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STUDY ON GROWTH AND DEVELOPMENT OF SOYBEAN UNDER VARIOUS CONCENTRATION OF FLY ASH

Arun Prajapati[1] and Praveen Kumar[2]
Ph.D. Research Scholar[1], Associate Professor[2]
Department of Botany
Bipin Bihari College, Jhansi (UP) India

Abstract: *The most significant source of protein from plants worldwide comes from the soybean, also known as Glycine max (L.) Merr., which is a member of the legume family. Because of the growing human population and increased demand for soy-based animal feed, the total amount of land used for soy farming is increasing globally. The findings indicate that adding 20% FA amendment to the soil produced the best germination conditions. The study's results indicate that 20% FA Amendment in the soil had the best results for enhancing shoot length rather than higher concentration of FA. The findings also show that adding 20% FA amendment to the soil produced the best conditions for enhancing root length. The study revealed that for both the 20/15 and 30/25 C temperature regimes, there was a significant difference in the total aboveground biomass between the amounts of ambient and enhanced CO2. it was found that on increasing the fly ash concentration adverse effect faced by crop but may be beneficial at lower concentration. Use of fly ash as a fertilizer for agricultural purposes can be an economically viable and environmentally conscious means of disposal.*

Index terms: *Growth, Development, Soybean, Fly ash.*

INTRODUCTION: The most significant source of protein for plants worldwide comes from the soybean, also known as Glycine max (L.) Merr., which is a member of the legume family. Because of the growing human population and increased demand for soy-based animal feed, the total amount of land used for soy farming is increasing globally. Though only allowed for use in the production of food and animal feed in Europe, genetically modified (GM) soybeans make up more than 80% of the world's crop.

Soybeans are used in a variety of foods. It stands up and has a bushy and hairy appearance. Blooms on this plant can be anywhere from white to a purplish-pink colour, and its leaves have three lobes each. The blooms are relatively little as far as decoration is concerned, and they are quite small, with a maximum diameter of one quarter of an inch.

The fruit is a pod that is hairy and grows in clusters of three to five. The number of pods in a cluster might vary. There is a range of two to four seeds that can be contained in each pod.

The by-product created by the ignition process in thermal power plant is often fly ash. Actually, its great amount dispersed from coal-fired power plants' chimneys. The fly ash that is continuously building up in the soil near to the Parichha Thermal Power Station may have a substantial quantity of nitrogen, potassium, magnesium, and phosphorus (Sharma et el. 2016). In general, it is understood to be rich in numerous trace elements, such as B, Ca, Mo, S, Sr and Se, etc. it becomes toxic when these constituent elements cross its beneficial limit (Mehra et al.,2000). The higher levels of fly ash (40 and 50%) are poisonous to plants, while the lower levels of fly ash (up to 30%) could be utilized as fertilizer in agricultural fields to boost vegetable and other food crops in a sustainable way (Ahmad et al, 2021). The soil's crop productivity increased on the addition of fly ash because of the presence both macro- and micronutrients. Additionally Crop production could decline if the amount of hazardous metal present is very high in the fly ash (Sharma et al., 2015; Murugan and Vijayarangam, 2013). FA has the ability to provide plants with a variety of macro and microelements, including certain hazardous metals (Mehra et al., 1986). Almost all of the necessary plant nutrients are present, although nitrogen and phosphorus levels are low (Rai et al.,2002). The higher levels of fly ash (40 and 50%) are poisonous to plants, while the lower levels of fly ash (up to 30%) could be utilized as fertilizer in agricultural fields to boost vegetable and other food crops in a sustainable way.

MATERIALS AND METHODS: Experiment was conducted in clay pots of diameter 30 cm with four treatments of Fly ash 0%, 10% ,20%,30% and 40%. the fly ash that was used collected from Parichha Thermal Power Jhansi (U.P.), India. The soil that was used for pot experiment prepared by mixing farmyard manure in 3:1 ratio. Seed purchased from local market of a well-known Glycine max cultivar known as JS -9560. The seeds were cleaned in a pot and soaked for some minute in clean water. Each pot had just three plants when the seeds were sown, and this number was used for seed germination percentage.

