Original Research Article

Effect of Maize and Chickpea Intercropping under the Different Row Ratios on Air Temperature and Vapoure Pressure Profile in Crop Canopy

ABSTRACT

An experiment was laid out to study the effect of maize and chickpea intercropping under the different row ratios on air temperature and vapoure pressure profile in crop canopy at Agronomy farm, B. A. College of Agriculture, AAU, Anand (Gujarat), India during the *rabi* crop season of the year 2021-2022. The soil of the experimental field was loamy sand. The objective was to determine the effect of maize and chickpea intercropping under the different row ratios on air temperature and vapoure pressure profile in crop canopy. The experiment was laid out in a randomized block design with six treatments replicated four times. The treatments details are T_1: Sole maize, T_2: Sole chickpea, T_3: Maize paired row, T_4: Maize + chickpea (1 : 1), T_5: Maize + chickpea (1 : 2), T_6: Maize + chickpea (2 : 2). During the early crop growth inversion profile of air temperature was observed because crops canopy was short. Air temperature was lowest at ground level, with increase in height air temperature increase. At upper canopy air temperature is lower than lower canopy because active transpiration by the dense foliage at upper canopy lower down the air temperature. During the early crop growth lapse profile of vapour pressure was observed. Highest value of vapour pressure was observed at the ground, but with an increase in height vapour pressure decreased. In the case of within crop canopy, strong gradient of vapour pressure was observed in upper crop canopy and weak gradient at lower crop canopy.

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Keywords: *maize, chickpea, intercropping, row ratios, air temperature, vapoure pressure profile*

1. INTRODUCTION

Next to rice and wheat, maize (*Zea mays L.*) is the third most important cereal crop, with the highest production potential among cereals. Due to its high photosynthesis efficiency owing to the C_4 mechanism, maize produces a high biological yield as well as grain yield in a short period of time, achieving it the title of "Queen of Cereals."

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After beans and peas, chickpeas (*Cicer arietinum L.*) are the world's third-largest pulse crop. It is a significant semi-arid tropics pulse crop, especially in India's rainfed ecosystem. Chickpea is a Fabaceae family legume crop. By retaining atmospheric nitrogen in their root nodules, chickpea can improve soil fertility and maintain soil productivity. Chickpea is also known as the "King of Pulses" because it contains 21.1% protein, 61.5% carbohydrates, and 2.2% oil [1].

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In comparison to other cropping systems, intercropping is a good approach for higher yield, growth, and development [2]. The purpose of intercropping is generally to increase the total productivity per unit area per unit time by growing multiple crops in the same field, with the main objective is efficient utilization of environmental resources [3]. Intercropping minimizes the risk of total crop failure in the event of a serious disease infestation or insect pest attack and scarcity of resources because two or more crops are cultivated on the same field.

2. MATERIALS AND METHODS

A field experiment was conducted on the Agronomy farm of B. A. College of Agriculture, AAU, Anand. The research farm is located at the latitude of 22°35' N and longitude of 72°55' E. The altitude of the farm is 45.1 m above the mean sea level. The experiment was laid out in a randomized block design with six treatments replicated four times. The treatments details are T_1: Sole maize, T_2: Sole chickpea, T_3: Maize paired row, T_4: Maize + chickpea (1 : 1), T_5: Maize + chickpea (1 : 2), T_6: Maize + chickpea (2 : 2). The soil at the experiment location was sandy loam in type and typical of that found in the Charotar region of Gujarat, which includes Anand. Locally, this soil is known as "Goradu Soil." The variety for maize is "Gujarat Anand Yellow Maize Hybrid 3" (GAYMH 3) and for chickpea, Gujarat Junagadh Gram 6 (GJG 6) was used.

After field preparation, the layout of the experiment was laid out. Fertilizers were applied as per the recommendation for maize and chickpea crops 150-40-00 NPK kg ha^{-1} and 25-50-00 NPK kg ha^{-1} respectively through urea and diammonium phosphate (DAP). Half quantity of nitrogen and full quantity of phosphorus was applied in furrows as basal dose. After applying the basal dose of fertilizer in the rows, sowing was done at a depth of about 5 cm by dibbling method with a seed rate of 20 kg ha^{-1} for maize and 60 kg ha^{-1} for chickpea crops. The first irrigation was given immediately after sowing to ensure uniform and better establishment of the crop. Thereafter, irrigation was applied according to the critical stages of the crops. Thinning and gap filling were done to maintain 20 cm and 10 cm intra-row spacing for maize and chickpea, respectively. To eliminate weeds from the field, weeding was frequently done and intercultural operation was carried out by wheel hoe for better aeration to plant roots.

