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Influence of planting date on phenology and yield of soybean genotypes in Sierra Leone

Yila, K. M.[1], Momoh, E. J. J.[2], Ndoko, E. J.[1], Mansaray, A.[1] and Conteh, A. R.[1]

[1]Sierra Leone Agricultural Research Institute, Njala Agricultural Research Centre, PMB 540, Freetown
[2]Dept. of Crop Science, School of Agriculture, Njala University, Njala, PMB Freetown, Sierra Leone

✉ For any information: ask.author@journalbinet.com, Available online: 14 May 2018.

ABSTRACT

Field experiments were conducted at SLARI's on-station sites located at Rogbasha, Sumbuya and Serabu during the year 2013 cropping season to evaluate the influence of planting date on the phenology and yield of soybean genotypes in Sierra Leone. The experiment was arranged in a split plot design with 3 replications in each location. Five planting dates (June 7, June 28, July 14, August 15 and September 5) were assigned to the main plots and five soybean genotypes (TGx 1448-2E, TGx 1904-6F, TGx 1951-3F, TGx 1951-4F and TGx 1955-4F) to the subplots using a randomized complete block design. Planting date had a significant influence on the phenology and yield of the soybean genotypes evaluated. The number of days from emergence (VE) to full flower (R2), full pod (R4) and physiological maturity (R7), thenumber of pods plant^{-1}, 100-seed mass and grain yield for each soybean genotype decreased significantly in each location when planted late i.e. August 15 and beyond.The grain yield, number of pods plant^{-1} and 100-seed mass of soybean depend directly on the influence of the days to full fower, full pod and physiological maturity. The significant decrease in the days to full fower, full pod and physiological maturity in soybean when planted after July 14 altered the optimum yield potential in the soybean genotypes. For optimum grain yields, farmers in Sierra Leone should plant TGx 1448-2E, TGx 1904-6F, TGx 1951-3F, TGx 1951-4F and TGx 1955-4F not later than mid-July under rain-fed conditions.

Key Words: *Planting date, Soybean, Phenology, Genotype and Grain yield*

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I. Introduction

Soybean [*Glycine max* (L.) Merr] is a leguminous grain crop that adapts to a wide range of specific agro-ecologies (Dlamini, 2015). It is a multipurpose crop that is grown for oil production, human food, livestock feed, industrial purposes, and recently for bio-energy (Mathu et al., 2010). The growing environment of soybean influence changes in its phenological growth stages and yield. The duration of the phenological growth stages and yield in soybean greatly depends on the genetic constitution of the crop and environmental factors, i.e., rainfall, photoperiod, temperature, and their interactions (Heatherly, 2005). Research indicates that unsuitable planting date predisposes soybean plants to

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different climatic factors (water, temperature, relative humidity, and day length) that greatly affect its phenological growth stages, yield and yield components (Nielson, 2011). The vegetative stage (VE) starts with the emergence of the cotyledons. After emergence, unifoliolate leaves on the first node unroll and the cotyledon (VC) stage starts. The number of nodes defines the subsequent vegetative stages with fully developed trifoliate (V1 – V5). The reproductive growth stage starts with flowering (R1: flower initiation and R2: full bloom) and progress to pod formation (R3: pod initiation and R4: full pod), seed development (R5: seed initiation and R6: full seed) and plant maturation (R7: physiological maturity and R8: full maturity). The duration of soybean developmental stages is very critical for yield determination (Chen and Wiatrak, 2010). The reproductive stages are the most important phase concerning yield determination. The duration from emergence (VE) to flower initiation (R1) and R1 to beginning of seed formation (R5) are critical in determining the number of pods and seeds that a plant will produce, while R5 to physiological maturity (R7) are important stages in the determination of seed size (Pedersen and Lauer, 2004).

