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Morphological Growth of Soybean (*Glycine max L.*) Treated with Soil Application of Humic Acid under Different Cultivation Periods

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ABSTRACT

The demand of organic cultivation of plants is increasing and soil application of organic fertilizer reduces the hazardous usage of inorganic fertilizer and Humic acid is an organic compound derived from plant and animal residues and microbial cells with long-term physical, chemical, and biological processes. In addition, ultivation of soybean in Kurdistan region is not in a wide value therefore, the objective of this study was to determine the impact of soil application of different rates of Humic acid as an organic fertilizer on the growth characteristic of soybean cultivated and determining the best cultivation period for soybean growth. The experiment was conducted in randomized complete block design with two factor treatments and 3 replication, the first factor was one dose soil application of four different Humic Acid rates (HAR) which were (0 (control), 2,4,6,8 g/L) and two cultivation period (CP) which were cultivation Period 1 (CP1) on 15 May 2022 and cultivation Period 2 (CP2) on 1st of June 2022. Observations were made against the growth parameters of plant height number of branches, leaf area, root length, shoot fresh weight and shoot dry weight. The effect of soil application of humic acid rates (HAR) was highly significant on the plant height and root length and significant on the No. of branches, shoot fresh and dry weight. While, cultivation period insignificantly affected the growth parameter except for leaf area. was significant. The maximum plant height, number of branches, leaf area, root length, shoot fresh and dry weight were observed with soil application of 8 g/L of humic acid which were (82.83 (cm), 23.33, 8815 (mm^2), 68.83 (cm), 503.33 (g) and 190.00 (g) respectively. The highest plant height (72 cm), number of branches (18.87), leaf area (7714 mm^2), root length (57.13 g), shoot fresh (263.67 g) and dry weight (102.93 g) were observed when the planted cultivated in 1st period (CP1) compared to CP2.

Keywords: Humic acid, cultivation period, soybean, morphological charactersitic

1. INTRODUCTION

The most significant leguminous crop species is soybean *(Glycine max* (L.)), which is grown in 95 different nations (Gao, Guo, Li, Li, & He, 2020). Its also known as one of the most widely grown and traded crops worldwide (FAO, 2018). The area planted with soybeans in 2019 was 120.5 million ha, and the average yield was 2.77 (Jańczak-Pieniążek et al., 2021). Due to its chemical composition, the soybean is essential for both humans and animals. Its seeds are loaded with vitamins, minerals, substantial amounts of unsaturated fatty acids, and several proteins and lipids. (Wilk, 2017). The crop is crucial for the economy of the nation because Brazil is the largest

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producer of soybeans in the world (FAO, 2018), surpassing the United States for the 2019–20 season with an expected production of 123.2 million tons (Brazil, 2001). The ability of the legumes, including soybean, to bind atmospheric nitrogen is a desirable trait, and the process itself is advantageous for this plant as well as succeeding crops (nitrogen fertilization is not much essential for the cultivation of soybean) (Mahmud, Makaju, Ibrahim, & Missaoui, 2020). Various pressures are presented to soybeans as they mature. Drought is one of the main abiotic factors that hinders their growth and development. However, there are just a few ideal locations for increasing soybean farming. (Battisti et al., 2017).

The worth of a seed lot for its intended use is determined by the physiological quality of a seed, which is based on a seed's germination and vigor (Ghassemi-Golezani, Bakhshi, Dalil, & Moghaddam Vahed, 2015). The physiological capacity of the seeds directly affects how quickly a crop will take root. Depending on the potential of this physiological trait, seedling emergence in the field will vary in percentage, speed, and uniformity (Ebone, Caverzan, & Chavarria, 2019). Failures to germinate are typically related to the use of poor-quality seeds and are frequently brought on by a lack of initial vigor. Knowing the yield potential of soybean based on planting date alone and how planting date influences other agronomic characteristics of soybean production, such as days to maturity, plant height, and canopy closure is crucial because soybean planting dates span from late March through mid-June (Bateman et al., 2020).