Six enormous Convenor growth chambers of the CG72 type, each with a height of 2.20 meters and a floor area of 8.64 square meters, were used in this experiment. An automated injection system was used to provide carbon dioxide to the chambers, and a CO2 delivery system and chamber vents were used to control the quantity of carbon dioxide inside the chambers. Each individual LI-COR infrared gas analyser (LI-800 GasHound CO2 Analyzer) was used to measure the CO2 levels in each chamber. At a concentration of 700 ppm, the analyzers had a 2% accuracy. Additionally, each chamber included a drip watering system.

We were able to execute a total of six different treatments since we gave each chamber a unique temperature and CO2 level. A 400 ppm CO2 concentration and a 20/15 °C Day/night temperature, a 400 ppm CO2 concentration and a 25/20 °C Day/night temperature, a 400 ppm CO2 concentration and a 30/25 °C Day/night temperature, and a 700 ppm CO2 concentration and a 20/15 °C Day/night temperature, respectively. The photoperiod was set at 12 hours in each compartment. At the top of the pots where the plants were placed and at the top of the canopy as the experiment went on, the quantity of photosynthetically active radiation (PAR) that was present inside the growth chambers was measured. It was 753.7 _molesm2 s1 in value.

3 RESULTS AND DISCUSSION

3.1 EFFECT OF FLY ASH ON GERMINATION OF SEED

The following table (1) displays the results of a study on soybean seed germination. The experiment was carried out in a variety of soil matrices, each of which had an addition of fly ash (FA). A (soil having no FA), A1 (soil containing 10% FA), A2 (soil containing 20% FA), A3 (soil containing 30% FA), and A4 (soil containing 40% FA) are the five different types of soil. The results of the experiment showed that the amount of various types of fly ash supplied to the soil has a significant (P0.05) impact on how well the soybean seed functions. In particular, just 30% of the seeds in group A grew, whereas 40%, 70%, 40%, and 60% of the seeds in groups A1, A2, A3, and A4 did. The study's findings indicate that adding 20% FA amendment to the soil produced the best germination conditions. A 70% germination rate was obtained from this mixture. As a result, it can be said that the quantity of FA does in fact influence how well soybean seeds germinate. Similar findings seemed by Shweta et al., (2014) at lower concentration of fly ash that support germination in soybean and wheat.

Table 1: Germination of soybean seeds in soil (soil + FA).

Treatment (Soil+FA)	N	Mean	SD	SE	Min.	Max.
A (0%)	3	30	±5.0	2.9	25	35
A1 (10%)	3	40	±2.0	1.2	38	42
A2 (20%)	3	70	±3.0	1.7	67	73
A3 (30%)	3	40	±1.0	0.6	39	41
A4 (40%)	3	60	±2.0	1.2	58	62
Total	15	48	±15.4	4.0	25	73

SD: Standard Deviation; SE: Standard Error; Min.: Minimum; Max.: Maximum;

3.2 SHOOT LENGTH (CM) OF SOYBEAN

The results of the investigation into the plant shoot length of soybean under different soil matrices that contained fly ash (FA) as an amendment (Table-2). There are five different types of soil, and they are designated A (the only soil that includes no FA), A1 (a soil that contains 10% FA), A2 (a soil that contains 20% FA), A3 (a soil that contains 30% FA), and A4 (a soil that contains 40% FA). The experiment's findings revealed that the length of the soybean shoots changed significantly (P 0.05) depending on the different FA additions provided to the soil. For example, the shoot length for A was 10.7 centimeters, but for A1, A2, A3, and A4 it rose dramatically to 14.0 centimeters, 29.3 centimeters, 18.6 centimeters, and 12.9 centimeters, respectively. The study's findings indicate that 20% FA Amendment in the soil, followed by A3 and A4, had the best results for enhancing shoot length. The inference that can be made from this is that shoot length is indeed influenced by the proportion of Fly Ash (Fig.-1).