Air temperature and vapour pressure was measured using Assman Psychrometer. It consists of two thermometers, one of which has its bulb covered by awick that was kept wet by placing its lower end in a reservoir of distilled water when air flows past the thermometer, water gets evaporated from the wick and as a result the wet bulb thermometers recorded a lower temperature than the dry one. The observations were recorded at various heights of crop canopy at 30, 60, 90 DAS and Physiological maturity. From the simultaneous readings of both thermometers, the vapour pressure was calculated by the below given formula.

$$Vp = Svp - \frac{[480(Dt - Wt)]}{[810 - Wt]}$$

$$Svp = 4.58\exp\left[\frac{(17.269 \times Wt)}{Wt + 237.7}\right]$$

Where, Vp = Actual vapour pressure
Svp = Saturated vapour pressuret
Dt = Dry bulb temperature
Wt = Wet bulb temperature

3. RESULTS AND DISCUSSION

3.1 Air Temperature

The analyses of the energy and water balance include a number of crucial elements, including temperature and water vapour. Because of their significance in the transfer of heat and moisture from the earth, the changes in temperature and water vapour with the change in crop height have caught the attention of many people working in agriculture. The primary objective of this study is to examine the distribution of temperature and water vapour in a maize and chickpea field. The nature of the variation in temperature and water vapour in the vertical is governed largely by the underlying surface

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conditions and to a certain extent by the prevailing weather conditions. It was measured how the air temperature fluctuated vertically as influenced by different row ratios at 30, 60, 90 DAS and physiological maturity. Data regarding air temperature displayed in Figure 1.

In sole maize, maize paired row and respective intercropping treatments, the air temperature was measured at the surface, in the middle of the canopy (40 cm), and above the canopy (80 cm), whereas in the case of sole chickpea, it was measured at the surface and above the canopy (40 cm), as chickpea had not yet attained significant plant height at 30 DAS.

At the surface lowest air temperature was observed in the maize + chickpea (2 : 2) row ratio followed by maize + chickpea (1 : 1) row ratio, while the highest air temperature was observed in sole chickpea followed by maize paired row among all the treatments. The effect of solar radiation is nearly identical on the ground surface of the cropped field as on the bare ground surface when the plant height is short because the crop cover is ineffective at completely shading the ground from solar radiation. Widely spaced rows and crops with short canopies allow more radiation to reach the ground, which results in more heating and higher air temperature. This may be the cause of the greater air temperature near the ground during the early growth stages in the sole chickpea and maize paired row. These results were supported by Cole and Symes [4], who investigated the vertical distribution of temperature and humidity within tobacco plots, and reported that the gradients of temperature and humidity were quite similar to those found in the open ground when plant height was short. As the plant grew taller, the profiles approximated those typically seen in a crop with medium ground cover and density.

At the middle of the canopy (40 cm) in sole maize, maize paired row and respective intercropping treatments air temperature is recorded as slightly greater as compared to the ground but lower than the above canopy air temperature. Air temperature at above the canopy (80 cm) was recorded highest among all the heights of observations. In the case of chickpea also reported a similar thing that the air temperature above the canopy (40 cm) is higher than the air temperature at the ground.

At 60 DAS air temperature was measured at surface, 80, 130 and 160 cm heights in sole maize, maize paired row and respective intercropping treatments. While in sole chickpea it was measured at surface, 40 cm and 60 cm. The lowest air temperature was recorded at the surface among all the heights of observations. With further increase in height air temperature also increases. At 80 cm height air temperature was reported higher than the ground. Air temperature recorded slightly decreased at 130 cm height and at above canopy (160 cm) air temperature was recorded highest as compared to other heights of observations. In sole chickpea clearly, an inversion profile of air temperature was observed, with the increase in height air temperature also increased. The lowest air temperature at the surface and highest air temperature above the canopy (60 cm) were recorded. Among all the treatments highest air temperature at the surface was reported in sole chickpea, while the lowest air temperature was recorded in maize + chickpea (2 : 2) row ratio. More shading, completely covered ground and little wind movement in comparison to other treatments may be the cause of the lowest air temperature in the maize + chickpea (2: 2) row ratio and maize + chickpea (1: 1) row ratio. The temperature dropped at 130 cm and increased at 160 cm above the canopy, possibly due to active transpiration by the dense foliage at 130 cm lower down the air temperature, while more wind movement and turbulence at 160 cm above the canopy led the temperature to increase. Temperature decreased with height in this layer (130 cm) for tall canopies like sole maize, maize paired row and respective intercropping treatments, the same increased with height in the short canopy like sole chickpea, clearly indicating the role of plant height in influencing the distribution of air temperature. The similar result was observed by Prine [5] in tall and short canopies of grasses.