Humic acids (HA), a type of biostimulant, are crucial for plant growth, yield, and resistance to abiotic stress. However, this phenomena highlights the intricate intricacy of the issue (Canellas, Canellas, da S Irineu, Olivares, & Piccolo, 2020). The dosage, origin, molecular size, level of hydrophobicity and aromaticity, and spatial distribution of hydrophilic and hydrophobic domains of HA all have a significant impact on their biological activity (Nardi, Schiavon, & Francioso, 2021). HA affect plant growth both directly and indirectly. Improvements in soil characteristics including aggregation, aeration, permeability, water-holding capacity, and the transport and availability of micronutrients are examples of indirect influences, whereas an increase in overall plant biomass is an example of direct influences (Açik, Turan, Çelik, & Katkat, 2009). Reactive oxygen species, enzyme activity, protein metabolism, photosynthesis, respiration, absorption of water and nutrients, hormone fluxes, and cell membrane permeability are just a few of the activities that are impacted by HA in plants (Calvo, Nelson, & Kloepper, 2014). The literature claims that it is unable to definitively determine if HA's effect on plants is connected to its molecular mass (Nardi et al., 2007) or the structural molecules properties (Muscolo et al., 2007). Despite divergent views on how HA affects plant processes, most writers concur that HA has

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favorable impacts on plants and that HA and higher metabolic efficiency go hand in hand. (Berbara & García, 2014).

The best time to plant soybeans is crucial for determining plant development and yield, and it varies based on the climate and cultivar responses to changes in day duration (Bastidas et al., 2008) Given that the soybean seed yield is positively connected with the length of flowering, pod setting, and seed-filling stages, an earlier sowing date means a longer time of vegetative and generative development(Egli & Bruening, 2000). Many authors such as (Hu & Wiatrak, 2012) showed that postponing sowing had an adverse effect on soybean development and growth, especially when there was high humidity. The demand of organic cultivation of plants is increasing and soil application of organic fertilizer reduces the hazardous usage of inorganic fertilizer and Humic acid is an organic compound derived from plant and animal residues and microbial cells with long-term physical, chemical, and biological processes. In addition, ultivation of soybean in Kurdistan region is not in a wide value therefore, the objective of this study was to determine the impact of soil application of different rates of Humic acid as an organic fertilizer on the growth characteristic of soybean cultivated and determining the best cultivation period for soybean growth.

2. RESEARCH METHOD

This study was conducted in 2022 in Bakrajo, Sulaimani *(located at 35°32'52.8"N and 45°21'16.6"E)* belongs to Kurdistan region of Iraq with the silty clay soil type.

Materials and Tools:

Materials used in this study are soybean seed varieties Lee- 74 Humic acid organic fertilizer. The tools used in this study was the hoe, water pump, roll meter, ruler, sprayer, digital scales, electric oven.

Experimental Design and Treatment:

The experiment was conducted in randomized complete block design with two factor treatments and 3 replication, the first factor was one dose soil application of four different Humic Acid rates (HAR) which were (0 (control), 2,4,6,8 g/L) and two cultivation period (CP) which were cultivation Period 1 (CP1) on 15 May 2022 and cultivation Period 2 (CP2) on 1st of June 2022. Land prepared by cleaned from the remains of plants and weeds then the research plotting were prepared. Plot size 2 m x 3 m. The Soybean seed varieties was Lee-74 . Before planting the seeds were soaked in water for 8 hours the Rhizobium inoculant was not done because the pH of the cultivation soil was more than 6. The seeds of soybean were cultivated by inserting 2

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soybean seeds in each hole, with a depth of 5 cm, the spacing of 25 cm. Irrigation was done on weekly basis drainage channels and watering was done once a week at the beginning of planting until the time of flowering and seed formation. Pest and disease control was done by using Garden Safe HG-93179 Neem Oil Extract Concentrate. Spraying began at age 1 week after planting and once a week for 60 days so that the plants are protected from pest attack. Harvesting was done by pulling out the plant with roots carefully. Then washing the plant with distilled water to remove excessive mud and then required observations were done.

Observations were made against the growth parameters of plant height number of branches, leaf area, root length, shoot fresh weight and shoot dry weight. The statistical analysis and analysis of variance was determined by Statistical Analysis System (SAS) (release 9.4, SAS Institute Inc., Cary, NC, USA. For comparison of the treatments mean, Fisher's Least Significant Differences (LSD) was used when F values were significant at ($P \leq 0.05$). The texture of Bakrajo soil is varying from clay soil to silty loam and the chemical characteristic of the soil is showed in Table (1).

