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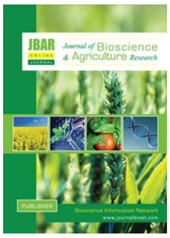

Effect of elevated temperature on growth and yield of rice in central hill of Nepal

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ABSTRACT

Climate change and its consequences have severely affected Nepalese agriculture. The higher temperature in the lower elevations of the tropical region as well as lower temperature in the higher elevations has adversely affected rice cultivation. Therefore, to evaluate the performance of different rice genotypes in central hills present experiment was carried out at Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal in 2017 A.D. under irrigated main season rice system. Split Plot design with three different heights of plastic chamber (Chamber with height of 4', 5'4" and 6'9") and one open field as a main plot factor and four different rice genotypes (Khumal 10, NR 1105 B-B- 27, Khumal 8, 08 Fan-10) as a sub plot factor were used. 25 days seedlings were transplanted in 12 m² plot area in July 1, 2017 at 20×20 cm spacing. The result showed that the temperature increments inside the chamber have not significantly influenced the yield of rice. Within 4 rice genotypes, Khumal 10 and Khumal 8 were found to produce significantly higher yield.

Keywords: *Chamber, Rice, Temperature, Elevation and Yield*

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I. Introduction

Rice is the staple food of majority of the world's population. In Nepal, rice (*Oryza sativa* L.) is grown under different altitude and climate, extending from 60 to 3,050 meters from sea level. With the help of different climate models, it is predicted that the air temperature of earth surface will be increased by 04–5.8^{0}C in the next few decades (IPCC 2007). The temperature increment in the earth surface will reduce the likely benefit of increasing atmospheric carbon dioxide (CO_2) on crop plants. The rice yield would be reduced in the future climatic conditions depending on the environmental condition of growing season if the trend of increasing temperature continues as predicted. (Nagarajan et al. 2010; Wassmann et al. 2009a, b; Welch et al. 2010). Matsui et al. (2001) stated that the production of rice could be totally wiped out if the predictions made for future climatic conditions are correct.

Wahid et al. 2007 states that the combined effect of duration, intensity (temperature in degrees) and rate of increase in temperature is a high temperature stress in a plant. High temperature stress in the tropical region and low temperature stress in the temperate region is adversely affecting the production of rice in rice producing areas throughout the globe. Heat stress due to temperature increment has detrimental effects on growth, yield and quality of the crop. However, growth and yield of rice has been studied as affected by several agronomic factors (Sultana et al. 2019; Hossain and Siddique, 2015). In particular, different phases of growth and development of rice is differentially sensitive to temperature stress; Hossain et al. (2015) studied effects of temperature on rice variety. The rice seedlings can have better growth up to 35^{0}C above which it declines acutely and at above 40^{0}C, the seedling die. Similarly, for shoot elongation and development, critical minimum temperature ranges from for 7 to 16^{0}C and that for root elongation is 12 to 16^{0}C (Nishiyama 1977). Gao et al. 1992 and Ritchie 1993 stated that temperature is one of the major environmental facto to govern leaf appearance in rice and leaf emergence is fastened due to moderate increase in temperature too. Lalitha et al. 1999 found that daily mean temperature more than 26^{0}C during tillering period restricts the tillering phase only to five weeks. Likewise, Ziska et al. 1997 found that five days early maturation in wet season rice due to increase in temperature by 4^{0}C during the growing season. Higher spikelet sterility and lesser duration for grain filling phase has been observed due to high temperature at flowering stage and grain filling phase that causes the reduction in rice yield (Tian et al. 2007; Xie et al. 2009). By undertaking these findings, a study was conducted to provide a scenario of the influence of elevated temperature on rice phenology and yield in central hill of Nepal.

II. Materials and Methods

The design for the experiment was split plot with three different height of plastic chamber and one open field as a main plot factor while four different type of rice varieties as a sub plot factor under irrigated condition in 2017 A.D. at Nepal Agriculture Research Institute (NARC), Khumlatar, Lalitpur, Nepal. 25 days seedlings of four different varieties of rice were transplanted in 3 different height open top chamber and one open field with 12 m^2 area plot in July 1, 2017 at 20×20 cm spacing. The treatment combination was:

Main Plot (Factor A)	Sub- Plot (Factor B) Rice Varieties(Genotypes)
1) Chamber with 4' height plastic cover	1) Khumal 10
2) Chamber with 5' 4" height plastic cover	2) NR 1105 B-B- 27
3) Chamber with 6' 9" height plastic cover	3) Khumal 8
4) Open field	4) 08 Fan-10

Fertilizers were applied @ 100:30:30 ($N:P_2O_5:K_2O$) kg ha^{-1} under which nitrogen was applied in two split doses, half as basal dose and rest 1/4th at 20 days after transplanting and remaining 1/4th at 35 days after transplanting. Each of the chambers consists of thermometer to record maximum and minimum temperature. A common thermometer was set up to record the temperature of open field. The phenological parameters, yield attributes and yield were recorded and are presented in result and discussion section.

III. Results and Discussion

Table 01: Average temperature of chamber and field for rice growing period, 2017.

S.N.	Treatment	T. Max. (^{0}C)	T. Min (^{0}C)
1	Chamber 4'	38.5	16.2
2	Chamber 5'4"	39.5	17.2
3	Chamber 6'9"	40.7	18.4
4	Open field	34.8	15.6

The average maximum temperature was found 3.7^{0}C, 4.7^{0}C and 5.9^{0}C higher in 4', 5'4" and 6'9" height open top chamber respectively in compare with open field condition. However, increase in minimum temperature (T. min) was found nominal (0.6⁰C, 1.6⁰C and 2.8⁰C respectively) in three chambers compared to open field condition. The average seasonal increase in temperature was 2.5, 3.3 and 5.2⁰C in three chambers (4', 5'4'' and 6'9'' height).

