International Journal on Food, Agriculture, and Natural Resources
Volume 7, Issue 3, Page 14-20
ISSN: 2722-4066
http://www.fanres.org

Original Paper

Determination of the appropriate sowing date for irrigated soybean varieties in low land of Amhara, Ethiopia

Fentahun Biset[1], Tesfaye Jorgi[1], Melaku Azanaw[1], Tesfa Kasahun[1], Mogose Marie[1], and Anteneh Adebabay[1]*

1) Amhara Agricultural Research Institute, Gondar, Ethiopia, P.O.Box 1337
**) Corresponding Author: fentahunb11@gmail.com*

Received: 30 March 2026; Revised: 06 July 2026; Accepted: 30 September 2026
DOI: *https://doi.org/10.46676/ij-fanres.v7i3.638*

***Abstract*—Soybean sowing date and varieties experiment was conducted at Metema from 2022 to 2023 and at Belesa during the 2023 irrigation seasons, to determine the appropriate sowing date for irrigated soybean varieties. A factorial combination of two varieties (Pawi-03 and Gazelle) and five sowing dates (20th November, 30th November, 10th December, 20th December, and 30th December) was laid out in RCBD design with three replications. Data on phenological, yield, and yield-related traits were recorded. The generated data were statistically analyzed using R statistical software version 4.4.0. The result showed that the combined main effects of variety and sowing date highly significantly affected all recorded parameters except plant height and seed per pod, whereas the interaction effect highly significantly affected only pod per plant and grain yield at Metema. At Belesa, the main effects had a highly significant effect for all traits, and the interaction effect significantly affected plant height, pod per plant, hundred seed weight, and yield. The highest grain yield (2646.7 kg ha-1) was obtained when the Pawi-03 variety was sown on 30th November at Metema, whereas at Belesa the highest grain yield (1927.5 kg ha-1) was obtained when the Pawi-03 variety was sown on 10th December. Therefore, it is suggested that early sowing from 20th to 30th November, for Metema areas, and from 30th November to 10th December for Belesa areas and similar agro-ecology using the late maturing variety soybean production under irrigation.**

***Keywords*—Irrigated, soybean, Sowing date, varieties.**

I. INTRODUCTION

Soybean (Glycine max L. Merrill), often referred to as the "Golden Bean" of the 21st century [1], is one of the most important crops in the Leguminosae family. It serves as both an oil and pulse crop, thriving in tropical, subtropical, and temperate climates. Soybean seeds are rich in essential nutrients, containing approximately 20% oil and 40-42% protein [2] as well as all the essential amino acids, including tryptophan, glycine, and lysine. Additionally, soybeans are a source of cholesterol-free fat, which aids in the absorption of vitamin A. Beyond its nutritional value, soybeans contribute to soil fertility by fixing large amounts of nitrogen through root nodules and decaying leaves [3].

Soybean grows best at altitudes ranging from 500 to 1900 meters above sea level (m.a.s.l.), with optimal growth between 750 and 1600 m.a.s.l. It requires an annual rainfall of at least 500 mm, with daily moisture needs of approximately 7.6 mm per plant. The crop thrives in temperatures between 23°C and 35°C. Soybean yields are positively correlated with irrigation, particularly during flowering and seed formation[4], [5]. Critical moisture requirements are during germination and grain filling, with low night temperatures near flowering potentially delaying or limiting flowering [6].

In Ethiopia, soybean production is significant. According to the Central Statistical Agency [7], the national production reached 2,232,002.02 quintals across 90,805.02 hectares, with a productivity rate of 24.58 quintals per hectare. In the Amhara region, soybean was cultivated on 54,304 hectares, yielding 1,241,389.44 quintals at a rate of 22.86 quintals per hectare.

The timing of planting plays a crucial role in soybean growth and yield. The period between planting and flowering varies depending on factors such as photoperiod, temperature, and variety. However, the interval between flowering and maturity remains consistent across soybean types [8]. Planting earlier or selecting varieties with earlier flowering can ensure pod set and seed development when environmental conditions are more favorable. Delayed planting, on the other hand, often results in reduced yields, as studies show that planting later than the optimal date significantly diminishes both yield and quality [9], [10]. Photoperiodism affects not only the time to flowering but also the duration of vegetative growth, influencing the overall yield potential [3]. Therefore, understanding the impact of planting date is essential for maximizing soybean yield and ensuring economic efficiency.

