Effect of Phosphorus Fertilizer and Temperature on Plant Growth and Fruit Parameters in *Capsicum* spp.

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Abstract - Chili pepper (*Capsicum* spp.) is an important spice in the world food industry. Plant growth and fruit parameters vary with changing environmental factors and many experiments have been conducted to find out environmental effect for plant and fruit parameters in chili pepper except phosphorous (P) fertilizer and high temperature. Japanese agricultural soil rich in P fertilizer because of long term fertilizer application. High temperature is one of the major abiotic stress affecting plants, having adverse effects on growth and quality of the fruits of most plants. Therefore present experiment was conducted to find out the effect of excess phosphorus fertilizer and high temperature stress on plant growth and fruit parameters of chili. Three P fertilizer treatment (60, 300 and 600 g. m^{-2}) and two temperature treatment (high temperature stress and control) were used for this experiment respectively in 2019 and 2020. According to the results, high temperature stress and excess P fertilizer condition negatively affected the plant growth and reduced the fruit size, length, weight and number of fruits than the control conditions. Therefore when growing chili pepper it is better to control temperature condition and supply only adequate P fertilizer quantity to get good growth and yield.

Keywords: Temperature stress, Phosphorus fertilizer, Chili pepper

I. Introduction

Capsicum annuum L. is the most widely grown spice in the world and one of five domesticated chili pepper species. Capsaicinoids, which accumulate in the vesicles and vacuoles of epidermal cells of the placenta, are substances that are responsible for the pungent taste in chili [1]. Chili is mainly used in the food industry and capsaicinoids in the pharmaceutical and medical industries. Chili plant growth and yield are changed by environmental factors such as drought stress, Salinity stress, parthenocarpy, temperature condition, light condition and fertilizer condition. Plants require P to synthesize adenosine triphosphate (ATP), sugars, and nucleic acids. Japanese agricultural soil is typically enriched in P due to long-term excessive P fertilizer application [2]. According to the Climate Change models predictions, the air temperature will increase between 1 to 4°C by the end of the 21st century, because of the greenhouse effect [3]. But, there are a limited number of experiments on the effect of temperature stress with chili pepper because it is difficult to provide temperature stress without causing an effect on drought stress and light condition. Therefore, the objective of this study was to find out the effect of excess P fertilizer and high temperature stress conditions on chili pepper plant growth and fruit parameters.

II. Materials and method

Experiments were conducted in Alpine Field Research and Education Centre, Faculty of Agriculture, Shinshu University, Minamiminowa, Nagano, Japan (a. s. l. 733 m) in 2019 and 2020.

Experiment 1 (high-temperature effect)

The temperature experiment was conducted from 30th of June to 15th of September in 2019 using the 'Takanotsume' and 'Sapporo' (*C. annuum*) variety treated with two different temperature conditions (High temperature stress and control). High temperature stress was provided to the chili plants in a greenhouse with an average temperature between 42.9 ^{0}C - 13.4 ^{0}C. As the control, a set of chili plants were grown outside the greenhouse where the average temperature lied between 35.9 ^{0}C -11.6 ^{0}C. Plastic water logging plates were used to provide the excess water condition to avoid drought stress. 50% black shade net was used as control the light condition effect.

Experiment 2 (excess P fertilizer effect)

P fertilizer experiment was conducted from the 15th of May to the 30th of September, 2020. The maximum average temperature was 35 ^{0}C and the minimum average temperature was 20.5 ^{0}C. Same chili varieties used in the above experiment, were used with three different levels of P fertilizer treatments 60, 300 and 600 g·m^{-2} by adding 'Multi Phosphate' (available P: 35%). Water was applied considering the daily temperature and weather conditions. If the temperature was above 30 0C, 130 mL of water was added to the soil 3 times a day. On rainy days or if the day temperature was below 30 0C, 130 mL of water was applied twice a day.

In both experiments, plants were transplanted into plastic pots (18 cm in diameter, 3.5 L) filled with commercial potting media

(Nae-Ichiban; Sumitomo Forestry Landscaping Co., Ltd, Tokyo, Japan), when seedlings have approximately grown up to 100-150 mm in height. The potted plants were placed in the greenhouse with 50% shading. Five individual replicates were carried out for each treatment in both experiments. The first set of flower buds were removed after applying the treatments. Other crop management practices and standard recommendations followed in Japan were applied for growing peppers for both experiments. The pericarp of fruits turned into fully red colour fruit is considered as late mature fruits and those fruits were harvested on a pre-decided day. Fruit and plant parameters (fruit length, fruit weight, number of fruits, number of branches, number of leaves and plant height) were measured after harvesting.

III. Results and Discussion

In experiment 1, measured fruit length, weight, number of fruits, branches, leaves and plant height of both chili varieties were significantly high in numbers in the control temperature condition than the temperature stress condition (Table 1). High temperature adversely affects the physiological parameters of tomato plants, and consequently reduces plant biomass production [4].

In experiment 2, 60 P fertilizer treatment showed significantly high values for all plant parameters except the number of branches and number of leaves in 'Takanotsume' and 'Sapporo'(Table 1). Excess P indirectly affects plant growth by reducing Fe, Mn and Zn uptake [5]. That might be affected to reduce fruit and plant parameters in chili plants.

IV. Conclusion

Temperature stress and excess P fertilizer negatively affect plant growth and reduce fruit size and weight. Therefore before planting chili pepper, it is important to control temperature stress conditions and measure the soil-available P level and avoid adding excess P fertilizer to obtain proper plant growth and big sized chili fruits.

References

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Table 1. Change in plant and fruit parameters of 'Takanotsume' and 'Sapporo' in given different temperature treatment in 2019 and different P fertilizer treatments in 2020.

	Varity		Fruit length (cm)	Fruit weight (g)	No. of fruit	No. of Branches	No. of leaves	Plant height (cm)
Temperature treatment (2019)	Takanotsume	Control	6.68 a	3.31 a	88.4 a	8.2 a	226.4 a	80.2 a
		High T- Stress	5.7 b	2.8 b	70 b	6.8 b	187.8 b	70.6 b
	Sapporo	Control	12.26 a	6.34 a	78.2 a	11.2 a	169.6 a	71 a
		High T- Stress	9.16 b	5.22 b	62 b	8.2 b	140.6 b	55.8 b
P fertilizer treatment (2020)	Takanotsume	60 g. m^{-2}	6.46 a	3.18 a	85.8 a	7.0 a	220.8 a	78.8 a
		300 g. m^{-2}	5.48 b	2.39 b	68.2 b	7.8 a	225.2 a	69.6 b
		600 g. m^{-2}	5.46 b	2.34 b	64.2 b	8.0 a	217 a	66.8 b
	Sapporo	60 g. m^{-2}	11.88 a	5.98 a	74 a	9.6 b	174 a	72.4 a
		300 g. m^{-2}	9.4 b	5.26 ab	56.2 b	11.8 a	176.6 a	55 b
		600 g. m^{-2}	8.84 b	4.96 b	58 b	11.4 a	177 a	57.8 b

Different letters a and b indicate significant differences of each treatment using Tukey pairwise test at the 5% level.