Date of planting is an important crop management practice that affects soybean phenology and yield (Calvino et al., 2003), which is also important for other crops (Siddique et al., 2007). The grain yield of soybean is usually higher when planting is done early, this could be attributed to the longer duration of the vegetative and reproductive growth stages and favourable environmental conditions that supports soybean growth and development (Chen and Wiatrak, 2010). In Sierra Leone, farmers usually plant soybeans late, i.e., during the second season (mid-August to early September). Even though early planting of soybean produces higher grain yieldlate planting during the second season is mostly preferred in order to obtain good quality grains. The second season in Sierra Leone is characterized by suboptimal day lengths and low and erratic rainfall. These environmental conditions can greatly influence flowering, pod formation, and seed development and maturity period in soybean (Nielson, 2011). According to Hu (2013), days to flowering, pod formation and maturity period are important phenological stages that affect soybean yield and yield components. As production of soybean is expected to increase in Sierra Leone due to its increasing demand for human food and animal feed, it is, therefore, important to study the phenological and yield response of diverse soybean genotypes to varying environmental conditions under rain-fed conditions. In this regard, the present study evaluated the influence of planting date on the phenology and yield of soybean genotypes in Sierra Leone.

II. Materials and Methods

Description of the experimental sites: The experiment was conducted at SLARI's on-station sites located at Rogbasha (N 08.76625°; W 011.98317°), Sumbuya (N 08.04088°; W 011.78955°) and Serabu (N 07.85249°; W 011.27757°) during the year 2013 cropping season. The land at each experimental site was relatively flat and no indication of soil degradation. The soils were loamy-sand and acidic in nature with low organic carbon, available phosphorus, total nitrogen and potassium (Table 01).

Table 01. Soil properties of experimental site

	Location		
Soil Properties	Rogbasha	Sumbuya	Serabu
Texture	Loamy-sand	Loamy-sand	Loamy-sand
Sand (%)	91	90	88
Silt (%)	1	4	6
Clay (%)	8	6	6
Organic carbon (%)	2.4	1.9	2.3
PH (1:2:5)	5.2	5.2	4.7
Total Nitrogen (%)	0.3	0.2	0.5
Available Phosphorus(μgPg^{-1})	0.7	2.3	5.4
Exchangeable Potassium (Meq/100g soil)	0.32	0.43	0.26

Standard rain gauges (Model: SRG, HyQuest Solutions) were installed at each trial site to collect rainfall data. The total rainfall from June to December in Rogbasha, Serabu and Sumbuya during the year 2013 cropping season were 2164.9 mm, 2404.8 mm and 2005.1 mm respectively. Rainfall declined gradually in each location after the month of August (Table 02).

The data for day length was obtained from http://www.sunrise-and-sunset.com/en/sun/sierra-leone. Day length for Kenema, Bo and Makeni represented the trial sites at Serabu, Sumbuya and Rogbasha respectively. Similar day length was observed at each location. The lowest and highest day length was observed in the month of December and June respectively. The average day length in October, November and December was less than 12 hours (Table 02).

Table 02. Monthly rainfall and day length at each location

Month	Rogbasha		Serabu		Sumbuya	
	Rainfall (mm)	Day length (Hr: Min)	Rainfall (mm)	Day length (Hr: Min)	Rainfall (mm)	Day length (Hr: Min)
June	247.1	12:34	333.5	12:34	262.5	12:34
July	512.3	12:31	443.3	12:31	438.0	12:31
August	702.5	12:21	788.0	12:21	530.5	12:21
September	389.0	12:09	568.0	12:09	473.5	12:09
October	288.0	11:56	200.0	11:56	285.6	11:56
November	26.0	11:45	35.0	11:45	15.0	11:45
December	0.0	11:39	37.0	11:39	0.0	11:39

Experimental design and treatments: The experiment was arranged in a split plot design with three replications in each location. Five planting dates (June 7, June 28, July 14, August 15 and September 5) were assigned to the main plots and 5 soybean genotypes (TGx 1448-2E, TGx 1904-6F, TGx 1951-3F, TGx1951-4F and TGx 1955-4F) to the subplots using a randomized complete block design. TGx 1448-2E is a late maturity, TGx 1904-6F and TGx 1955-4F are medium maturity, whilst TGx 1951-3F, TGx 1951-4F are early maturity genotypes. The early, medium and late maturity soybean mature less than 100 days, 100 – 115 days and above 115 days respectively (Tefera, 2011).