Table 2: The length of the soybean plant shoot in centimeters when it is grown in soil and fly ash.

Treatment (Soil+FA)	N	Mean	SD	SE	Min.	Max.
A (0%)	3	10.7	±0.2	0.1	10.5	10.9
A1 (10%)	3	14.0	±2.0	1.2	12.0	16.0
A2 (20%)	3	29.3	±0.4	0.2	28.9	29.7
A3 (30%)	3	18.6	±0.3	0.2	18.3	18.9
A4 (40%)	3	12.9	±0.2	0.1	12.7	13.1
Total	15	17.1	±6.9	1.8	10.5	29.7

SD: Standard Deviation; SE: Standard Error; Min.: Minimum; Max.: Maximum.

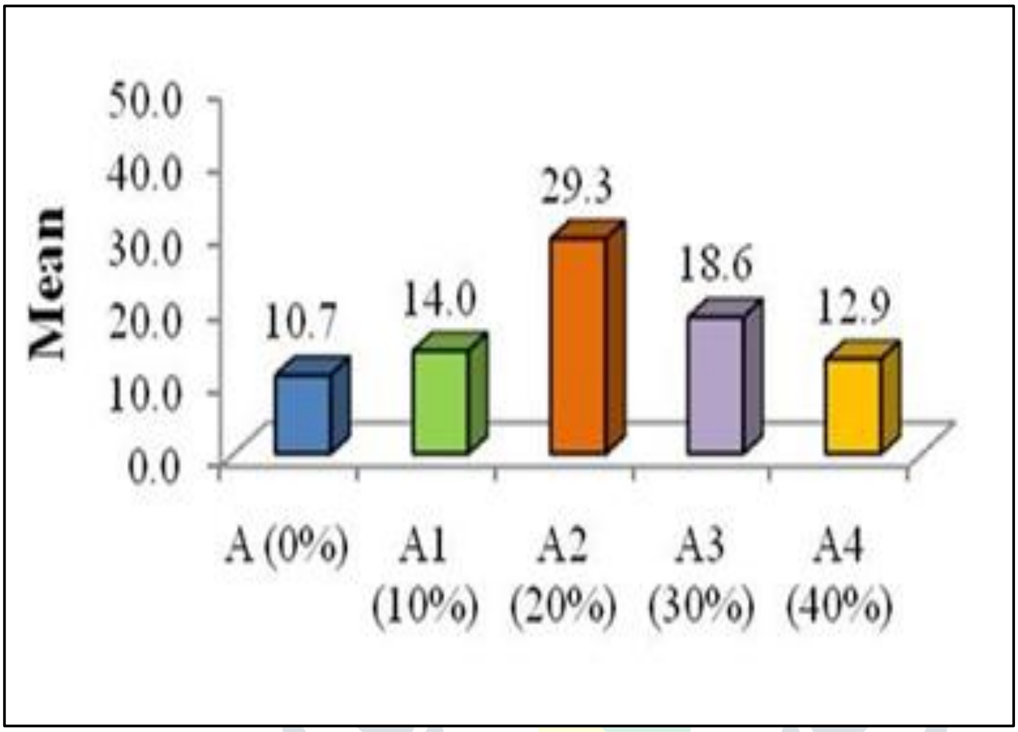

Fig. 1: Shoot length of the soybean plant, measured in centimeters, in the presence of Fly ash.

3.3 Root length (cm) of soybean: Data from research on the root length of soybean plants grown in a range of soil matrices that contained fly ash (FA) as an amendment are shown in the table (3). A (soil having no FA), A1 (soil containing 10% FA), A2 (soil containing 20% FA), A3 (soil containing 30% FA), and A4 (soil containing 40% FA) are the five different types of soil. The experiment's findings revealed a significant variation (P 0.05) in the length of the soybean roots depending on the different FA additions provided to the soil. For example, the root length for A1, A2, A3, and A4 showed significant increases of 6.0 centimeters, 9.9 centimeters, 8.0 centimeters, and 4.8 centimeters, respectively. The root length for A was measured at 5.0 centimeters. The study's findings show that adding 20% FA amendment to the soil produced the best conditions for enhancing root length. Then came A3 and A4 after that. From this, it may be inferred that the quantity of FA in fact affect root length.