Optimal planting dates depend on the soybean variety, cropping system, and local environmental conditions. To optimize production, it is crucial to develop improved agronomic practices, including identifying the appropriate sowing date for different regions in Ethiopia. Research on this topic will help align soybean production with its yield potential and local environmental suitability. This study aims

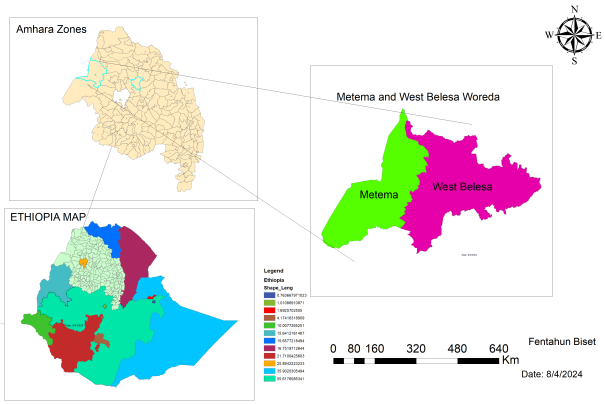


Fig. 1. Study area map

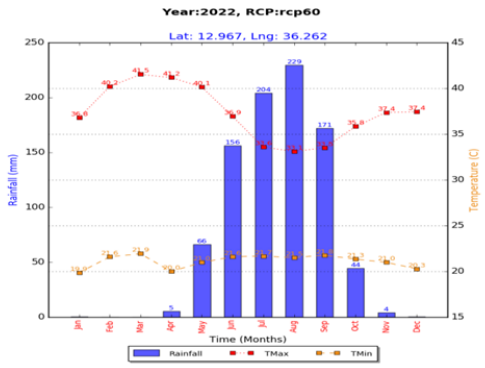


Fig. 2. Metema Weather conditions of 2022

to determine the optimal sowing time for soybean under irrigation in Northern Western Gondar, Ethiopia.

II. Materials and Methods

A. Description of the study area

Field experiments were conducted in the lowlands of West Gondar at Metema for two consecutive (2022-2023) irrigation seasons and in mid-land of Central Gondar at Belesa for one (2023) irrigation season. Metema district is located at 12°24'48'' to 13°09'71'' N Latitude and 36°15'19'' to 36°64'71'' E longitudes with an altitude ranging from 710 to 898 meters above sea level (Fig. 1). It is characterized by rainfall 700 to 1160 mm and temperature 19.9-41.5°c. Metema soil is clay with an average 52% clay, 24% silt, and 24 %loam. The Belesa area is located with a latitude of 12° 19' to 12° 46' N and a longitude of 37° 37' to 38° 29' E at an altitude of 1300-1747 meters above sea level. Belesa Soil is clay with a textural class of silt clay.

B. Weather Conditions

The weather data (Max Temperature, Min Temperature, and Rainfall) of Metema and Belesa were collected from https://gisweb.ciat.cgiar.org/MarksimGCM/# as shown in Fig.2 and Fig.3, respectively.

C. Experimental Design and Treatments

A factorial combination of two varieties (Late type = Pawi-03 and Early type = Gazale) and five sowing dates (Nov-20, Nov-30, Dec-10, Dec-20, and Dec-30) was laid out

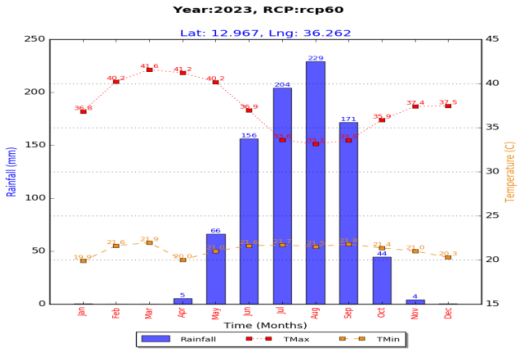


Fig. 3. Metema Weather conditions of 2023

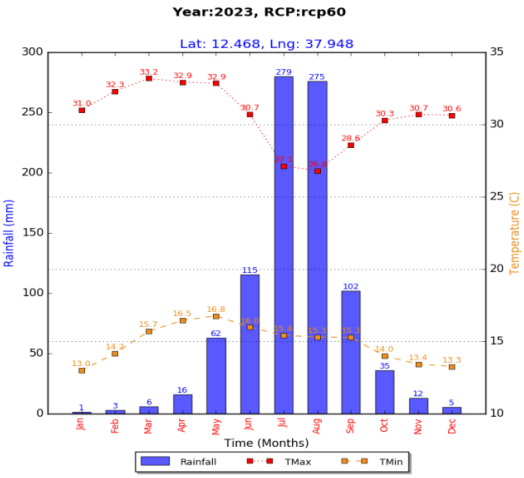


Fig. 4. Belesa Weather conditions of 2023

in a randomized complete block design (RCBD) with three replications. The sowing dates for this experiment were set apart at 10-day intervals to evaluate the effects of varying planting times on soybean crop performance. The spaces between rows, between plants, between plots, and replications were maintained at 0.6m, 05m, 1m, and 1.5m, respectively. Two rows were laid in one bed, and eight rows were laid in one plot. The gross plot size was 4.8m x 3m (14.4m²). The net plot area was 3.6m x 3m (10.8m²). The outermost row on both sides of the row spacing served as border rows for all row spacing. Furrows included the net plot area.

