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Original article

Phenological phases and yield components in nine soybean cultivars (*Glycine max* L.) in Granma province

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ABSTRACT

In order to evaluate the phenological phases and yield components in nine soybean cultivars, in the dry season, on a soft fluvisol soil, an investigation was carried out in areas of the "Jucaibama" Agricultural Experimental Station, belonging to the Institute of Agricultural Investigations "Jorge Dimitrov", located on the Bayamo-Mabay highway km 13½, Bayamo municipality, Granma province. The sowing was carried out in the month of December 2016, with a sowing frame of 0.70 m between rows and 0.05 m between plants, in plots of four rows of five meters long, for a total area of 14 m^2, in a randomized block design with four replications. A double classification analysis of variance was performed and the multiple comparison of means was performed using the Tukey test for $p \leq 0.05$. Different responses were observed between varieties in all the variables evaluated, except at full physiological maturity. The Vencedor and Brillante varieties expressed yields of 1.86 and 1.85 t ha^{-1}, respectively, without significant differences with the varieties IS-24, IS-1, IS-36, William-82 and IS-27, which showed yields between 1.46 and 1.67 t ha^{-1}.

Key words: phases, flowering, fruiting, maturity, variables

INTRODUCTION

Soy (*Glycine max* (L.) Merrill) is one of the oldest crops of humanity, it is grown in tropical, subtropical and temperate zones [(1)]. Its phenology, development of the foliar area and the accumulation of dry matter, are closely related to the behavior of environmental factors [(2)].

Phenology is the science that studies the phases of the life cycle of living beings and it is based on the periodic observation of the environment and its species. The dates of the changes in the biological cycles (phenophases) are noted [(3)].

The study of phenological behavior is among the most important, because it is very useful for the development of phytotechnical activities, since the best time for fertilizing, for watering, for pruning, etc. is known. In addition, it allows to prevent pests and diseases. There are times of the year when insect pests are most active and reproduce faster. Knowing this, prevention techniques can be started when the time of most insect activity approaches [(4)].

Legumes constitute a region of agricultural importance on a world scale and within them soy (*Glycine max* L.) stands out, as it is a food with high protein and oligosaccharide content, high concentration of unsaturated fatty acids, high levels of vitamin E, lecithin and other compounds, used universally in the human and animal diet [(5)].

In Cuba, very important actions are developed to develop soybean cultivation at all levels, for which the search for varieties and appropriate technologies for the different times of the year is essential [(6).]

Considering the above, the objective of this work was to evaluate the phenological phases and components of the yield in nine soybean cultivars in the dry season on a soft fluvisol soil [(7)], in Granma province.

MATERIALS AND METHODS

The research was carried out in the dry season, in the period 2016-2017 on a soft Fluvisol soil [(7)], in areas of "Jucaibama" Agricultural Experiment Station of the "Jorge Dimitrov" Agricultural Research Institute, belonging to the Ministry of Science, Technology and Environment, located on the Bayamo-Mabay highway km 13½, Bayamo, Granma province.

The main chemical characteristics of the soil of the experimental area were determined in the Provincial Laboratory of Soils and Fertilizers of Granma (Table 1). They were

determined through the techniques described by the Ministry of Agriculture (1985), cited by other authors [8].

Table 1. Soil chemical characteristics

Depth (cm)	pH		MO	P_2O_5	K_2O	Interchangeable cations				T
	H_2O	KCl	(%)	Mg 100 g of soil^{-1}		Ca	Mg	Na	K	CCC
						cmol kg^{-1}				
0-20	6.43	4.98	3.27	3.82	16.87	13.33	5.20	0.22	0.31	19.27

According to the results of the analyzes carried out, the pH appears as slightly acid, medium content of organic matter, very low content of P^2O^5 and medium content of K^2O. The data of the main climatic variables, during the period in which the experiment was developed, were obtained from the record of the Meteorological Station of CITMA (Ciencia Tecnología y Medio Ambiente according its acronyms in Spanish) Delegation in Granma, belonging to the Ministry of Science, Technology and Environment, which are shown in Table 2.