Table 3: Root length of the soybean plant, measured in centimeters, in the presence of Fly ash.

Treatment (Soil + FA)	N	Mean	SD	SE	Min.	Max.
A (0%)	3	5.0	±0.2	0.1	4.8	5.2
A1 (10%)	3	6.0	±2.0	1.2	4.0	8.0
A2 (20%)	3	9.9	±0.1	0.1	9.8	10.0
A3 (30%)	3	8.0	±0.3	0.2	7.7	8.3
A4 (40%)	3	4.8	±0.2	0.1	4.6	5.0
Total	15	6.7	±2.2	0.6	4.0	10.0

SD: Standard Deviation; SE: Standard Error; Min.: Minimum; Max.: Maximum.

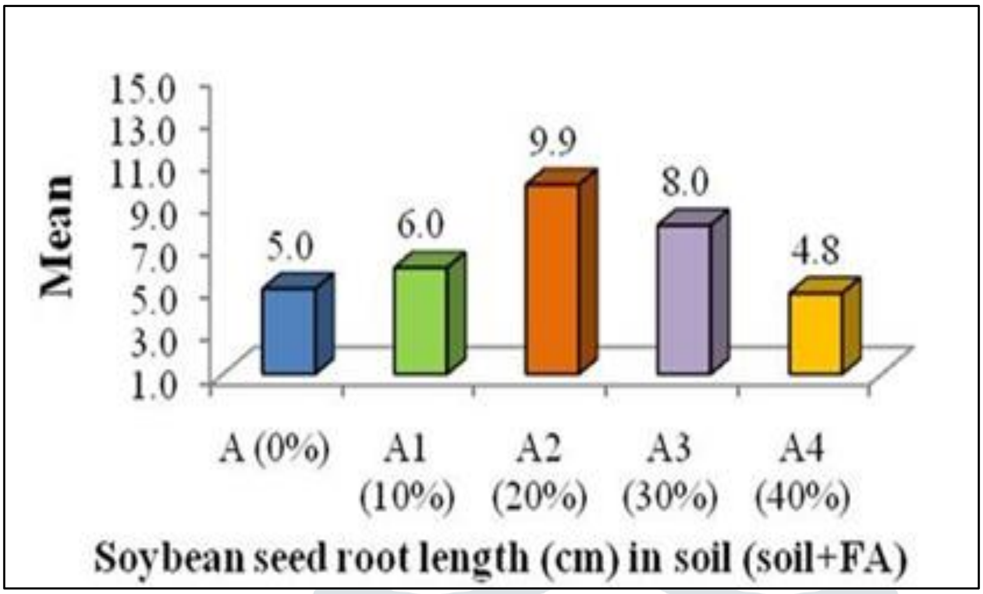

Fig. 2: Root length of the soybean plant, measured in centimeters at different proportion of fly ash.

3.3 THE GROWTH RATES FOR THE VARIOUS CO2 LEVELS

The comparisons between the growth rates for the various CO2 levels at each temperature regime as well as the maximum probability estimates of the growth rates for total aboveground biomass and leaf mass (table 4 and 5). For both the 20/15 and 30/25 C temperature regimes, there was a significant difference in the total aboveground biomass between the amounts of ambient and enhanced CO2 (p = 0.0064 and 0.0001, respectively. Under the temperature regime of 20/15 C, the rate of growth in biomass, represented by, was larger at the elevated level of CO2 (2.03 g ˚Cday plant^{-1}) than it was at the ambient level of CO2 (1.72 g ˚Cday plant1).