D. Experimental Materials, Watering, and Management

Pawi-03 variety (Late type) and Gazale variety (Early type) were used as planting materials. NPS fertilizer rate of 121 kg/ha was applied at sowing time as a source of N and P2O5. The seeds were planted by placing a single seed per hole at a specific inter and intra row spacing at a depth of about 5 cm and covered by a 3.5 cm layer of soil for adequate emergence. Land preparation started at the end of October. Tractors with conventional land preparation implements were used for plowing, and the experimental sites were oxen-ploughed, harrowed, and leveled by human labor to a fine tilt. All necessary agronomic management practices were done frequently throughout the growing period. The wedding was done appropriately three times. The first weeding was done 15days after emergence, the second weeding on 20 days after

TABLE I. COMBINED MEAN SQUARE VALUES OF ANOVA FOR SOYBEAN IN METEMA DURING THE 2022 AND 2023 IRRIGATION SEASONS

Source of variation	DF	DM	PH	PPP	SPP	BPP	HSW	GY
Var	2407**	2458**	3524**	24257**	4.5**	82**	325**	2.04E+08**
Sd	153**	44**	42NS	1044**	0.3NS	2.2**	22**	875710**
Var*Sd	6.7NS	22NS	79NS	1023**	0.1NS	1.2*	3NS	894722**
Y	576**	3025**	48NS	60NS	0.1NS	2.6**	62**	135414NS
Var*Y	459**	0.1NS	0.9NS	5.2NS	0.5**	2.1**	15**	12416NS
Sd*Y	15NS	16NS	12NS	58.1NS	0.02NS	1.2**	5*	129210*
Var*Sd*Y	9.4NS	9NS	6NS	21.3NS	0.01NS	0.7*	0.8NS	418029**

N: B Var= Variety, Sd= Sowing date, Y= Year, DF= days to flowering, DM= days to maturity, PH= Plant Height, PPP=Pod per plant, SPP= Seed per pod, BPP= Branch per plant, HSW= Hundred seed weight and GY= GrainYield

the first weeding, and the third weeding on 20 days after the second weeding.

The plots were managed under optimal conditions of irrigation by the furrow irrigation method as needed to avoid water stress. Irrigation was given using furrows in four-day intervals during the seedling stage, whereas in seven-day intervals during the vegetation stage, during flowering, seed formation, and near maturity [8]. Harvesting was done after physiological maturity from the net plot at full ripening. Drying was done by setting the harvested stems with pods in sacs until all the pods dried in the sun. Threshing was done by beating the pods properly until all the seeds dropped out of the pods.

E. Data Collection and Analysis

Days to 50% flowering and Days to 95% maturity data were collected on a harvestable plot basis. Data on a plant basis were plant height (cm), number of branches per plant, number of pods per plant, and Number of seeds per pod. Five randomly selected samples of plants in each plot from harvestable rows were taken to estimate plant height, number of branches per plant, number of pods per plant, and number of seeds per pod. Grain yield was collected from the net plot, and hundred seeds were counted. Grain yield and hundred-seed weight were adjusted to a moisture content of 12.5% on a wet basis, and the moisture content was measured with a moisture tester. The generated data were statistically analyzed by using R statistical software version 4.4.0. [11]. Significant pairs of means were separated using the Least Significant Difference Test (LSD) at 5% level of significance and used for mean separation for all agronomic parameters.

III. RESULTS AND DISCUSSION

The results of the combined analysis of variance on soybean sowing date over years at Metema in the 2022 and 2023 irrigation seasons on growth parameters, yield, and yield-related parameters are presented in Table 1. Main effects of variety highly significantly($P<0.01$) affected all recorded parameters, whereas sowing date also highly significantly($P<0.01$) affected all recorded parameters except plant height and seed per pod (Table 1). The interaction effect of variety and sowing date was highly significant ($P<0.01$) affected only pod per plant and grain yield, and significantly($P<0.05$) affected branch per plant. The interaction effect of Variety, sowing date, and year significantly($P<0.05$) affected branch per plant and highly significantly affected grain yield (Table 1).

The variance analysis at Belesa in 2023 showed the main effects of variety had a highly significant ($P < 0.01$) effect for all traits. The main effects of sowing date had a highly significant ($P<0.01$) affected all recorded parameters except seed per pod. The interaction effect of variety and sowing date had a highly significant ($P<0.01$) effect on pod per plant and yield, and significantly($P<0.01$) affected plant height and hundred seed weight (Table 2).