Table 1. Chemical Characteristic of Bakrajo Soil

Parameter	Amount
pH	7.3
Electrical conductivity(EC) mmhos/cm)	1.3
N (%)	0.26
P ($mgkg^{-1}$)	3.0
Potassium (K) ($mgkg^{-1}$)	234.3
Calcium(Ca) ($mgkg^{-1}$)	4775.7
Mg ($mgkg^{-1}$)	219.1
Na ($mgkg^{-1}$)	45.8
Fe ($mgkg^{-1}$)	8.3
Zn ($mgkg^{-1}$)	1.0
Cu ($mgkg^{-1}$)	1.7
Mn ($mgkg^{-1}$)	32.4
O.M (%)	1.7

3. RESULTS AND DISCUSSION

According to the results of ANOVA which is shown in Table 2. it's obvious that effect of soil application of humic acid rates (HAR) was highly significant on the plant height and root length and significant on the No. of branches, shoot fresh and dry weight.

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While, cultivation period insignificantly affected the growth parameter except for leaf area. was significant. The interaction effects of humic acid rates (HAR) and cultivation period was significant for plant height while insignificantly affected the other growth parameters.

Table 2. Analysis of variance (ANOVA) morphological characteristics of Soybean **(*Glycine max*)** as influenced by Humic Acid Rates (HAR), Cultivation Periods (CP) and interaction of Humic Acid Rates (HAR) and Cultivation Periods (CP).

S.O.V.	MS						
	DF	Plant height (cm)	No. of Branches	Leaf area (m m^2)	Root Length (cm)	Shoot fresh weight (g)	Shoot Dry weight (g)
Block	2	32.5^{ns}	26.083^{ns}	388849.3^{ns}	187.6^{ns}	13903.33^{ns}	2946.133^{ns}
HAR	4	464.717**	90.783*	15352956*	1223.468**	160257.083*	22914.116*
CP	1	4.8^{ns}	20.833^{ns}	24606963*	224.133^{ns}	563.333^{ns}	740.033^{ns}
HAR*CP	4	263.55*	12.083^{ns}	5691733^{ns}	78.633^{ns}	31002.917^{ns}	5887.617^{ns}
Error	18	48.907	12.244	3002062	108.415	17051.481	2540.541

*, ** and ns represent significant at $P \leq 0.05$, $P \leq 0.01$ and non-significant, respectively. S.O.V.: Source of Variance, DF: Degree of Freedom and MS: Mean Square

Effect of Humic acid Rates (HAR) on Growth Characteristic

By soil application of humic acid (Table 3.) the plant growth was positively affected as the humic acid rates increases and compared to untreated plants (HAR (0 g/L control) the maximum plant height, number of branches, leaf area, root length, shoot fresh and dry weight were observed with soil application of 8 g/L of humic acid which were (82.83 (cm), 23.33, 8815 (cm^2), 68.83 (cm), 503.33 (g) and 190.00 (g) respectively.

The plant height elongation under HAR (8 g/L) might be due to the role of organic acid in the humic acid in rising cell division and cell elongation and enhance the cell division (Shaaban, Manal, & Afifi, 2009).This is consistent with the results of a research which was done by (Baqir & Zeebon, 2019) who indicated that with increasing the rate of humic acid the height of the plant will be increased. An increase in the plant height of wheat was also observed by improving the rate of humic acid (Alfatlawi & Alrubaiee, 2020). Since the use of Humic acid and bio-fertilizers is suggested to affect soil texture, soil structure integrity, aeration, and increase nutrient absorption, plant height is correlated with nitrogen application and dose (Ali et al., 2017). The maximum leaf area was observed with soil application of highest rate of humic acid HAR (8 g/L) (Table 3) ,

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perhaps the cause of this is that acid spraying increased the biological activity of the plant, including the absorption of the nutrient as aresult, the efficiency of enzyme activity. It also increased the production of chlorophyll content, the formation of sugars and amino acids, and the formation of chlorophyll, all of which effectively increase the efficiency of photosynthesis and, consequently, increase the area of the leaf area (Baqir & Zeebon, 2019). These findings are in accordance with those obtained by Ali et al. (2017) on leaf area of wheat and by Mahmoud, Hassanein, Mansour, and Khalefa (2011) on soybean.