Management practices: Land preparation at the experimental sites was done manually and plots demarcated according to the experimental design. The subplots were 12 m^2 (3 m x 4 m) and each plot consisted of six rows of soybean plants. Plant spacing was 0.5 m between rows and 0.1 m between plants. Two soybean seeds were planted per hill giving a population of 400,000 plants ha^{-1}. The soybean seeds were inoculated with *Rhizobium* species before planting. The inoculated seeds were planted immediately at a depth of 3 cm. At planting, 30 kg ha^{-1} of P_2O_5 in the form of single super phosphate (SSP) was applied in a 2-cm deep trench, 10 cm away from the planting line. Regular hoe weeding was done to keep the plots free from weeds.

Data collection procedures and analysis: The number of days from emergence (VE) to full flowering (R2), emergence to full pod formation (R4), and emergence to physiological maturity (R7) was recorded. The duration of the phenological growth stage was determined by daily observation of the soybean plants and it was defined when at least 50% of the plants were in the same stage.

At full maturity, a sampled area of 8 m^2 (2 m x 4 m) was established within the four middle rows in each subplot to collect data on yield and yield attributes. The average number of filled pods $plant^{-1}$ was determined from 10 plants randomly selected from the centre two rows in each subplot. The pods having at least two seeds were considered filled-pods. The grains were separated from the pods harvested from the 8 m^2 sample area and sun-dried to 10% moisture content. One hundred seeds were selected and weighed on a digital scale (Model: KD-200-510, Tanita Worldwide) to determine the 100-seed mass (g). The total grains for each treatment plot was weighed on a digital scale and the mass used to calculate the grain yield (t ha^{-1}).

The data was analysed by location using the PROC MIXED procedure of SAS 9.4 (SAS Institute, 2012). Planting date, soybean genotype and their interactions were considered as fixed effects in determining the expected mean square and appropriate F-test whilst replication was considered as a random effect. Means were separated using the LSMEANS statement of PROC Mixed code of SAS with option pdiff. The LSMEANS statement computes the least squares means (lsmeans) of fixed effects. The pdiff option calculates the difference between two lsmeans and their standard error of the difference (SED) at 5% level of probability. PROC CORR procedure of SAS 9.4 (SAS Institute, 2012) was used to calculate Pearson's correlation coefficient among the parameters studied.

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III. Results and Discussion

Days to full flowering (VE - R2)

The number of days from emergence to full flowering was significantly influenced by date of planting ($P < 0.0001$) at each location. Days to full flowering decreased significantly at each location when soybean was planted on August 15 and beyond. With respect to the earlier planting dates (June 7, June 28 and July 14), days to full flowering decreased by approximately 2 days when planted on August 15 and 3 days when planted on September 5 in all the locations (Figure 01). Ngalamu et al. (2012) have also reported similar results of early flowering in soybean due to late planting in Sudan. Soybean is very sensitive to photoperiod, a variation in day length by 15 minutes; and a day length of below 12 hours can induce flowering in soybean irrespective of the maturity period of the variety (http://ecocrop.fao.org/ecocrop/srv/en/cropView?id=1150). Day length gradually decreases at each location (Table 02), this may have triggered the early flowering in the late-planted soybean.