At 90 DAS air temperature was measured at surface, 80, 180 and 240 cm heights in sole maize, maize paired row and respective intercropping treatments. While in sole chickpea it was measured at surface, 60 and 90 cm. Results were observed almost similar as mentioned earlier in 60 DAS except for one thing the highest air temperature at the surface was recorded in maize paired row instead of sole chickpea. This is might be due to the complete ground covered by sole chickpea while in the case of maize paired row plant canopy attained significant height at this stage but wider row spacing allow more solar radiation to reach at the ground and cause heating. Brown and Covey [6] reported the same result, claiming that because lower layers are not as heated in the field, the air temperature is low. The evaporation of soil moisture also reduces air temperature.

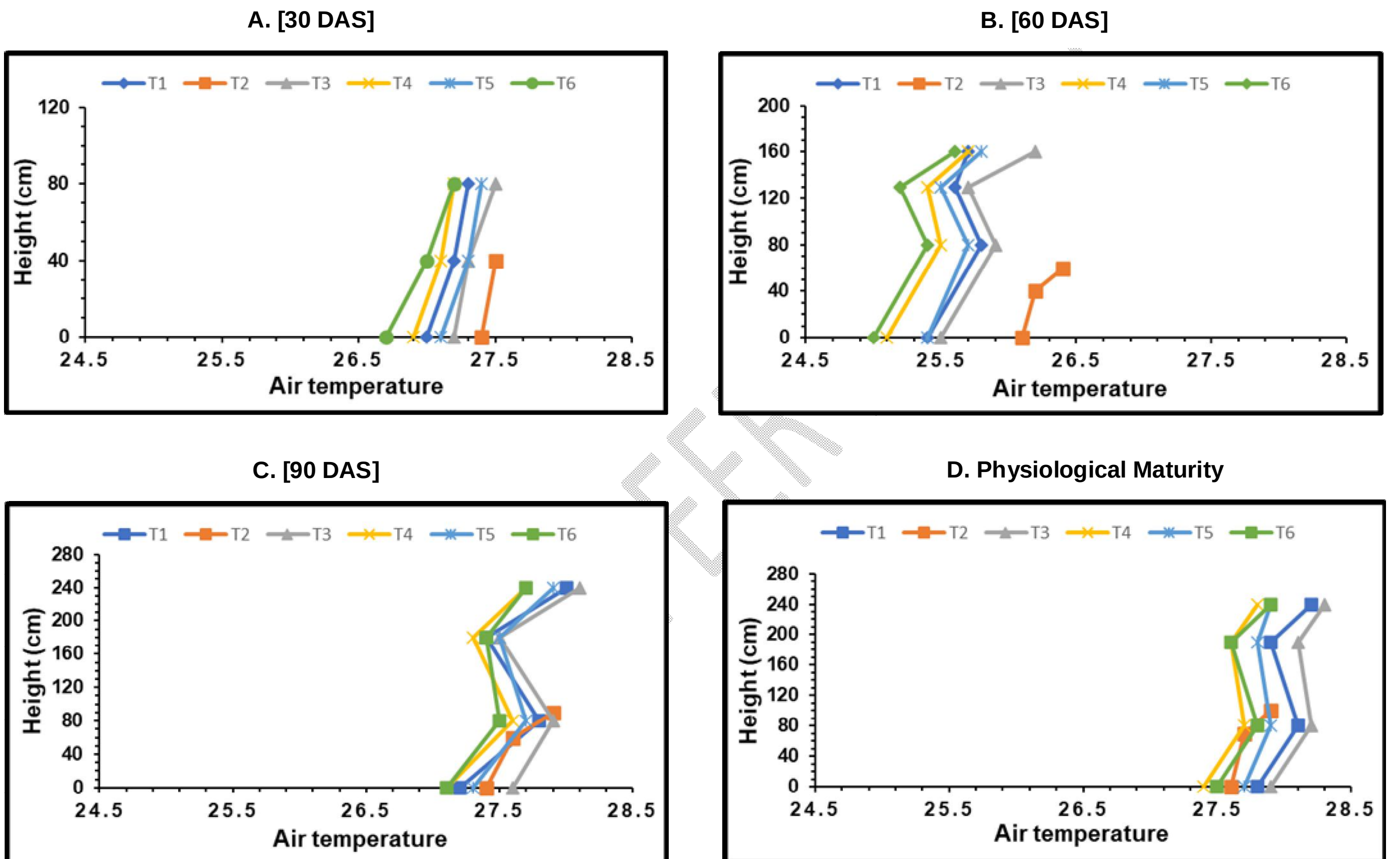

Figure 1: Effect of different row ratio treatments on vertical profile of air temperature in the crop canopy

At Physiological maturity air temperature was measured at surface, 80, 190 and 240 cm heights in sole maize, maize paired row and respective intercropping treatments. While in sole chickpea it was measured at surface, 70 and 100 cm. vertical profile of air temperature as influenced by height was observed almost similar to those mentioned in 60 DAS and 90 DAS except few things the highest air temperature at the surface was recorded in maize paired row followed by sole maize and maize + chickpea (1: 2) row ratio. It was indicated that penetration of light at the ground is more restricted in maize + chickpea (2: 2) row ratio followed by maize + chickpea (1: 1) row ratio and sole chickpea as compared to other treatments at this stage. Variation of air temperature between the different treatments was a little bit more as compared to 90 DAS. It is indicated that the senescence of crops at this stage also influences the air temperature profile. These investigations have demonstrated that the effect of plant cover on temperature distribution under different treatments is only noticeable when plant height is sufficiently higher. According to Aslyng and Stendal [7], who reported the distribution of air and soil temperatures at different profiles, the temperature variance was largest close to the soil surface.

3.2 Vapoure Pressure

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The influence of different row ratio treatments on the distribution of vapour pressure with varying heights was determined at 30, 60, 90 DAS and physiological maturity. The data pertaining to the vapour pressure was presented In Figure 2. The various heights at which vapour pressure is measured are the same as those previously mentioned in air temperature measurement.