Table 3. Growth characteristics of Soybean **(*Glycine max*)** as influenced by Humic Acid Rates (HAR)

Humic Acid Rates (HAR g/L)	Parameters					
	Plant height (cm)	**No. of Branches**	**Leaf area (mm^2)**	**Root Length (cm)**	**Shoot fresh weight (g)**	**Shoot Dry weight (g)**
HAR (0 g/L control)	58.67	13.83	6316	32.33	103.33	43.33
HAR (2 g/L)	70.17	15.50	4904	51.17	152.50	51.17
HAR (4 g/L)	71.00	16.83	5941	52.17	193.33	74.50
HAR (6 g/L)	75.17	20.67	8069	67.50	344.17	130.83
HAR (8 g/L)	82.83	23.33	8815	68.83	503.33	190.00
L.S.D. 5%	8.48	**4.41**	**2102**	**12.63**	**158.39**	**61.138**

Effect of cultivation periods (CP) on Growth characteristic

Date presented in Table (4) showed marked increases in the growth characteristic of plant cultivated in 1st period(CP1). The highest plant height (72 cm), number of branches (18.87), leaf area (7714 mm^2), root length (57.13 g), shoot fresh (263.67 g) and dry weight (102.93 g) were observed when the planted cultivated in 1st period (CP1) compared to CP2. The results of this study are consistent with several studies showing that soybean crops develop more quickly if planting is postponed, which may have an impact on plant height. (Bastidas et al., 2008; Thomas & Raper Jr, 1976). The plant height face more lodging With increased developmental time (Bastidas et al., 2008). As mentioned in the material and methods section the date for the second period cultivation was early june and it has been observed by Bateman et al. (2020) when soybeans are planted early, plant height increases with planting date, but starts to decline with plantings early June. The Similar results from earlier studies suggested that soybean plants planted in June reached a higher plant height than those planted before June, leading to more lodging (Beatty, Eldridge, & Simpson Jr, 1982; Sweeney, Granade, & Burton Jr, 1995). There are some factors affecting the plant height for early plantings such as day length and temperature s and late plantings (Zhang & Du, 1999). As it is shown in table 4 the number of

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branches, leaf area, root length, shoot fresh and dry weight were maximum in CP2 compared to the CP2 which was a delayed sowing and delayed sowing date is the reason of shortened vegetative growth of a plant (Serafin-Andrzejewska et al., 2021). Decrease of the growth characteristic of CP2 might be due to lodging which is because of the plant reached a length that amplified the impact that wind had on the plants. In order to avoid the loses that occur it's better to plant early(Bateman et al., 2020). These results are in consistent with the results of current study.

Table 4. Growth characteristics of Soybean (*Glycine max*) as influenced by cultivation periods (CP)

Cultivation Periods (CP)	**Parameters**					
	Plant height (cm)	**No. of Branches**	**Leaf area (mm^2)**	**Root Length (cm)**	**Shoot fresh weight (g)**	**Shoot Dry weight (g)**
CP1	72	18.87	7714	57.13	263.67	102.93
CP2	71.2	17.2	5903	51.67	255	93
L.S.D. 5%	5.365	2.79	1329	7.99	100.18	38.67

The data shown in table 5 indicates the interaction effects of of Humic Acid Rates (HAR) and Cultivation Periods (CP) on the growth characteristic of soybean. The highest plant height (87.33 cm), number of branches (25.32), leaf area (9810.33 mm^2), root length (71.67 g), shoot fresh (616.67 g) and dry weight (243.30g) were observed when the planted was treated with HAR (8 g/L) and cultivated in 1st period (CP1).