N: B SV= Source of variation, V= Variety, S= Sowing date, DF= days to flowering, DM= days to maturity, PH= Plant Height, PPP=Pod per plant, SPP= Seed per pod, BPP= Branch per plant, HSW= Hundred seed weight and GY= Grain Yield

A. Days to flowering and maturity

For sowing dates, the maximum number of days to flowering (53) and days to maturity (114) in Metema were recorded when sowing was done on November 20th, while the minimum number of days to flowering(48) and days to maturity (110) was recorded when sowing was delayed to December 30th. The Pawi-03 variety took the longest time to flower (57 days) and reach maturity (118 days), while the Gazale variety exhibited the shortest flowering (44 days) and maturity (105 days) periods (Table 3). Early sowing took 5 and 4 additional days to flowering and maturity compared with the late sowing date, respectively. Late variety (Pawi-03) took 13 additional days to flowering and maturity compared with the early variety (Gazale). Soybean is a short-day plant, being induced to flowering when there is exposure to the short photoperiod. Thus, the late sowing causes the shortening of the cycle, the period of emission, and the final node number [12].

Days to flowering and maturity were highly significantly($P<0.01$) affected by the main effects of sowing date and variety at Belesa. The maximum number of days to flowering (50) and days to maturity (106) in Belesa was recorded when sowing was done on November 20th.The minimum number of days to flowering (46) and days to maturity (101) recorded as sowing was delayed to December 30th. Related to varieties, the longest days to flowering (52days) and days to maturity (111 days) were recorded at the Pawi-03 variety, while the shortest days to flowering(44days) and days to maturity (97 days) were on the Gazale variety (Table 4). Early sowing took 5 and 4 additional days to flowering and maturity compared with the late sowing date, respectively. Late variety (Pawi-03) took 13 additional days to flowering and maturity compared with the early variety (Gazale). This result is in agreement with[13], who reported

TABLE II. MEAN SQUARE VALUES OF ANOVA FOR SOYBEAN IN BELESA, 2022

SV	DF	DM	PH	PPP	SPP	BPP	HSW	GY
V	521**	1442**	906**	11564**	7.1*	43**	175**	2564430**
S	19.6**	23**	332**	416**	0.4*	1.3**	3.2**	241745**
V*S	0.6NS	4.9NS	19.6*	469**	0.05NS	0.3NS	2.1*	68108**

that Days to flowering and maturity decreased with all varieties as the sowing date was delayed.

B. Plant height

Plant height was highly significantly($P<0.01$) affected by the main effects of variety but not by sowing date in Metema, whereas in Belesa, interaction effects of sowing date with variety significantly affected ($P<0.05$) plant height. The taller (81.5cm) and shorter plant height (66.2cm) were recorded in Pawi-03 and Gazele variety at Metema, respectively (Table 3). At Belesa, the tallest plant height (79.3cm) and the shortest plant height (49.5cm) were recorded when the Pawi-03 variety (late type), sown on 10th December, and the Gazele variety (early type), sown on 30th December, respectively (Table 6). The highly significant difference among varieties indicates the presence of genetic variability among the varieties for plant height. [14] also reported that the plant height was significantly superior with soybean variety JS-335 (53.6 cm) compared to JS-93-05 (49.5 cm) and local (46.0 cm) varieties.

C. Seed per pod

Variety had a highly significant ($P<0.01$) affected number of seeds per pod of soybean. The highest (2.6) and the lowest (2) number of seeds per pod were recorded in the Pawi-03 variety and the Gazele variety at Metema, respectively (Table 3). At Belesa, seed per pod was significantly ($P<0.01$) affected by the main effect of sowing time and variety. The highest number of seeds per pod (2.9) was recorded from 10th December, and the lowest (2.1) was observed from 20th November. The higher (2.9) and the lower (1.9) number of seeds per pod were recorded in the Pawi-03 variety and the Gazele variety at Belesa, respectively (Table 4). The difference in seeds per pod among varieties was recorded due to the presence of genetic variability among the varieties. This result is in line with [15], who reported that the number of seeds pod-1 depends on genotype and is independent of environmental factors.

D. Hundred seed weight

From sowing dates, the maximum hundred seed weight (13.5g) was recorded on 30th November, and the minimum hundred seed weight (10.3 g) was found on 30th December. Variety Gazele gave the highest (14.3g), whereas variety Pawi-03 gave the lowest (9.7g) hundred seed weight at Metema (Table 3). At Belesa, the maximum hundred seed weight (13.4g) and the minimum hundred seed weight (6.6 g) were recorded when the Gazelle variety was sown on 10th December and when the Pawi-03 variety was sown on 30th December, respectively (Table 6). This might be due to the short vegetative growth period and long reproductive and grain filling period that significantly raised the 1000-seed weight and the presence of genetic variability among the varieties. This result is similar to that of [15], in the case of soybean, who stated that the average seed weight from early sowing was higher than that from late sowing. This result is also in line with [1], who reported that early sowing attributed to higher pods plant-1, more seeds pod-1, and greater 100 seed weight.