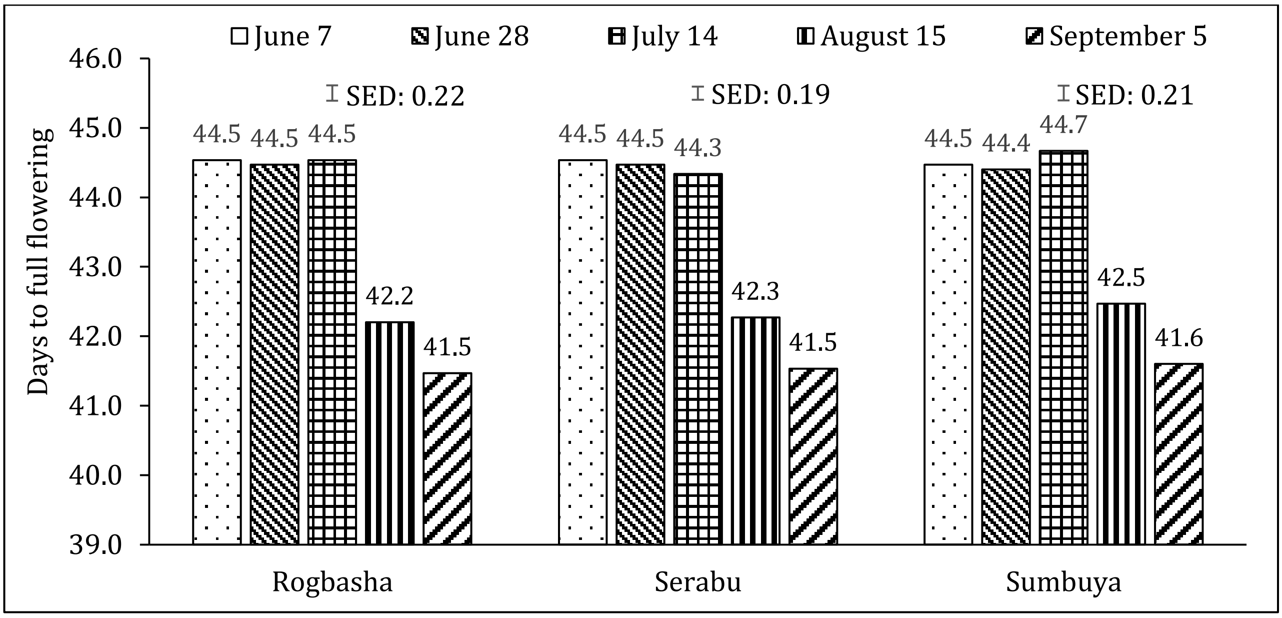

Figure 01. Effect of date of planting on days to full flowering (VE – R2) at each location.

Days to full pod formation (VE - R5)

The number of days from emergence to full pod formation was significantly influenced by date of planting ($P < 0.0001$) at each location. Soybean genotype significantly influenced the days to full pod formation at Rogbasha ($P < 0.0001$), Serabu ($P = 0.0001$) and Sumbuya ($P < 0.0001$). The number of days from emergence to full pod formation in soybean decreased significantly when planted beyond July 14. With respect to the earlier planting dates (June 7, June 28 and July 14), days to full pod formation decreased by approximately 3 days when planted on August 15 and September 05 (Table 03). Ngalamu et al. (2012) have earlier reported a significant decrease in the number of days from emergence to pod formation in soybean when planting was delayed. The reduction in the days to full pod formation when planting was delayed could be associated to the early flowering of late-planted soybeans as evidence in the significant and positive correlations ($P < 0.0001$, $r = 0.68$) between days to full flowering and full pod formation. According to Muhammad (2008), the number of days from emergence to flowering depicts the successive reproductive stages in soybean. At each location, days to full pod formation differ significantly among the soybean genotypes except for TGx 1904-6F and TGx 1951-4F which were not significantly different. Variation in the days to full pod formation among the soybean genotypes could be associated with genetic factors because the soybean genotypes have different maturity periods.