Table 2. Behavior of the main climatic factors during the experimental period

Year	Months	Temperature (º C)			Relative humidity	Precipitations
		Maximum	Minimum	Mean	(%)	(mm)
2016-2017	December	36.3	18.1	25.2	87.1	84.2
	January	35.2	15.9	24.6	100	6.3
	February	35.8	14.3	23.5	100	87.3
	March	37.4	14.2	25.7	100	47.2

Source. CITMA, 2017

Soil preparation was carried out with animal traction. Fertilization was organic with well decomposed sheep manure, applied manually to the bottom of the furrow at the time of sowing, at a rate of 5 t ha^{-1}.

The evaluated cultivars were: IS-1, IS-24, IS-27, IS-36, Brillante, Duokrop, DT-99, Vencedor and William-82, because they had not been studied in the dry season in this territory. . These were sown in December 2016, with a planting frame of 0.70 m between rows and 0.05 m between plants, in plots of four rows of five meters long, for a total area of 14 m^2. , in a randomized block design with four replications.

Four irrigations were carried out: at the time of sowing, after the emergence of the plants, at flowering and at fruiting. Weed control was carried out manually with a hoe, keeping

the experiment free of undesirable plants during its execution. The rest of the cultural attentions were carried out according to the agrotechnical management of soybean cultivation [9].

The following variables were evaluated, according to the morphoagronomic descriptors [10].

Start of flowering (days): days elapsed from emergence until 50 % of the plants had at least one open flower.

Full flowering (days): an open flower is observed in one of the upper nodes of the main stem with fully unfolded leaves.

Beginning of fruiting (days): a 5 mm long pod in one of the 4 upper nodes of the main stem and with a fully unfolded leaf.

Full fruiting (days): 2 cm long pod at one of the four upper nodes of the main stem, with a fully unfolded leaf.

Beginning of seed formation (days): 3 mm long seed in a pod in one of the four upper nodes of the main stem, with a fully unfolded leaf.

Maximum seed size (days): the pod with green seeds that completely fill the cavity of the fruit, in one of the four upper nodes of the main stem, with a fully unfolded leaf.

Beginning of ripening (days): some normal pods on the main stem have reached their typical color when ripe.

Full maturity (days): 95 % pod with typical maturity color.

Yield (tha^{-1}): it was calculated on the basis of the weight of the seeds of the plants located in the calculation area of each furrow, when they had around 14 % humidity.

A double classification analysis of variance was performed and the multiple comparison of means was performed using the Tukey test for $p \leq 0.05$.

RESULTS AND DISCUSSION

The results of the analysis of variance are shown in Table 3. The beginning of flowering occurred between 29 and 36 days after emergence. The varieties Brillante, IS-27, IS-1, DT-99 and Wlliam-92 stood out as the earliest, without significant differences with the varieties IS-24 and Duokrop. The latest turned out to be the IS-36 variety, without statistical differences with the IS-24, Duokrop and Vencedor varieties.

Table 3. Behavior of phenological phases in nine soybean cultivars in the dry season on a Fluvisol soil in Granma province

Variety	BF	FF	CFr	BFr	BSF	MSS	BFM
IS-1	29 c	31 c	33 b	41 cde	43 d	55 bc	72 d
IS-24	32 abc	34 bc	38 b	47 ab	50 b	66a	78 bc
IS-27	29 c	31 c	35 b	43 abcd	48 c	61 ab	77 c
IS-36	36a	38a	46a	49a	55a	66a	80 ab
Brillante	29 c	32 c	38 b	44 abc	48 c	62 ab	83a
Duokrop	31 abc	35 bc	39 b	43 bcde	47 c	58 abc	82 ab
DT-99	29 c	32 c	35 b	38 cdef	43 d	55 bc	61f
Vencedor	34 ab	37 ab	45 a	37 ef	43 d	55 bc	81 ab
William-82	30 c	32 c	37 b	36 f	42 d	50 c	82 a
sE x	0,43	0,29	0,40	0,38	0,11	0,61	0,05

Var: Varieties, BF: Beginning of flowering, FF: Full flowering, BFr: Beginning of fruiting, FFr: Full fruiting, BSF: Beginning of seed formation, MSS: Maximum seed size, BFM: Beginning of physiological maturity

The value expressed by the IS-1 variety presents some similarity with those obtained by other authors [(11)], who in the characterization of this variety in spring, in the western region of the country, reported that the beginning of flowering occurred 29 days after sowing. However, the value reached by the IS-36 variety differs from that obtained in another investigation, where it began its flowering 45 days after sowing, in the rainy season in Cauto Cristo municipality [(12)], which may be due to an interaction of this genotype with the environment.