E. Number of branches per plant

The number of branches per plant was highly significantly($P<0.01$) affected by the main effects of sowing date and variety in Belesa, whereas the interaction effect of sowing date and variety had a significant ($P < 0.05$) effect for the number of branches per plant in Metema. The highest number of branches per plant (3.1) was recorded on 10th December, and the lowest (2) was observed on 30th December in Belesa. The higher (3.8) and the lower (1.4) average number of branches per plant were recorded in the Pawi-03 variety and the Gazele variety at Belesa, respectively (Table 4). The highest number of branches per plant (5) was produced by the Pawi-03 variety, sown on 30th November, and the lowest number of branches per plant (1) was produced by the the Gazelle variety, sown on 30th December at Metema (Table 5). As the planting date was delayed from 30th November to 30th December at Metema, the number of branches per plant was decreased from 5 to 3 in the late variety pawi-03. This variability in the number of branches per plant was genetically determined and also affected by the favorable environmental conditions. This result is similar to [16], who reported that taller plants are more likely to produce a greater number of branches per plant and number of pods per plant, and the number of branches per plant was affected significantly by sowing date.

N: B DF= Days to flowering, DM=Days to maturity, PH= plant height, SPP= Seed per pod, PBZ= Pod bearing zone, HSW=Hundred seed weight

N: B DF= Days to flowering, DM=Days to maturity, BPP= Branch per plant, SPP= Seed per pod

N: B BPP = Branch per plant

N: B PH= Plant Height, HSW= Hundred

F. Number of pods per plant

The interaction effects of sowing date and variety had a highly significant ($P < 0.01$) effect on the number of pods per plant. The highest numbers of pods per plant (104) in Metema (Table 5) and 93.8 in Belesa (Table 6) were produced by the Pawi-03 variety, sown on 30th November, and the lowest numbers of pods per plant (29) in Metema and 24.4 in Belesa were produced by the Gazelle variety, sown on 30th December. The temperature requirement of soybeans ranges from 20-35 °C [17]. In Metema, daily air temperatures early in the experiment were minimum (17.8°C) and maximum (32°C), however, the minimum and maximum daily air temperatures later in the experiment were 24.5 °C and 40 °C respectively (Fig. 1). As planting date was delayed from 30th November to 30th December at Belesa the numbers of pods per plant

TABLE III. THE COMBINED MAIN EFFECT OF VARIETIES AND SOWING DATE ON PHENOLOGICAL, GROWTH, AND YIELD-RELATED TRAITS OF SOYBEAN IN METEMA, 2022 AND 2023 IRRIGATION SEASONS

Treatment	DF	DM	PH	SPP	HSW
Sowing date					
20-Nov	53[a]	114.3[a]	72.85	2.2	12.9[ab]
30-Nov	51[b]	113.2[a]	75.783	2.5	13.5[a]
10-Dec	50[c]	111.67[b]	73.217	2.4	12.4[b]
20-Dec	50[c]	110[c]	75.833	2.3	10.9[c]
30-Dec	48[d]	109.9[c]	71.667	2.1	10.3[c]
LSD (5%)	1.06	1.4	NS	NS	1
Variety					
Pawi-03	57[a]	118[a]	81.5[a]	2.6[a]	9.7[b]
Gazale	44[b]	105[b]	66.2[b]	2[b]	14.3[a]
LSD (5%)	0.67	0.88	4.2	0.104	0.63
Grand Mean	50.4	111.8	73.87	2.3	12
CV	2.55	1.52	10.88	8.63	10.1
year	**	**	NS	NS	**
Var*Sd	NS	NS	NS	NS	NS
Var*year	**	NS	NS	**	**
Sd*year	NS	NS	NS	NS	*
Var*Sd*year	NS	NS	NS	NS	NS

TABLE IV. THE MAIN EFFECT OF VARIETIES AND SOWING DATE ON PHENOLOGICAL, GROWTH, AND YIELD-RELATED TRAITS OF SOYBEAN AT BELESA IN THE 2023 IRRIGATION SEASON