Table 5: Growth characteristics of Soybean **(*Glycine max*)** as influenced by interaction of Humic Acid Rates (HAR) and Cultivation Periods (CP)

Humic Acid Rates (HAR g/L)	Parameters											
	Plant height (cm)		No. of Branches		Leaf area (mm^2)		Root Length (cm)		Shoot fresh weight (g)		Shoot Dry weight (g)	
	Cultivation Periods (CP)											
	CP1	CP2	CP1	CP2	CP1	CP2	CP1	CP2	CP1	CP2	CP1	CP2
HAR (0 control)	69.33	48.00	15.67	12.00	7793.00	4838.33	33.33	31.33	103.33	103.33	41.67	45.00
HAR (2 g/L)	73.33	67.00	15.33	15.67	6480.00	3328.67	56.67	45.67	126.67	178.33	50.67	51.67
HAR (4 g/L)	69.00	73.00	15.67	18.00	5522.67	6358.33	56.67	47.67	113.33	273.33	40.67	108.33
HAR (6 g/L)	70.00	80.67	22.33	19.00	8966.33	8663.00	73.00	62.00	315.00	373.33	138.33	123.33
HAR (8 g/L)	87.33	78.33	25.32	21.33	9810.33	6327.33	71.67	66.00	616.67	390.00	243.30	136.67
L.S.D. 5%	11.99		6.24		2972.17		17.86		223.99		86.46	

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4. CONCLUSIONS

It was concluded from the results noted that Humic Acid play an important role in growth characteristic of soybean. Though Humic Acid had significant effect on the vegetative characteristic of the plant but highly desirable results can be obtained from soil application of Humic acid with a rate of (8 g/L) . in addition, cultivation time has a great impact on the growth characteristic of soybean and the best cultivation period for soybean is in the mid of may as in CP1. It was also noted that balance combination of both soil applied humic acid (8 g/L) and cultivation period (CP1) (have very good effect on the plant growth.

REFERENCES

Açik, B. B., Turan, M. A., Çelik, H., & Katkat, A. V. (2009). Effects of Humic Substances on Plant Growth and Mineral Nutrients Uptake of Wheat (Triücum durum cv. Salitili) Under Conditions of Salinity.

Alfatlawi, Z. H. C., & Alrubaiee, S. H. A. W. (2020). EFFECT OF SPRAYING DIFFERENT CONCENTRATIONS OF HUMIC ACID ON THE GROWTH AND YIELD OF WHEAT CROP (IPA 99 CULTIVAR) IN DIFFERENT STAGES. *Plant Archives*, *20*(2), 1517-1521.

Ali, B., Ilyas, M., Ali, J., Bacha, S. W. A., Khan, W., & Shah, M. B. A. (2017). Effect nitrogen and humic acid levels on plant height and number of florets per spike of gladiolus cultivars. *International Journal of Environmental Sciences & Natural Resources*, *7*(1), 01-05.

Baqir, H., & Zeebon, N. (2019). RESPONSE OF SOME WHEAT GROWTH TRAITS FOR FOR FOLIAR SPRAYING WITH HUMIC AND GLUTAMIC ACID. *The Iraqi Journal of Agricultural Science*, *50*(5), 1455-1464.

Bastidas, A., Setiyono, T., Dobermann, A., Cassman, K. G., Elmore, R. W., Graef, G. L., & Specht, J. E. (2008). Soybean sowing date: The vegetative, reproductive, and agronomic impacts. *Crop Science*, *48*(2), 727-740.

Bateman, N. R., Catchot, A. L., Gore, J., Cook, D. R., Musser, F. R., & Irby, J. T. (2020). Effects of planting date for soybean growth, development, and yield in the southern USA. *Agronomy*, *10*(4), 596.

Battisti, R., Sentelhas, P. C., Boote, K. J., Camara, G. M. d. S., Farias, J. R., & Basso, C. J. (2017). Assessment of soybean yield with altered water-related genetic improvement traits under climate change in Southern Brazil. *European Journal of Agronomy*, *83*, 1-14.

Beatty, K., Eldridge, I., & Simpson Jr, A. (1982). Soybean Response to Different Planting Patterns and Dates 1, 3. *Agronomy Journal*, *74*(5), 859-862.

 DOI : https://doi.org/10.55173/agriscience.v6i2.96

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Berbara, R. L., & García, A. C. (2014). Humic substances and plant defense metabolism *Physiological mechanisms and adaptation strategies in plants under changing environment* (pp. 297-319): Springer.

Brazil, C. (2001). Ministry of Agriculture, Livestock and Food Supply. *Governmental Directive nº 21, of 16th May 2001*.

Calvo, P., Nelson, L., & Kloepper, J. W. (2014). Agricultural uses of plant biostimulants. *Plant and soil, 383*(1), 3-41.