Table 03. Effect of date of planting and soybean genotype on the number of days from emergence to full pod formation at each location

	Location		
Treatments	Rogbasha	Serabu	Sumbuya
Date of planting			
June 7	72.5	72.6	72.8
June 28	73.4	74.1	73.1
July 14	73.3	73.6	73.5
August 15	70.2	69.8	69.1
September 5	70.2	69.9	70.1
SED	0.32	0.35	0.50
Soybean genotype			
TGx 1448-2E	72.9	72.9	73.0
TGx 1955-4F	72.5	72.4	72.5
TGx 1904-6F	71.5	71.6	71.4
TGx 1951-3F	71.1	71.7	70.3
TGx 1951-4F	71.7	71.4	71.4
SED	0.32	0.35	0.50

SED: Standard error of difference between two means at 0.05 level of probability.

Table 04. Interactive effect of date of planting (D) and soybean genotype (G) on the number of days from emergence to physiological maturity at each location

		Soybean Genotype					
Location	Date of plating	TGx 1448-2E	TGx 1904-6F	TGx 1955-4F	TGx 1951-4F	TGx 1951-3F	Mean
Rogbasha	June 7	116.3	111.7	110.3	102.3	100.3	108.2
	June 28	115.7	111.3	110.3	102.7	100.3	108.1
	July 14	115.7	111.0	110.7	102.7	100.3	108.1
	August 15	112.7	108.3	105.3	96.7	96.3	103.9
	September 5	103.7	104.3	103.3	96.7	96.3	100.9
	Mean	112.8	109.3	108.0	100.2	98.7	
	SED: D			0.23			
	SED: G			0.23			
	SED: D x G			0.52			
Serabu	June 7	116.7	111.7	110.7	102.3	100.7	108.4
	June 28	115.7	111.7	110.3	102.3	100.7	108.1
	July 14	115.3	111.7	110.7	102.3	100.3	108.1
	August 15	112.7	108.7	105.7	96.7	96.7	104.1
	September 5	103.3	104.3	103.3	96.3	96.3	100.7
	Mean	112.7	109.6	108.1	100.0	98.9	
	SED: D			0.26			
	SED: G			0.26			
	SED: D x G			0.57			
Sumbuya	June 7	116.7	111.3	110.7	102.7	100.3	108.3
	June 28	115.3	111.7	110.7	102.7	100.3	108.1
	July 14	116.0	111.7	110.3	102.7	100.7	108.3
	August 15	112.3	108.3	105.3	96.3	96.3	103.7
	September 5	105.0	104.7	103.7	96.7	96.7	101.3
	Mean	113.1	109.5	108.1	100.2	98.9	
	SED: D			0.23			
	SED: G			0.23			
	SED: D x G			0.51			

SED: Standard error of difference between two means at 0.05 level of probability.

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Days to physiological maturity (VE - R7)