Treatment	DF	DM	BPP	SPP
Sowing date				
20-Nov	50[a]	106[a]	2.4[cd]	2.1[c]
30-Nov	50[a]	105[ab]	3[ab]	2.3[bc]
10-Dec	48[b]	104[bc]	3.1[a]	2.9[a]
20-Dec	46[c]	102[cd]	2.6[bc]	2.4[b]
30-Dec	46[c]	101[d]	2[d]	2.5[b]
LSD (5%)	0.67	1.6	0.45	0.19
Variety				
Pawi-03	52[a]	111[a]	3.8[a]	2.9[a]
Gazale	44[b]	97[b]	1.4[b]	1.9[b]
LSD (5%)	0.42	1.1	0.28	0.12
Grand Mean	47.833	103.73	2.6	2.43
CV	1.16	1.33	14.35	6.65

were decreased from (93.8) to (52.6) in late variety pawi-03. Negative effects of a delayed sowing date are observed for the years with unfavorable temperature conditions. The highest soybean number of pods per plant in late variety Pawi-03 was observed only at favorable total temperature; however, the number of pods per plant of earlier variety were more stable and lower. Hence, an early soybean sowing date is necessary for using the biological plant potential. This variability in the number of pods per plant is genetically determined and also affected by the favorable environmental conditions. This result is in agreement with [1], who reported that early sowing attributed to higher pods plant-1, more seeds pod-1, and greater 100 seed weight. This result is also in line with [16] who reported that the highest numbers of pods per plant (54.1) were produced by genotypes sown on 10th August, 2009, and on 12th July, 2010, whereas planting on 12th October, 2009,, and

TABLE V. COMBINED INTERACTION EFFECT OF SOYBEAN SOWING DATE AND VARIETIES ON GROWTH OF SOYBEAN AT METEMA IN 2022 AND 2023 IRRIGATION SEASONS.

Treatment	BPP	
	Variety	
Sowing date	***Pawi-03***	***Gazale***
20-Nov	4.1[b]	1.1[f]
30-Nov	4.7[a]	1.7[de]
10-Dec	3.5b[c]	1.4[ef]
20-Dec	3.8b[c]	2.2[d]
30-Dec	3.2[c]	1.1[ef]
Grand Mean	2.68	
LSD (5%)	0.62	
CV (%)	19.7	
year	**	
Var*Sd	**	
Var*year	**	
Sd*year	**	
Var*Sd*year	*	

TABLE VI. INTERACTION EFFECT OF SOYBEAN SOWING DATE AND VARIETIES ON GROWTH AND YIELD-RELATED TRAITS OF SOYBEAN AT BELESA IN 2023

Treatment	PH		HSW	
	Variety			
Sowing date	***Pawi-03***	***Gazale***	***Pawi-03***	***Gazale***
20-Nov	70.5[bc]	54.1[e]	7.2[e]	11.8[bc]
30-Nov	73.8[b]	65.5[d]	7.8[e]	11.2[c]
10-Dec	79.3[a]	70.8[b]	9.2[d]	13.4[a]
20-Dec	66.4[cd]	57.6[e]	7.6[e]	12.9[ab]
30-Dec	62.4[d]	49.5[f]	6.6[e]	13.1[ab]
G. Mean	65.017		10.11	
LSD (5%)	4.4		1.35	
CV (%)	3.91		7.83	

on 6th September, 2010, produced the lowest number of pods per plant (27.1).

G. Grain yield:

Significantly, the highest grain yield (2646.7 kg ha-1) was obtained when the Pawi-03 variety (late) was sown on 30th November, and the lowest grain yield (828.4kg ha-1) was recorded when the Gazelle variety was sown on 30th December at Metema (Table 7). As the planting date was delayed from 30th November to 30th December at Metema, the grain yields decreased from (2646.7 kg ha-1) to (1380.4 kg ha-1) in late variety pawi-03. In this experiment, 50% grain yield reduction was recorded when the soybean late variety Pawi-03 was sown late. However, there was non-significant difference in the first two early sowing dates, 20th November grain yield (2421.5 kg ha-1) and 30th November grain yield (2646.7 kg ha-1).

The interaction and the main effects of sowing date and variety had a highly significant ($P < 0.01$) effect for grain yield at Belesa. The highest grain yield (1927.5 kg ha-1) was obtained when the Pawi-03 variety (late) was sown on 10th December, and the lowest grain yield (724.4kg ha-1)

TABLE VII. COMBINED INTERACTION EFFECT OF SOYBEAN SOWING DATE AND VARIETIES ON YIELD AND YIELD-RELATED TRAITS OF SOYBEAN AT METEMA IN 2022 AND 2023 IRRIGATION SEASONS.