It is also observed that the beginning of flowering in the DT-99 variety, in this experience, does not coincide with results where 33 days were registered in the appearance of this phase in this variety, in an evaluation carried out in spring time in the center of the country [(13)], this could be due to the differences in the edaphoclimatic conditions where these studies were carried out.

Full flowering appeared between 31 and 38 days after the emergence of plants. The IS-36 variety was the one that took the longest to reach this phase, without significant difference with Vencedor variety. The latter did not show significant differences with the IS-24 and Duokrop varieties. The Brilliant, IS-27, IS-1, DT-99 and William-82 varieties were the earliest, without significant differences with the IS-24 and Duokrop varieties.

The days to flowering, expressed by the varieties under study, are similar to those obtained in an experiment with five varieties in spring time, in the western part of the country, where values between 33 and 40 days were recorded, after sowing [(13)].

The behavior of the IS-36 variety, both in the beginning and in full flowering, coincides with what has been referred to in an investigation carried out on a fluvisol soil, in the rainy season, in Cauto Cristo municipality, where they found that this variety was among the latest [12].

The beginning of fruiting was observed between 33 and 46 days after emergence. The IS-36 and Vencedor varieties were the latest, significantly exceeding the rest of the varieties, which in turn did not show significant differences between them.

The appearance of flowers and fruits occurs in a wide temperature range, but the best occur when the air temperature is 23 ºC [14]. During the execution of the experiment, the temperature was 24.8 °C (Table 2), which indicates that they were not favorable for the culture. However, although only four irrigations were made at critical moments, there was a monthly average of 56 mm of rain, which contributed to meeting the water requirements of the crop.

Between 35 and 49 days after emergence, the presence of full fruiting was observed in the evaluated varieties. The IS-36 variety was the one that took the longest to reach this phase, with an average value of 49 days, without significant differences with the IS-24, Brillante and IS-27 varieties.

The IS-24 variety did not show significant differences with the Brillante, IS-27 and Duokrop varieties, but it was superior to the rest of the varieties. The William – 82 variety was the earliest without statistical differences with the DT-99 and Vencedor varieties.

The value expressed by the IS-36 variety is lower than that referred to in a study carried out on this variety, in the Cauto Cristo municipality area in summer, where an average of 62 days was recorded [15].

The beginning of seed formation was observed between 42 and 55 days after seed emergence. The earliest varieties were IS-1, DT-99, Vencedor and William-82, without significant differences between them, they differed statistically from the rest of the varieties.

It is followed by the Brillante, IS-27 and Duokrop varieties, which do not differ from each other, but were statistically surpassed by the IS-36 and IS-24 varieties. These last two turned out to be the latest, with significant differences between them.

This phase is very important, since any adverse weather condition on this state determines a decrease in performance proportional to the damage caused. The same occurs in the case of attacks carried out by parasites, both of animal and plant origin [16].

The maximum size of the seeds occurred in the period between 50 and 66 days after emergence. The highest values corresponded to the IS-36 and IS-24 varieties, without significant differences with the Brillante, IS-27 and Duokrop varieties and the lowest value was expressed by the William-82 variety, without statistical differences with the Duokrop, IS-1, DT-99 and Vencedor varieties.

Normally the filling of the grains is the most sensitive plant phase, with regard to its relationship with environment elements, so any stress that occurs in this phase will directly affect the production of grains [17].