The number of days from emergence to physiological maturity was significantly influenced by date of planting ($P < 0.0001$), soybean genotype ($P < 0.0001$) and their interaction ($P < 0.0001$) at each location. Averaged across genotypes, the days to physiological maturity of the soybean planted on June 07, June 28 and July 14 were not significantly different at each location. When compared to these planting dates, the days to physiological maturity significantly decreased by approximately 4 days when planted on August 15 and 7 days when planted on September 5 at each location. Averaged across planting dates, the average days to physiological maturity at each location differ significantly among the soybean genotypes. TGx 1448-2E took a significantly longer time to mature followed by TGx 1904-6F, TGx 1955-4F, TGx 1951-4F and TGx 1951-3F. However, days to physiological maturity were not significantly different whenTGx 1951-4F and TGx 1951-3F were planted on August 15 and September 5, TGx 1448-2E and TGx 1955-4F when planted on September 5 at Rogbasha and Serabu, and TGx 1448-2E and TGx 1904-6F when planted on September 5 at Sumbuya (Table 04). Muhammad (2008) has also confirmed the consistent reduction in the number of days from planting to maturity in soybean when planted late. There was a significant and positive correlation between days to physiological maturity and days to full flowering ($P < 0.0001$; $r = 0.42$) and days to full pod formation ($P < 0.001$; $r = 0.57$) indicating a decrease in the number of days of full flowering and full pod formation soybean can cause a decrease in the days to physiological maturity. The significant reduction in the number of days to physiological maturity when planted on August 15 and beyond could be associated with drought stress as rainfall declined towards the end of the growing season at each location, which resulted in some genotypes with different maturing periods reaching physiological maturity at almost the same time. According to Frederick et al. (2001), water stress during the reproductive stages in soybean may shorten the maturation period in diverse soybean genotypes. The differences in the number of days from emergence to physiological maturity among the soybean genotypes may be attributed to the variability in the genetic attributes of the soybean genotypes. TGx 1448-2E is a late maturing genotype, TGx 1904-6F and TGx 1955-4F are medium maturing genotypes whilst TGx 1951-4F and TGx 1951-3F are early maturing genotypes.

Number of filled pods plant^{-1}

The number of filled pods plant^{-1} was significantly influenced by date of planting ($P < 0.0001$) at each location. Soybean genotype significantly influenced the number of filled pods plant^{-1} at Rogbasha ($P < 0.0001$) and Sumbuya ($P = 0.0007$). The number of filled pods plant^{-1} decreased by 62.9% at Rogbasha, 64.0% at Serabu and 64.5% at Sumbuya when planting was delayed planting from July 14, which had the highest number of filled pods plant^{-1} to August 15 at each location. The number of filled pods plant^{-1} was significantly higher in TGx 1448-2E than the other soybean genotypes (Table 05). Desclaux et al. (2000) have also reported a reduction in the number of pods plant^{-1} in late-planted soybean. Soybean planted later in the rainy season (August 15 and September 5) flowered prematurely, causing a reduction in the vegetative growth period. Conversely, soybean planted in June and July planting dates were exposed to longer vegetative growth period, thus producing more nodes and flowers for subsequent pod formation than those planted in August and September at all the locations. This was evident in the significant and positive correlation ($P < 0.0001$, $r = 0.89$) between the number of filled pods plant^{-1} and days to full flowering which indicates an increase in the vegetative growth stage, i.e., from planting to flowering could increase the number of filled pods plant^{-1} in soybean. Kumudini et al. (2007) confirmed that early planting exposes soybean plants to longer vegetative growth periods, and this could increase the number of pods plant^{-1} as suggested by Hu (2013). Morphological characteristics such as the number of pods plant^{-1} are dependent on the genetic constitution of the genotype. This was evident in the significant variability in the number of pods plant^{-1} among the soybean genotypes. Differences in the number of pods plant^{-1} among soybean genotypes have also been reported by Ugur et al. (2005).

Table 05. Effect of date of planting and soybean genotype on the number of filled pods plant^{-1} at each location

Treatments	Location		
	Rogbasha	Serabu	Sumbuya
Date of planting			
Jun_7	22.6	22.6	22.8
Jun_28	22.3	22.6	23.4
Jul_14	23.6	23.8	23.9
Aug_15	8.8	8.6	8.5
Sep_5	8.1	8.8	8.7
SED	0.56	0.51	0.41
Soybean genotype			
1448_2E	17.6	18.2	18.5
1955_4F	17.0	17.1	17.2
1904_6F	17.1	16.9	17.7
1951_3F	17.2	17.4	17.2
1951_4F	16.6	16.9	16.7
SED	0.56	0.51	0.41

SED: Standard error of difference between two means at 0.05 level of probability

Table 06. Interactive effect of date of planting (D) and soybean genotype (G) on 100-seed mass (g) at each location