At 30 DAS highest vapour pressure was determined at the ground level and the lowest vapour pressure was reported above the canopy (80 cm) among all the heights of measurement. In the case of all the treatments, the maximum vapour pressure was recorded in the maize + chickpea (2: 2) row ratio followed by maize + chickpea (1: 1) row ratio and the of vapour pressure was reported in sloe chickpea followed by maize paired row in all the heights of observations. There is higher water vapour content near the ground surface, in the microlayer, and this is due to evaporation of water from the ground surface and from the foliage of vegetation. The gradual decline in the moisture content with height is due to the fact that water vapour added to the air by evaporation at the lower layer is diffused and dispersed by vertical and horizontal currents of air.

At 60 DAS highest vapour pressure was observed at the surface, but with an increase in height vapour pressure decreased. In the case of sole maize, maize paired row and respective intercropping treatments vapour pressure recorded lower than the surface at 80 cm height, with further increase in height vapour pressure increase at 130 cm height. The lowest vapour pressure was noted above the canopy (160 cm). In the case of sole chickpea vapour pressure continuously decreased with an increase in height. It indicated a lapse profile of vapour pressure. The highest vapour pressure was observed in the maize + chickpea (1 : 1) row ratio followed by maize + chickpea (2 : 2) row ratio and the of vapour pressure was reported in sloe chickpea followed by maize paired row. Our finding is supported by Baldocchi *et al.* [8] who studies the microclimate in soybean and found that vapor pressure profiles generally lapse throughout the day with a strong gradient in the upper canopy and a weak gradient in the lower canopy.

At 90 DAS results were observed almost similar as mentioned earlier in 60 DAS except for a few things, that in the case of sole maize, maize paired row and respective intercropping treatments the highest vapour pressure was recorded in maize + chickpea (1: 1) row ratio at surface. The maize + chickpea (2 : 2) row ratio recorded the highest vapour pressure at 80 cm height, while at 180 cm height maize + chickpea (1: 1) row ratio was reported highest vapour pressure among all the treatments. The lowest vapour pressure was observed same in the sole chickpea and maize paired row at the ground (0 cm). This is might be due to more exposure allowing more radiation to reach the ground and cause heating, resulting in more air temperature lower down the value of vapour pressure in those treatments. The variation of water vapour in the lower layer was studied by Ramdas [9] using Asmann Psychrometer. The study revealed that the moisture content of the surface layers of the soil was maximum at the epoch of the minimum air temperature and minimum at the epoch of the maximum air temperature.

