INFLUENCE OF DIFFERENT LEVELS OF NITROGEN FERTILIZER AND IRRIGATION ON RADISH (*Raphanus sativus*) UNDER INCREASED TEMPERATURE CONDITION

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INTRODUCTION

Radish is one of the highly consumable vegetables in Sri Lanka and it is cultivated in many areas of the country due to its short growing periods. Root of the radish is used as the edible portion and is consumed as salad or cooked vegetable. Radish owes their taste to the diverse chemical compound produced by the crop, including glucosinolate, myrosinase and isothiocyanate. Temperature and water stress are two factors which influences yield of radish as well as vegetative and reproductive stages of crops (Nishyma, 1970).
Global food production threatened by the rise of climate change is one of the most vital demanding situations in the 21st century, to supply enough meals for the growing population while maintaining the already stressed environment. Crop production will decrease in future due to increment of temperature and fluctuation of precipitation (Kang *et al.,* 2009). HadCM3 general circulation model has found out that the temperature will boom in coming years and in 2050s the highest temperature by 2^{0}C increment is anticipated in Anuradhapura as compared to the baseline temperature of 1961-1990 (De Silva *et al.*, 2007). Further, rainfall will be decreased in many locations of Sri Lanka specially the Dry zone (De Silva, 2006).
Nutrition is vital for the production in vegetable cultivation to ensure sufficient yield with optimum quality (Zhag *et al.,* 2015). Major nutrients play an important role in crop cultivation and especially nitrogen is one of the principal nutrients required for better growth and yield of plant (Singh *et al.*, 2003). Nitrogen fertilizer affects length and girth of root, fresh weight of root, quality and quantity of leaves per plant (Sounda *et al.*, 1998). Furthermore, nitrogen fertilizer is one of the nutrients required for radish cultivation, which leads to thicken wholesome root improvement (Patel, 2016). Furthermore, nitrogen is very important for the plant to develop the ability to tolerate high temperature and water stress condition (Waraich, 2012). However too much of nitrogen fertilizer application will produce poor yield with low quality (Chen *et al.*, 2004).
This study is carried out to identify the effect of temperature, various rates of nitrogen fertilizer and field capacity levels on growth and yield performances of radish.

METHODOLOGY

A pot experiment was carried out during the year 2019-2020 at The Open University of Sri Lanka, Nawala. The variety of *Beralu* was used and an experiment was carried out in completely randomized design with three replications. Reddish brown earth soil was used in this study. In this experiment three factors were used as three levels of nitrogen fertilizer (recommended level of nitrogen – N1 ,150% of recommended level of nitrogen N2, 200% of recommended level of nitrogen N3), three levels of field capacity (field capacity I1 ,150% of field capacity,200% of field capacity and two temperature condition as ambient temperature (32-33 ^{0}C– net house) and increased temperature (36-37 ^{0}C – Polytunnel). The temperature 36 – 37 ^{0}C used as increased temperature condition and selected based on the HadCM3 (UK) prediction of Sri Lankan air temperature in 2050 for the A2 scenarios of IPCC (De Silva, 2006). The variation of the temperature inside the Polytunnel and the net house over 24 hours was observed and the temperature inside the net house was always lower than the highest temperature given for the polytunnel. Further, relative humidity and light intensity inside the structures were measured daily and there had been no significant difference. Polytunnel consists of top-vent roof structure, and it facilitates the natural movement of air and also, in there automated temperature control unit was installed and when the temperature inside the poly tunnel increased than the maximum temperature set in the thermostat, the ventilation fan starts to rotate until temperature reach to the set temperature. Growth parameters were measured once a week and yield parameters were determined at the end of the experiment when radishes were harvested. ANOVA was conducted and variation among the means was in comparison for significant use in a revised least significant different (LSD) test at 0.05 levels.

RESULTS AND DISCUSSION

Growth parameters of Radish

Plant height

The influence of temperature, different rates of nitrogen fertilizer application and field capacity level on plant height is shown in Table 1. Plant height was significantly ($P < 0.05$) affected by the interaction effect of temperature, nitrogen fertilizer and field capacity level. Plants applied with 150% of nitrogen and irrigated to 150% field capacity at ambient temperature condition were shown the highest plant height. However, it was not significantly different with plants treated with 150% of nitrogen, irrigated to 100% of field capacity under ambient temperature condition and the treatment applied with 150% of nitrogen, irrigated to 100% field capacity under increased temperature condition. Increment of radish plant height might be due to application of nitrogen fertilizer because of its ability to tolerate increased temperature condition (Rupp and Hubner, 1995)

Table 1: Interaction effect of temperature, different level of nitrogen fertilizer application and field capacity levels on growth parameter of Radish (*Raphanus sativus*)

