Introduction
Agriculture largely depends on climatic parameters like rainfall, humidity and temperature. Agriculture, particularly rain-fed, is extremely sensitive to climate change (Ramay et al., 2011). A temperature increase of more than 2.5°C Celsius will severely affect crop production in Nepal because of increased evaporation and evapo-transpiration leading to increased heat stress on the soil and crops (Regmi, 2007).

Rice (Oryza sativa L.) is the second most important crop in the world after wheat and also the most important crop in Nepal. The production of rice is influenced by various biotic and abiotic factors. Temperature is the major constraint for the crop yield. The present experiment was conducted to study the impact of temperature on straw and crop productivity from June to October 2014. The experiment was conducted under temperature control chamber, in which temperature was elevated from the ambient level by 2°C and 3°C for the entire crop growth period. Grain and straw yield was measured using electronic weighing machine. Maturity of grain was 10 and 7 days earlier at elevated temperature by 3°C and 2°C respectively. Under similar condition of water depth, plant spacing, rice variety and soil nutrient, rise in temperature up to 2°C is favorable for rice straw yield and crop productivity. Yield loss under elevated temperature by 3°C is due to floret sterility. Further research on temperature resistance rice variety is necessary.

Key words: Production, Straw yield, Temperature

Impact of elevated temperature on rice productivity: A case of Lalitpur, Nepal

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Abstract
Rice (Oryza sativa L.) is the second most important crop in the world after wheat and is also the most important crop in Nepal. The production of rice is influenced by various biotic and abiotic factors. Temperature is the major constraint for the crop yield. The present experiment was conducted to study the impact of temperature on straw and crop productivity from June to October 2014. The experiment was conducted under temperature control chamber, in which temperature was elevated from the ambient level by 2°C and 3°C for the entire crop growth period. Grain and straw yield was measured using electronic weighing machine. Maturity of grain was 10 and 7 days earlier at elevated temperature by 3°C and 2°C respectively. Under similar condition of water depth, plant spacing, rice variety and soil nutrient, rise in temperature up to 2°C is favorable for rice straw yield and crop productivity. Yield loss under elevated temperature by 3°C is due to floret sterility. Further research on temperature resistance rice variety is necessary.

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Numbers of research works on climate change impact on rice yield have been conducted, but the control experiment focusing on impact of elevated temperature on straw and crop yield is limited. The present study was conducted to understand temperature relationship with straw and crop productivity which will be helpful to the farmers, agronomist, scientist, decision makers and planners.

**Materials and Methods**

Experiment was conducted from July to October, 2014. During the experimental period, the average maximum temperature of 28.85, 28.40, 27.14 and 24.5°C and minimum temperature of 15.64, 20.60, 21.45 and 15.13°C was recorded. Similarly, the total rainfall received was 782.2 mm during the growing period of rice, i.e., June to October.

**Experimental details for varied temperature**

The experiment was conducted under temperature control chamber, in which temperature was elevated from the ambient level by 2°C and 3°C for the entire crop growth period. Experiment was conducted on control environment at farmer’s field in Chapagaun Lalitpur, during June to October 2014. The altitude of the site is about 1463 meter from the sea level. Geographically, it is located at 27°35’34.6” North latitude and 85°19’32.2” East longitudes. Paddy was grown at 0.27% nitrogen, 215.3 kg/ha phosphorous, 256.03 kg/ha potassium and 5.51% organic matter. Addition of inorganic fertilizer throughout experiment period was avoided.

The experimental area was divided into three plots of 4 m x 4 m size maintaining a buffer of 0.5 m between adjacent plots. There were three treatments (one ambient condition and two elevated temperatures) and each treatment consists of four replicates (Fig. 1). Each replicated plot consist an area of 2 m x 2 m. The local high yielding rice variety namely ‘Khumal-4, Local Mangsuli’ was considered as the experimental crop for the study. Water depth of 6 cm was maintained throughout the experimental period.

The rice seedlings were transplanted on 2nd July, 2014 with 7 cm x 6 cm space. The date of maturity of each treatment was recorded i.e. 5th October for 3°C temperature elevation, 1st November for 2°C elevation and 4th November for ambient temperature condition.