Canellas, L. P., Canellas, N. O., da S Irineu, L. E. S., Olivares, F. L., & Piccolo, A. (2020). Plant chemical priming by humic acids. *Chemical and Biological Technologies in Agriculture, 7*(1), 1-17.

Ebone, L. A., Caverzan, A., & Chavarria, G. (2019). Physiologic alterations in orthodox seeds due to deterioration processes. *Plant Physiology and Biochemistry, 145*, 34-42.

Egli, D. B., & Bruening, W. P. (2000). Potential of early-maturing soybean cultivars in late plantings. *Agronomy Journal, 92*(3), 532-537.

FAO, F. (2018). Food and agriculture organization of the United Nations. *Rome, URL: http://faostat. fao. org*.

Gao, X.-B., Guo, C., Li, F.-M., Li, M., & He, J. (2020). High soybean yield and drought adaptation being associated with canopy architecture, water uptake, and root traits. *Agronomy, 10*(4), 608.

Ghassemi-Golezani, K., Bakhshi, J., Dalil, B., & Moghaddam Vahed, M. (2015). Physiological quality of soybean seeds affected by water and light deficits. *Journal of Plant Physiology and Breeding, 5*(2), 11-18.

Hu, M., & Wiatrak, P. (2012). Effect of planting date on soybean growth, yield, and grain quality. *Agronomy Journal, 104*(3), 785-790.

Jańczak-Pieniążek, M., Buczek, J., Bobrecka-Jamro, D., Szpunar-Krok, E., Tobiasz-Salach, R., & Jarecki, W. (2021). Morphophysiology, productivity and quality of soybean (Glycine max (L.) Merr.) cv. Merlin in response to row spacing and seeding systems. *Agronomy, 11*(2), 403.

Mahmoud, M., Hassanein, A., Mansour, S., & Khalefa, A. (2011). Effect of soil and foliar application of humic acid on growth and productivity of soybean plants grown on a calcareous soil under different levels of mineral fertilizers. *Journal of Soil Sciences and Agricultural Engineering, 2*(8), 881-890.

Mahmud, K., Makaju, S., Ibrahim, R., & Missaoui, A. (2020). Current progress in nitrogen fixing plants and microbiome research. *Plants, 9*(1), 97.

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Muscolo, A., Sidari, M., Attinà, E., Francioso, O., Tugnoli, V., & Nardi, S. (2007). Biological activity of humic substances is related to their chemical structure. *Soil Science Society of America Journal*, *71*(1), 75-85.

Nardi, S., Muscolo, A., Vaccaro, S., Baiano, S., Spaccini, R., & Piccolo, A. (2007). Relationship between molecular characteristics of soil humic fractions and glycolytic pathway and krebs cycle in maize seedlings. *Soil Biology and Biochemistry*, *39*(12), 3138-3146.

Nardi, S., Schiavon, M., & Francioso, O. (2021). Chemical structure and biological activity of humic substances define their role as plant growth promoters. *Molecules*, *26*(8), 2256.

Serafin-Andrzejewska, M., Helios, W., Jama-Rodzeńska, A., Kozak, M., Kotecki, A., & Kuchar, L. (2021). Effect of Sowing Date on Soybean Development in South-Western Poland. *Agriculture*, *11*(5), 413.

Shaaban, S., Manal, F., & Afifi, M. (2009). Humic acid foliar application to minimize soil applied fertilization of surface-irrigated wheat. *World Journal of Agricultural Sciences*, *5*(2), 207-210.

Sweeney, D. W., Granade, G. V., & Burton Jr, R. O. (1995). Early and traditionally maturing soybean varieties grown in two planting systems. *Journal of production agriculture*, *8*(3), 373-379.

Thomas, J. F., & Raper Jr, C. D. (1976). Photoperiodic Control of Seed Filling for Soybeans 1. *Crop Science*, *16*(5), 667-672.

Wilk, M. (2017). Soya as a source of valuable nutrient. *Food Sci. Technol. Qual*, *24*(2), 16-25.

Zhang, G., & Du, W. (1999). The effects of daylength on the growth of soybean and the creation of wide-adaptation germplasm. *Soybean genetics newsletter*, *26*.

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