW = Days to flowering
S/PLT = seeds per plant

PHFLW = plant height at 50% flowering
100SW = hundred seed weight

P/PLT= pods per plant
Y/PLT = yield per plant

The differences in these cropping environments possibly might have caused the responses of the 24 soybean genotypes with respect to the seed yield characters evaluated as the weather conditions for the growing periods showed that temperature values for the growing environments were relatively close (average values of 27.1, 27.9 and 25.8 °C) for Abeokuta, Lagos and Ibadan, respectively (Appendix 1). The highest rainfall was recorded in Ibadan (1161mm), followed by Abeokuta (804.2mm) while the least rainfall (729.9mm) was observed in Lagos.

Eigen value, percentage of total variation accounted for, cumulative of the character loading of the first four principal component axes among the 24 soybean genotypes is presented in Table 4. The first four

component axes accounted for 73% of the total variations observed among the genotypes. The first axis, (PC1) accounted for 32 of the total variation, while the second PC (PC2) and the third PC (PC3) accounted for 19 and 13% of the variation, respectively. However, the fourth (PC4) contributed 9% of the total variation among the 24 soybean genotypes. The variation observed along the first axis was attributed to characters with relative high loading scores (≥ 3.00) which included number of days to flowering (0.44). In PC2, number of pods per plant (0.51), number of seeds per plant (0.51) and yield per plant (0.44) had major contribution to variation within the axis. However, PC4 was loaded with plant height at flowering (0.59), 100 seed weight (0.44).

Table 4: Eigen value, percentage of total variation accounted for, cumulative of the character loading of the first four principal component axes among the 24 soybean genotypes

Variables	PC1	PC2	PC3	PC4
DFLW	0.44	-0.22	0.13	-0.02
PHFLW	0.05	0.10	0.23	0.59
P/PLT	0.21	0.51	-0.07	-0.11
S/PLT	0.23	0.51	0.10	-0.20
100SW	0.24	0.11	-0.12	0.44
Y/PLT	0.27	0.44	0.05	0.20
Proportion-of Variance	0.32	0.19	0.13	0.09
Cumulative Proportion	0.32	0.51	0.64	0.73
EigenValues	3.86	2.25	1.53	1.11

Bolded values recorded significant contribution (0.30 and above)

Table 5: Combined genotypic correlation coefficients between plant characters evaluated among 24 soybean genotypes across the three locations.

	PHFLW	P/PLT	S/PLT	100SW	Y/PLT
DFLW	0.01	0.03	0.24	-0.56**	0.09
PH50FLW		-0.26	-0.24	0.08	-0.11
P/PLT			0.84**	-0.66**	0.42*
S/PLT				-0.85**	0.52**
100SW					0.21

*,**significant at 1 and 5 %

DFLW = Days to flowering
S/PLT = seeds per plantPHFLW = plant height at 50% flowering
100SW = hundred seed weightP/PLT = pods per plant
Y/PLT = yield per plant

The combined genotypic correlation coefficients between plant characters evaluated among twenty-four genotypes of soybean across the three locations is presented in Table 5. It was deduced from the result that number of pods per plant recorded a significant and positive correlation with number of seeds per plant ($r=0.84^{**}$). Yield per plant also recorded positive and significant correlation with number of pods per plant ($r=0.42^{**}$), as well as number of seeds per plant ($r=0.52^{**}$).

CONCLUSIONS AND RECOMMENDATION

Results from this study concluded that the three environments differed significantly and affected the response of soybean yield traits evaluated. TGx 2004-10F was identified as stable and high yielding genotype in Lagos and Ibadan and therefore recommended for soybean improvement programme. More so, characters such as number of pods per plant and number of seeds per plant should be considered when selecting for yield in soybean. Yield being a complex trait; further studies should be conducted to determine other characters contributing to soybean yield.

Appendix 1: Average monthly rainfall, temperature, and relative humidity during growing periods of three locations in Nigeria.

	ABEOKUTA 2017			LAGOS 2018			IBADAN 2018		
	Rainfall (mm)	Temp. (°C)	R.H. (%)	Rainfall (mm)	Temp. (°C)	R.H. (%)	Rainfall (mm)	Temp. (°C)	R.H. (%)
April	112.8	28.6	63.2	25.2	29	75	149	28	76
May	146	27.8	68.9	57	28	76	151	27	75
June	111	27.5	73.8	119.5	27	77	184	26	76
July	156.1	26	74.5	95.9	26	82	166	28	81
August	90.5	25.4	77.4	61.5	26	81	144	27	85
Sept	50	25.5	69.1	146.6	26	81	186	16	83
Oct	92.2	27.6	72.8	117.3	30	74	162	27	80
Nov	45.6	28.9	65.7	106.9	31	73	19	27	71

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HOW TO CITE THIS ARTICLE:

Lawal, I.T., Olasunkanmi, T.C., Azeez, S. and Shittu, M.M. (2026) EVALUATING SEED YIELD AND YIELD RELATED TRAITS IN SOYBEAN (*Glycine max* L. Merrill) GENOTYPES AS INFLUENCED BY PLANTING ENVIRONMENTS IN SOUTH WESTERN NIGERIA. *Nigeria Journal Of Plant Breeding* (<https://pbanjournal.org/>), 3(2), 189-197. ISSN: 2814-3531