Regarding the beginning of maturity, the varieties that took the longest to reach this phase were Brillante and William, with values of 83 and 82 days, respectively, without significant differences with the varieties IS-36, Duokrop and Vencedor. The latter two also did not differ statistically from IS-24. The earliest, in this phase, was the DT-99 variety, followed by the IS-1 and IS-27 varieties, with average values of 61, 72 and 77 days after sowing, respectively. The latter without significant difference with the IS-24 variety.

All the evaluated varieties showed yields greater than 1 t ha^{-1} (Figure 1), observing statistical superiority in the Brillante, IS-27 and Vencedor varieties over the Duokrop and DT-99 varieties. The latter was also surpassed by the IS-36 and William-82 varieties.

Yield variability is closely related to the role that meteorological conditions play in defining these indicators for a given cultivar; For this reason, the yield behavior study of different soybean cultivars is of utmost importance, for certain environmental conditions [4].

The yields achieved by the Duokrop and IS-1 varieties were lower than those achieved in the cold season in pre-mountain conditions of Guisa municipality, where they reached values higher than 2.65 t ha^{-1} [17].

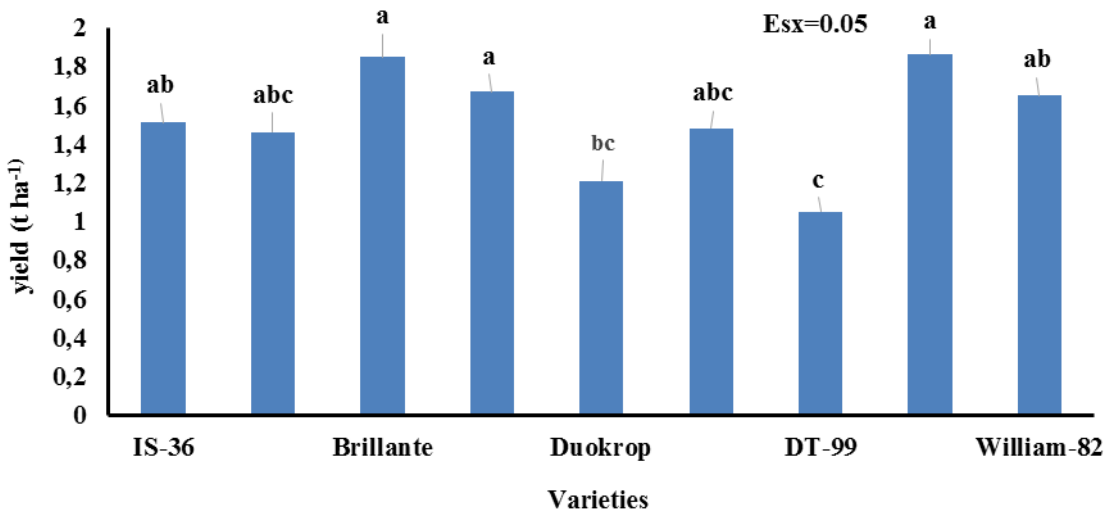

Figure 1. Behavior of the yield of soybean varieties in a soft Fluvisol soil in the dry season in Granma province

The values expressed by the varieties IS-24, IS-27 and IS-1, in an experiment developed in the period from January to April at the "La Victoria" farm, in Santiago de Cuba, were 0.97; 1.05 and 1.08 t ha^{-1}, respectively [18]. However, the reported yield in the IS-36 variety under the same experimental conditions was 1.74 t ha^{-1}, higher than that achieved in this research, which may be due to the ability of most plants to express different responses under different edaphoclimatic conditions.

Although the Vencedor and Brillante varieties expressed yields of 1.86 and 1.5 t ha^{-1} respectively, they are lower than those reached by the FT-2, Conquista, Inifat-382 and Incasoy-35 varieties in an experiment developed in Bayamo municipality in the dry season, in Vertisol soil where they exceeded 2 t ha^{-1} [19].

CONCLUSIONS

- The cultivar IS-36 turned out to be the latest, while DT-99 responded as the earliest.
- The Vencedor and Brillante cultivars expressed yields of 1.86 and 1.85 t ha^{-1}, without significant differences with the varieties IS-36, IS-24, IS-27, IS-1 and William-82.

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