Table 4: Estimates of the rate of biomass increase for each temperature and CO2 level for the models characterizing total aboveground biomass as a function of degree days after emergence (DDE)

Temperature (day/night) (˚C)	**CO2 (ppm)**	*β* ± standard error (g˚Cday plant^{-1})	***r*2a**	**a*β* diff.**	[c]*p*-Value
20/15	400	1.72814 ± 0.0779	0.97	−0.3063	<0.01[d]
20/15	700	2.03448 ± 0.0779	0.97		
25/20	400	1.71410 ± 0.0600	0.98	0.1044	0.27ns
25/20	700	1.60968 ± 0.0738	0.97		
30/25	400	1.57796 ± 0.0636	0.99	0.5440	<0.01[d]
30/25	700	1.03391 ± 0.0569	0.87		

- c p-value linked with t-test for comparison of values at similar temperatures and varying CO2 concentrations.
- Significant at the 0.05 level of probability

Table 5: Estimates of the leaf growth rate for the models characterizing leaf mass as a function of temperature and CO2 level for each degree day after emergence (DDE)

Temperature (day/night) (°C)	**CO2 (ppm)**	β ± standard error (g°C day plant^{-1})	***r*2a**	**aβ diff.**	[c]*p*-Value
20/15	400	1.42143 ± 0.1002	0.94	−0.3030	0.03[c]
20/15	700	1.72451 ± 0.1002	0.94		
25/20	400	1.17244 ± 0.0771	0.90	−0.1851	0.13ns
25/20	700	1.35754 ± 0.0949	0.95		
30/25	400	1.23398 ± 0.0818	0.96	0.4248	<0.01[c]
30/25	700	0.80918 ± 0.0731	0.77		

- b p-value linked with t-test for comparison of values at similar temperatures and varying CO2 concentrations.
- Significant at the 0.05 level of probability.

Sionit et al. (1987) found that soybean grew more vigorously at lower temperatures when the CO2 level was raised. Both experiments came up with the same conclusion. The total biomass growth rate was larger at the ambient CO2 level than it was at the enhanced CO2 level at the temperature regime of 30/25 degrees Celsius (1.53 and 1.03 g Cday plant1, respectively;). The empirical model that was used to fit the data showed that, after the R6 stage, there was an increase in the quantity of CO2 present in the ambient environment while a drop in the level of CO2 present in the elevated environment. This outcome was anticipated because, according to Pritchard et al. (1999), the ability of the entire plant to respond to elevated CO2 levels may eventually be limited by biochemical factors (such as a decline in rubisco activity), ultrastructural factors (such as chloroplast disruption), or changes at the canopy level (such as self-shading). Multiple variables may contribute to these restrictions.

CONCLUSION: Germination is one of the fundamental processes in plant growth, and it plays a vital part in determining both the final yield and the growth of the plant. Germination occurs when a seed is exposed to air for the first time. The relevance of the different amounts of fly ash that worked into the soil at different stages of the germination process is very important. Seven to ten days after the seeds was sown, signs of germination began to appear. After seven days, the germination rate was the same in both the control pot and the one that had been meliorated with 10% fly ash. The study's findings indicate that adding 20% FA amendment to the soil produced the best germination conditions. A 70% germination rate was obtained from this mixture. The study's findings indicate that 20% FA Amendment in the soil, had the best results for enhancing shoot length. The findings also show that adding 20% FA amendment to the soil produced the best conditions for enhancing root length. The comparisons between the growth rates for the various CO2 levels at each temperature regime as well as the maximum probability estimates of the growth rates for total aboveground biomass and leaf mass. For both the 20/15 and 30/25 C temperature regimes, there was a significant difference in the total aboveground biomass between the amounts of ambient and enhanced CO2 (p = 0.0064 and 0.0001, respectively. Under the temperature regime of 20/15 C, the rate of growth in biomass, represented by, was larger at the elevated level of CO2 (2.03 g Cday plant1) than it was at the ambient level of CO2 (1.72 g Cday plant1).

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