Treatment	PPP		GY(kg/ha)	
	Variety			
Sowing date	***Pawi-03***	***Gazelle***	***Pawi-03***	***Gazale***
20-Nov	82.1^{b}	37.9^{d}	2421.5^{a}	836.4^{f}
30-Nov	103.6^{a}	32.7^{de}	2646.7^{a}	895.4^{f}
10-Dec	65.7^{c}	38.1^{d}	2168.4^{b}	1134.4^{e}
20-Dec	66.1^{c}	36.4^{de}	1691.7^{c}	902.6^{f}
30-Dec	58.1^{c}	29.4^{e}	1380.4^{d}	828.4^{f}
Grand Mean	55.01		1478.6	
LSD (5%)	8.26		231.5	
CV (%)	12.85		13.4	
year	*		NS	
Var*Sd	**		**	
Var*year	NS		NS	
Sd*year	NS		*	
Var*Sd*year	NS		**	

TABLE VIII. INTERACTION EFFECT OF SOYBEAN SOWING DATE AND VARIETIES ON YIELD AND YIELD-RELATED TRAITS OF SOYBEAN AT BELESA IN 2023

Treatment	PPP		YD(kg/ha)	
	Variety			
Sowing date	***Pawi-03***	***Gazale***	***Pawi-03***	***Gazale***
20-Nov	75.1^{b}	35.5^{d}	1303.9^{c}	724.1^{g}
30-Nov	93.8^{a}	24.4^{d}	1575.5^{b}	884.5^{efg}
10-Dec	58.6^{c}	30.3^{d}	1927.5^{a}	1068.5^{de}
20-Dec	60.8^{bc}	30.4^{d}	1223.8^{cd}	937.6^{ef}
30-Dec	52.6^{c}	24.4^{d}	1290.8^{c}	783.1^{fg}
G. Mean	48.58		1171.9	
LSD (5%)	15.5		188.39	
CV (%)	18.69		9.37	

was recorded when the Gazelle variety was sown on 20th November at Belesa (Table 8). As the planting date was delayed from 10th December to 30th December, the grain yields decreased from (1927.5 kg ha-1) to (1290.8 kg ha-1), and planting date was delayed from 20th November to 10th December, the grain yields increased from (1303.9 kg ha-1) to (1927.5 kg ha-1) at Belesa in late variety pawi-03.

N: B PPP=Pod per plant, GY= Grain yield

N: B PPP=Pod per plant, GY= Grain yield

This variability in grain yield was genetically determined and was affected by the favorable environmental conditions. The temperature requirement of soybeans ranges from 20-32 °C [5]. Daily air temperatures early in the experiment were minimum (17.8°C) and maximum (32°C). However, the minimum and maximum daily air temperatures later in the experiment were 24.5 °C and 40 °C, respectively (Fig.1). Temperatures recorded (> 32°C) in delaying plating date exceeded the optimum temperature requirement of the soybean crop [18]. Delayed planting date and unfavorable environmental conditions have a negative effect on soybean growth and development, and thus affect the grain yield. This result is in line with [19] and [20] who reported that Soybeans sown in late were characterized by a smaller number of pods per plant, lower seed weight per plant, and lower thousand seed weight, which decreased seed yields.

IV. CONCLUSION AND RECOMMENDATION

This study demonstrates that both soybean variety and sowing date significantly influence yield under irrigation, with variety alone insufficient to maximize grain production. Optimal grain yields were achieved when sowing was timed to align with the variety's maturity cycle. At Metema, early sowing (November 20th–30th) is recommended for late maturing varieties (like pawe-3), whereas for early maturing varieties (like Gazale) sowing between November 30th and December 10th is optimal for higher yields, while at Belesa, sowing between November 30th and December 10th is optimal for both early and late maturing varieties. In both locations, the optimal time of sowing for the early maturing variety is ten days after the late maturing variety. Delayed sowing, especially beyond late December, negatively impacted growth and yield, likely due to temperature stress during critical reproductive stages. For sustainable and high-yielding soybean production in these regions, timely sowing based on the local agro-climatic conditions is essential.

ACKNOWLEDGMENT

The authors are thankful to all researchers and staff members of Gondar agricultural research centers for their assistance during the experimental research period. The authors are also thankful to all researchers and staff members of the Metema sub-center for their assistance. The authors acknowledge Gondar Agricultural Research Center and Amhara Agricultural Research Institute for the trial area and seed support.

References

[1] A. Nath, A. P. Karunakar, A. Kumar, and R. K. Nagar, "Effect of sowing dates and varieties on soybean performance in Vidarbha region of Maharashtra, India.," *J. Appl. Nat. Sci.*, vol. 9, no. 1, 2017, Accessed: Mar. 18, 2026. [Online]. Available: https://pdfs.semanticscholar.org/1454/9e42255adafe9f0a830d88430bfe180e9cb3.pdf

[2] M. A. Kassem, Ed., *Soybean Seed Composition: Protein, Oil, Fatty Acids, Amino Acids, Sugars, Mineral Nutrients, Tocopherols, and Isoflavones*. Cham: Springer International Publishing, 2021. doi: 10.1007/978-3-030-82906-3.

[3] B. A. Khan *et al.*, "Impact of planting date and row spacing on growth, yield and quality of soybean: A Review," *J. Biodivers. Environ. Sci.*, vol. 17, no. 2, pp. 121–129, 2020.