**Temperature measurement**

Temperature in the experimental plot/chamber was elevated by constructing open top chamber made up of plastic and bamboo. Difference in temperature was obtained by differenting in percentage coverage of plastic in chamber. Thermometer was used for the measurement of temperature. Temperature in the experimental chamber was recorded thrice a day at the interval of six hours from July to October, 2014 (Table 1). The ambient condition temperature data of Khumaltar, Lalitpur station (Table 2) was used for the analysis.

**Table 1** Average maximum temperature (°C) in experimental chamber

| Months | 1st chamber | 2nd chamber |
|--------|-------------|-------------|
| July   | 31.2        | 31.95       |
| August | 30.40       | 31.4        |
| September | 29.8    | 29.2        |
| October | 26.1        | 27.8        |
| Average maximum temperature during experiment | 29.37 | 30.08 |

**Table 2** Ambient temperature (°C) condition in Khumaltar station

| Months     | Minimum | Maximum | Average | Average maximum temperature during experiment (°C) |
|------------|---------|---------|---------|--------------------------------------------------|
| July       | 15.64   | 28.85   | 22.24   | 27.22                                            |
| August     | 20.60   | 28.40   | 24.5    |                                                  |
| September  | 21.45   | 27.14   | 24.29   |                                                  |
| October    | 15.13   | 24.50   | 19.81   |                                                  |

**Grain and straw yield measurement**

After harvesting of crop from the field, grain was dried, threshed and again sun-dried. Grain was weighed at 10.1% moisture content.
with the help of digital weighing machine. Grain moisture was measured at the laboratory of Soil Science Division, National Agriculture Research Council (NARC), Lalitpur using moisture and temperature meter.

Paddy was harvested in October. After removing grain, straw was weighed within six hours, with the help of electronic weighing machine (model GTP). Straw from each treatment was weighed separately.

Data Analysis
Data on crop productivity and straw yield were collected from the experimental plots. All the collected data was refined and entered in MS-Excel. Further, the data were analyzed through MS-Excel 2007, with the suitable charts, graphs, etc. Straw and grain yield was calculated in percentage coverage.

Results and Discussion
Temperature relation with straw and grain yield
Productivity of rice under elevated temperature along with ambient temperature is shown in Figure 2. Results revealed that productivity of crop was influenced by elevated temperature.

Grain yield was found to be increased by 11% and 3.5% at elevated temperature by 2°C and 3°C, respectively than the ambient condition under unchecked weed (Fig. 2). At 3°C temperature elevation, ripening of grain was earlier with poor grain filling (Fig. 2). Increasing temperature can cause increased spikelet sterility in rice and reduce grain yield (Wassmann & Dobermann, 2007). This might be the reason behind decrease in production when temperature was elevated by elevated temperature.

Similar results were reported by Rai et al. (2009) and Malla (2008). High temperature damage photosynthetic membranes (thylakoids) and cause chlorophyll loss, decrease leaf photosynthetic rate, increase embryo abortion, lower grain number, and decrease grain filling duration and rates, thus result in lower grain yield (Sultan et al., 2013). Maturity of grain was 10 and 7 days earlier at 5°C and 2°C elevated temperature respectively than the ambient condition (Table 1).

At elevated temperature by 2°C and 3°C, the straw yield was respectively 11.6% and 3.7% higher than the ambient temperature (Fig. 2). There was 8% increased in straw yield at 2°C elevated temperature in comparison to 3°C temperature elevation. High temperature damage photosynthetic membranes (thylakoids) and cause chlorophyll loss and decrease leaf photosynthetic rate. At the molecular level, high temperature adversely affect cell metabolism and cause changes in the pattern of protein synthesis (Sultan et al., 2013). This might be the reason behind reduction in straw yield at 3°C elevated temperature. Crop productivity in long run. The study suggests further researches on temperature resistance rice variety.

Conclusion
The present study reveals that there is increase in rice production at elevated temperature by 2°C and 3°C in comparison to the ambient condition. But, there is reduction in grain yield at elevated temperature by 3°C in compared to the temperature elevation by 2°C. This reduction in grain yield may be due to spikelet sterility at flowering stage. For the Khumal-4 rice variety increase in temperature by 2°C favored the crop production. This experiment shows elevated temperature has negative impact on straw and crop productivity in long run. The study suggests further researches on temperature resistance rice variety.

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