Location	Date of plating	Soybean Genotype					
		TGx 1448 2E	TGx 1904 6F	TGx 1955 4F	TGx 1951 4F	TGx 1951 3F	Mean
Rogbasha	June 7	14.5	14.6	15.4	14.9	15.5	15.0
	June 28	14.7	14.5	15.5	14.8	15.5	15.0
	July 14	14.7	14.5	15.5	14.6	15.4	14.9
	August 15	12.6	12.6	12.5	12.5	12.4	12.5
	September 5	12.4	12.5	12.5	12.5	12.4	12.4
	Mean	13.8	13.7	14.3	13.8	14.2	
	SED: D	0.09					
	SED: G	0.09					
	SED: D x G	0.20					
Serabu	June 7	14.5	14.6	15.5	14.5	15.5	14.9
	June 28	14.5	14.6	15.4	14.5	15.7	15.0
	July 14	14.5	14.4	15.6	14.5	15.6	14.9
	August 15	12.4	12.6	12.5	12.5	12.4	12.5
	September 5	12.5	12.5	12.5	12.4	12.4	12.4
	Mean	13.7	13.7	14.3	13.7	14.3	
	SED: D	0.05					
	SED: G	0.05					
	SED: D x G	0.12					
Sumbuya	June 7	14.5	14.5	15.6	14.4	15.5	14.9
	June 28	14.6	14.5	15.3	14.5	15.5	14.9
	July 14	14.4	14.5	15.6	14.5	15.5	14.9
	August 15	12.5	12.7	12.5	12.4	12.4	12.5
	September 5	12.5	12.4	12.5	12.5	12.5	12.5
	Mean	13.7	13.7	14.3	13.6	14.3	
	SED: D	0.04					
	SED: G	0.04					
	SED: D x G	0.10					

SED: Standard error of difference between two means at 0.05 level of probability.

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100-seed mass (g)

The 100-seed mass of soybean was significantly influenced by date of planting ($P < 0.0001$), soybean genotype ($P < 0.0001$) and their interaction ($P < 0.0001$) at each location. Averaged across genotypes, the mass of 100 seeds in soybean significantly decreased by 16.1% in Rogbasha, 16.4% in Serabu and 16.1% in Sumbuya when planting was delayed from July 14 to August 15. In each location, the 100-seed mass of TGx 1955-4F and TGx 1951-3F were higher (> 15 g) than the other genotypes when planted before August 15. However, the mass of 100 seeds for each soybean genotype when planted on August 15 and beyond was less than 13 g (Table 06). Reduction in 100-seed mass due to late planting of soybean has been reported by Rahman et al. (2006). The reduction of the 100-seed mass of soybean due to late planting could be attributed to the decline in rainfall in October and subsequent months (Table 02) subjecting the late planted soybean plants to drought stress. Drought stress during seed development can reduce the seed size in soybean (Frederick et al., 2001). With respect to genotype effect, the higher 100-seed mass for TGx 1955-4F and TGx 1951-3F could be attributed to variation in the genetic characteristic of the soybean genotypes. Under the same management condition, the seeds of TGx 1955-4F and TGx 1951-3F are relatively larger than the other genotypes.

Grain yield (t ha^{-1})

The grain yield of soybean was significantly influenced by date of planting ($P < 0.0001$), soybean genotype ($P < 0.0001$) and their interaction ($P < 0.0001$). Averaged across genotypes, the grain yield in soybean for each planting date differ significantly. Soybean planted on June 28 produced the highest grain yield. The average grain yield of soybean significantly decreased by 137.3% at Rogbasha, 137.6% at Serabu, and 137.6% at Sumbuya when planting was delayed from July 14 to August 15 (Table 07).