[4] P. R. Bharambe, A. H. Tajuddin, S. R. Oza, and D. K. Shelke, "Effect of irrigation and crop residue management on crop and soil productivity under soybean-sorghum cropping system," *J. Indian Soc. Soil Sci.*, vol. 50, no. 3, pp. 233–236, 2002.

[5] A. Tesfaye, A. Arega, B. Atero, T. Degu, and M. Hailemariam, "Progress of soybean [Glycine max (L.) Merrill] breeding and genetics research in Ethiopia: a review," *Ethiop J Crop Sci*, vol. 6, no. 3, pp. 129–152, 2018.

[6] T.-J. Ha *et al.*, "Maturity grouping of Korean soybean cultivars and character relationships according to the planting date," 한국작물학회지, vol. 54, no. 1, pp. 104–118, 2009.

[7] "Large
And Medium Scale Commercial Farms Sample Survey2020/21(2013

E.C) | Ethiopian Statistics Services.” Accessed: Mar. 18, 2026. [Online]. Available: https://ess.gov.et/download/2013-commercial-farm-report/

[8] A. Gupta *et al.*, “Optimizing furrow irrigation performance with WinSRFR software through field experiments and simulations in sunflower cultivation,” *Sci. Rep.*, vol. 15, no. 1, p. 33884, 2025.

[9] T. Nleya, M. Schutte, D. Clay, G. Reicks, and N. Mueller, “Planting date, cultivar, seed treatment, and seeding rate effects on soybean growth and yield,” *Agrosystems Geosci. Environ.*, vol. 3, no. 1, p. e20045, Jan. 2020, doi: 10.1002/agg2.20045.

[10] J. Berger-Doyle, B. Zhang, S. F. Smith, and P. Chen, “Planting date, irrigation, and row spacing effects on agronomic traits of food-grade soybean,” *Adv Crop Sci Tech*, vol. 2, no. 4, p. 149, 2014.

[11] R. Kabacoff, *R in action: data analysis and graphics with R and Tidyverse*. Simon and Schuster, 2022. Accessed: Mar. 18, 2026. [Online]. Available: https://books.google.com/books?hl=en&lr=&id=dCZoEAAAQBAJ&oi=fnd&pg=PR19&dq=+Kabacoff,+R.+(2022).+R+in+action:+data+analysis+and+graphics+with+R+and+Tidyverse.+Simon+and+Schuster.&ots=C3iAW7kdF6&sig=3k9f-YPzeLmd6GeHnXwtveXItz8

[12] Z. Sun *et al.*, “Post-flowering photoperiod sensitivity of soybean in pod-setting responses,” *Biology*, vol. 13, no. 11, p. 868, 2024.

[13] O. B. Eseigbe *et al.*, “The impact of planting dates on the performance of soybean varieties [Glycine max (L.) Merr.] in the Nigerian Savannas,” *Agronomy*, vol. 14, no. 10, p. 2198, 2024.

[14] S. D. Rajkumar and P. Murlidharan, “Lodging in soybean (Glycine max) as influenced by growth habit and other traits,” *Indian J Agric Sci*, vol. 84, pp. 896–898, 2014.

[15] P. K. Kundu, T. S. Roy, S. H. Khan, K. Parvin, and H. Mazed, “Effect of sowing date on yield and seed quality of soybean,” *J. Agric. Ecol. Res. Int.*, vol. 9, no. 4, pp. 1–7, 2016.

[16] T. Ngalamu, J. Odra, M. Ashraf, and S. Meseka, “Effects of planting date on yield related traits of some soybean genotypes in Sennar state of the Sudan,” *J. Appl. Agric. Res.*, vol. 5, no. 1, pp. 161–171, 2013.

[17] N. Thenveettil, R. Bheemanahalli, K. N. Reddy, W. Gao, and K. R. Reddy, “Temperature and elevated CO2 alter soybean seed yield and quality, exhibiting transgenerational effects on seedling emergence and vigor,” *Front. Plant Sci.*, vol. 15, p. 1427086, 2024.

[18] S. Chae, P. Shin, J. Youn, J. Sung, and S. Jeon, “The effect of sowing date on soybean growth and yield under changing climate in the southern coastal region of Korea,” *Agriculture*, vol. 15, no. 11, p. 1174, 2025.

[19] G. Fordoński, A. Okorski, J. Olszewski, J. Dąbrowska, and A. Pszczółkowska, “The effect of sowing date on the growth and yield of soybeans cultivated in north-eastern Poland,” *Agriculture*, vol. 13, no. 12, p. 2199, 2023.

[20] M. Borowska and J. Prusiński, “Effect of soybean cultivars sowing dates on seed yield and its correlation with yield parameters.,” *Plant Soil Environ.*, vol. 67, no. 6, 2021, Accessed: Mar. 18, 2026. [Online]. Available: https://www.agriculturejournals.cz/pdfs/pse/2021/06/07.pdf