Table 02. Growth and yield attributes of rice at NARC, Khumaltar, Lalitpur, Nepal, 2017

Treatments	PH (cm)	HD	MD	Tillers per hill	PL (cm)	GY (t ha^{-1})	SY (t ha^{-1})	Test weight(gm)
Chambers								
Chamber 4'	101	92.58	118.2	8.82^a	23.97	5.13	6.22^a	27.19
Chamber 5'4"	99.5	91.83	117.8	8.67^a	23.48	4.83	5.75^b	27.08
Chamber 6'9"	104.1	92.83	117.9	7.66^b	23.18	4.46	5.32^c	26.34
Open Field	97.9	92.75	118.3	8.62^a	23.35	5.20	6.29^a	27.35
SEm(±)	1.9	0.8	0.5	0.23	0.57	0.24	0.10	0.9
LSD	NS	NS	NS	0.8*	NS	NS	0.36**	NS
Varieties								
Khumal 10	117.4^a	92.42^b	115.8^b	7.78^b	23.07^b	5.35^a	6.06^b	28.5^a
NR 1105-B-B-27	105.9^b	92.08^b	116.9^b	8.67^a	22.05^b	4.75^b	5.68^c	25.50^b
Khumal 8	98^c	98.08^a	122.1^a	8.62^a	25.92^a	5.36^a	6.46^a	25,92^b
08 fan- 10	81.2^d	87.42^c	117.4^b	8.7^a	23.07^b	4.16^c	5.37^d	28.63^a
SEm(±)	2	0.7	0.7	0.23	0.62	0.18	0.09	0.7
LSD	5.8**	2.1**	2**	0.66**	1.81**	0.51**	0.26**	2.1*
CV	6.8	2.7	2	9.3	9.2	12.4	5.3	9.1
Grand total	101	92	118	8.4	23.5	4.90	5.9	27

Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance, * Significant, 88 Highly Significant, NS- Non- Significant
Note: PH- Plant Height, HD- Heading Days, MD- Maturity Days, PL- Panicle Length, GY- Grain Yield, SY- Straw Yield.

Plant Height

Plant height was not influenced by the different height of the chambers whereas statistically different with respect to different rice varieties grown. Significantly tall plant height (117.4 cm) was observed in Khumal-10 variety followed by NR 1105-B-B-27 (105.9 cm), Khumal-8 (98 cm), and 08 Fan-10 (81.2 cm) respectively. Alam et al. (2014) stated that the variety is the key component to produce quantitative and qualitative character such as plant height, yield of rice and any other crop depending upon their differences in genotypic characters, input requirements, growth mechanism and the persisting environmental conditions during the growing season. The significant differences in plant height have been reported between different rice varieties (Buri et al. 2015).

50% Heading days and Maturity days

No significant result was obtained by the effect of different chamber height on heading days as well while statistically different day length was required for 50% heading in case of different varieties. 50% heading of 08 Fan-10 was faster (87 days) in compare with other varieties grown. Khumal 8 requires 98 days for 50% heading being statistically most lately followed by Khumal 10 and NL 1105-B-B-27 (92 days). Similarly, Khumal 8 variety was matured lately i.e. at 122 DAT, which was statistically different with maturity days of other three remaining varieties.

Number of tillers per hill

The temperature differences due to chamber height have significantly influenced number of tillers per hill. The topmost chamber i.e. 6'9" height has produced statistically lower tillers per hill in compare with other chambers. Higher temperature in this chamber has reduced the tillers number per hill. The

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lowermost tillers per hill were observed in Khumal 10 and the other three varieties were found to be statistically at par.

Panicle Length

The longest panicle was produced by Khumal 8 variety (25.9 cm) which was statistically different with other varieties panicle length. Panicle length of remaining three varieties was statistically at par.

Grain Yield

In the experiment, grain yield was not influenced by the different chamber height while statistically significant result was obtained in between different varieties. The production of Khumal 8 (5.36 t ha^{-1}) and Khumal 10 (5.35 t ha^{-1}) was found to be superior and was statistically at par. Similarly the grain yield of NR 1105-B-B-27 (4.75 t ha^{-1}) and 08 Fan-10 (4.16 t ha^{-1}) varieties was also statistically at par.

Straw Yield

Straw yield was found to be significantly influenced by the different chamber height as well as in different varieties. The higher straw yield was produced under the open field (6.29 t ha^{-1}) which was statistically at par with the yield under 4' chamber (6.22 t ha^{-1}) followed by 5'4" chamber (5.75 t ha^{-1}) and lowermost under 6'9"chamer (5.32 t ha^{-1}) respectively.

In case of varieties, Khumal 8 (6.48 t ha^{-1}) produced significantly higher straw yield followed by Khumal 10 (6.06 t ha^{-1}), NR 1105-B-B-27 (5.68 t ha^{-1}) and 08 Fan-10 (5.37 t ha^{-1}) respectively.

Test Weight (1000-grain weight)

Test weight was found to be non-significant under different height chamber while influenced by different varieties of rice. Statistically similar and superior test weight for Khumal 10 (28.50 g) and 08 Fan-10 (28.83 g) was recorded while that of Khumal 8 (25.9 g) and NR 1105-B-B-27 (25.5 g) was the lower one.

IV. Conclusion

Temperature differences made by the use of open top chambers of three different height was found to be statistically non-significant in compare with open field in most of the growth and yield attributes as well as grain yield of the four different rice varieties (genotypes). On the other hand, among four different rice varieties, grain yield of Khumal 10 and Khumal 8 were found to be higher and statistically at par at elevated temperature regime.

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