Table 07. Interactive effect of date of planting (D) and soybean genotype (G) on grain yield (t ha^{-1}) at each location

Location	Date of plating	Soybean Genotypes TGx 1448-2E	TGx 1904-6F	TGx 1955-4F	TGx 1951-4F	TGx 1951-3F	Mean
Rogbasha	June 7	1.15	1.18	1.47	1.40	1.67	1.30
	June 28	1.58	1.70	1.71	1.46	1.59	1.61
	July 14	1.58	1.56	1.28	1.49	1.54	1.48
	August 15	0.72	0.59	0.59	0.59	0.66	0.62
	September 5	0.57	0.65	0.47	0.44	0.54	0.53
	Mean	1.12	1.13	1.11	1.08	1.20	
	SED: D			0.003			
	SED: G			0.003			
	SED: D x G			0.006			
Serabu	June 7	1.15	1.17	1.47	1.39	1.68	1.30
	June 28	1.58	1.70	1.72	1.47	1.59	1.62
	July 14	1.58	1.56	1.28	1.49	1.55	1.48
	August 15	0.71	0.59	0.60	0.59	0.66	0.62
	September 5	0.57	0.65	0.48	0.44	0.54	0.54
	Mean	1.12	1.13	1.11	1.08	1.20	
	SED: D			0.002			
	SED: G			0.002			
	SED: D x G			0.004			
Sumbuya	June 7	1.15	1.17	1.47	1.40	1.67	1.30
	June 28	1.59	1.70	1.71	1.47	1.59	1.62
	July 14	1.59	1.56	1.28	1.49	1.55	1.48
	August 15	0.72	0.59	0.60	0.59	0.66	0.62
	September 5	0.54	0.64	0.48	0.44	0.54	0.53
	Mean	1.12	1.13	1.11	1.08	1.20	
	SED: D			0.004			
	SED: G			0.004			
	SED: D x G			0.009			

SED: Standard error of difference between two means at 0.05 level of probability

The reduction in the grain yield with delayed planting has also been reported by Khan et al. (2004) and Rahman et al. (2006). Averaged across planting dates, the highest grain yield in soybean was produced by TGx 1951-3F. However, each genotype responded differently to the planting date. The highest grain yields were produced by TGx 1951-3F when planted on June 7, TGx 1955-4F when planted on June 28, TGx 1448-2E when planted on July 14 and TGx 1904-6F when planted on September 5 (Table 07). Malik et al. (2006) and Hu (2013) have also reported variation in grain yields among soybean genotypes when planted at different dates. The significant decrease in the grain yield of soybean when planted late i.e. August 15 and September 5 may be associated with the decrease in the number of pods plant^{-1} and 100-seed mass in the late planted soybean. The grain yield in soybean was significant, strong and positively correlated to the number of pods plant^{-1} ($P < 0.0001$, $r = 0.94$) and 100-seed mass ($P < 0.0001$, $r = 0.92$) which indicates that a decrease in the number of pods plant^{-1} and 100-seed mass in soybean can cause a decrease in the grain yield. The variability in the grain yield among the soybean genotypes may be attributed to the genetic constitution of the crop. According to Muhammad (2008), each soybean cultivar responds differently to changes in the climatic environment during its growth and development, and a slight change greatly affects soybean yield and yield components.

IV. Conclusion

Planting date had a significant influence on the phenology and yield of soybean genotypes. The number of days from emergence (VE) to full flower (R2), full pod (R4) and physiological maturity (R7), the number of pods plant^{-1}, 100-seed mass and grain yield for each soybean genotype decreased significantly in each location when planted late i.e. August 15 and beyond. The grain yield, number of pods plant^{-1} and 100-seed mass of soybean depend directly on the influence of the days to full flower, full pod and physiological maturity. The significant decrease in the days to full flower, full pod and physiological maturity in soybean when planted after July 14 altered the optimum yield potential in the soybean genotypes. For optimum grain yields, farmers in Sierra Leone should plant TGx 1448-2E, TGx 1904-6F, TGx 1951-3F, TGx 1951-4F and TGx 1955-4F not later than mid-July under rain-fed conditions.

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