Factor 1 (Temperature)	Factor 1 (Nitrogen)	Factor 2 (Irrigation)	Plant height (cm)	Number of leaves	Leaf area (cm^2)
T1	N1	I1	33.7^{c}	15^{c}	95^{f}
	N1	I2	30.4^{cd}	13^{cd}	91^{f}
	N1	I3	23.4^{e}	7^{e}	68^{i}
	N2	I1	44.6^{a}	22^{a}	155^{a}
	N2	I2	31.3^{cd}	21^{a}	151^{a}
	N2	I3	20.7^{ef}	7^{e}	87^{g}
	N3	I1	17.3^{f}	6^{f}	100^{e}
	N3	I2	34.2^{bc}	16^{bc}	143^{b}
	N3	I3	29.1^{d}	11^{d}	76^{h}
T2	N1	I1	45.3^{a}	23^{a}	152^{a}
	N1	I2	36.4^{b}	17^{b}	140^{b}
	N1	I3	23.6^{a}	7^{e}	130^{c}
	N2	I1	42.4^{a}	24^{a}	153^{a}
	N2	I2	45.6^{a}	24^{a}	151^{a}
	N2	I3	25.8^{e}	9^{e}	128^{c}
	N3	I1	21.7^{ef}	7^{e}	112^{de}
	N3	I2	39.3^{b}	18^{b}	123^{d}
	N3	I3	32.5^{cd}	14^{cd}	120^{d}

T1 – Increased temperature condition (36-37 0C), T2- Ambient temperature condition (32-33 0C)
N1 -100% of nitrogen, N2- 150% of nitrogen, N3- 200% of nitrogen

I1- 100% of field capacity, I2-150% of field capacity, I3 – 200% of field capacity
Note: Treatments are significantly difference if they do not share (s) in common adjusted P value <0.05.

Number of leaves
Treatments with 150% of nitrogen irrigated to 100 % field capacity, 150% field capacity at the increased temperature condition as well as at the ambient temperature condition have shown higher number of leaves while treatments with 200% of nitrogen with irrigated to 100% field capacity at increased temperature condition has shown lower number of leaves (Table 1). 150% of nitrogen with irrigated to 100% or 150 % field capacity soil moisture recorded higher number of leaves and began to decline significantly as the nitrogen levels raised to 200% with irrigated to field capacity either at increased temperature or ambient temperature condition. These results conform to the reports of Mohidin *et al.*, (2015)

Leaf area
Interaction effect of temperature, nitrogen fertilizer and field capacity level has shown significant influence on leaf area. Treatments with 150% of nitrogen, 100% field capacity was shown the highest leaf area at increased temperature condition. Leaf area began to decline significantly as the nitrogen level was raised to 200% nitrogen and it might be due to higher rates of nitrogen attain the level of toxicity, increased leaf senescence and retarded plant growth. These results are supported by the findings of Rupp and Hubner (1995).

Yield parameters of Radish
Length of tuber
Interaction effect of temperature, different rates of nitrogen fertilizer and field capacity levels has been significantly influenced on length of tuber. The highest tuber length was recorded when radish was fertilized at 150% of nitrogen irrigated to field capacity under increased temperature condition while treatments with 200% nitrogen produced lower tuber length either at the increased or ambient temperature conditions (Table 2). Further, findings of the study revealed that the recommended level of nitrogen was not enough to obtain higher length of tubers at increased temperature conditions.

Fresh weight of Radish
The yield of radish was significantly influenced by the interaction effect of temperature, nitrogen fertilizer and field capacity levels. The highest fresh weight of tuber at the increased temperature condition was observed when plants were fertilized with 150% nitrogen, irrigated to 100% field capacity while lowest value was noticed under 200% of nitrogen with irrigated to 100% field capacity (Table 2).

Table 2: Interaction effect of temperature, different rates of nitrogen fertilizer and field capacity levels on length of tuber and fresh weight of tuber

Treatments	Length of tuber (cm)	Fresh weight of tuber (g)	Treatments	Length of tuber (cm)	Fresh weight of tuber (g)
T2N1I1	14.3^{a}	196^{a}	T1N1I1	6.1^{d}	150^{c}
T2N1I2	11.5^{b}	170^{b}	T1N1I2	5.9^{d}	145^{c}
T2N1I3	9.5^{c}	110^{d}	T1N1I3	4.9^{d}	109^{d}
T2N2I1	14.9^{a}	201^{a}	T1N2I1	15.1^{a}	191^{a}
T2N2I2	13^{a}	198^{a}	T1N2I2	14.2^{a}	190^{a}
T2N2I3	8.9^{c}	120^{d}	T1N2I3	5^{d}	104^{e}
T2N3I1	8^{c}	98^{e}	T1N3I1	4^{e}	82^{f}
T2N3I2	8^{c}	140^{c}	T1N3I2	11.9^{b}	160^{b}
T2N3I3	8.7^{c}	137^{cd}	T1N3I3	7.1^{cd}	135^{cd}

T1 – Increased temperature condition (36-37 0C), T2- Ambient temperature condition (32-33 0C)
N1 -100% of nitrogen, N2- 150% of nitrogen, N3- 200% of nitrogen
I1- 100% of field capacity, I2-150% of field capacity, I3 – 200% of field capacity
Note: Treatments are significantly difference if they do not share (s) in common adjusted P value <0.05.

CONCLUSIONS/RECOMMENDATIONS

The results of the study demonstrated that with the increase of nitrogen fertilizer application, the growth dynamic, and yield of Radish were increased at 150% of recommended nitrogen and then decreased gradually at a level of 200% of recommended level of nitrogen at increased temperature conditions with the irrigation level of 100% field capacity moisture of soil. Under ambient temperature condition the recommended level of nitrogen fertilizer was enough to obtain higher yield while it produced least results under increased temperature conditions. However, 150% of nitrogen irrigated to field capacity can be mentioned as the better treatment to obtain higher yield under increased temperature conditions.

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