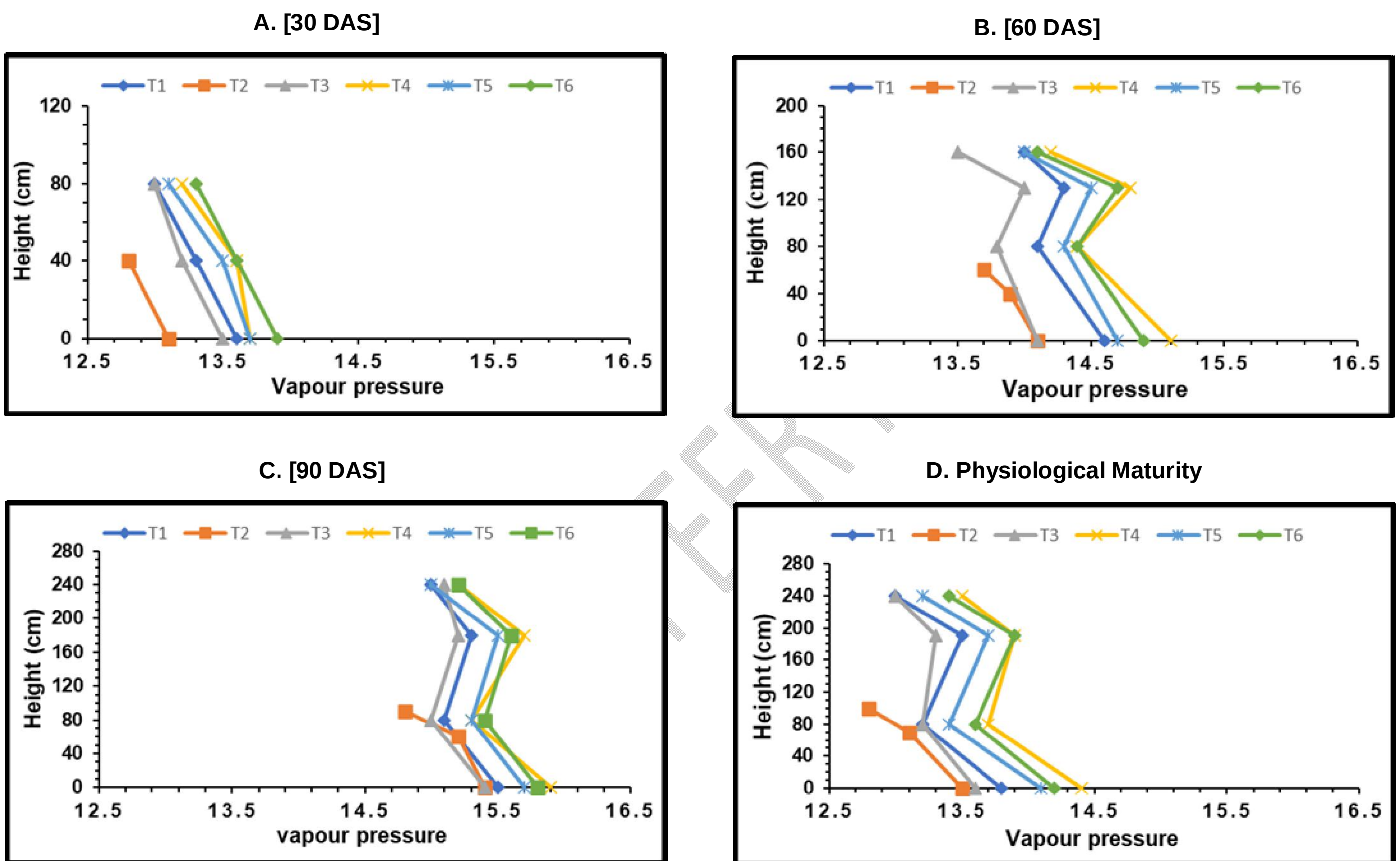

Figure 2: Effect of different row ratio treatments on vertical profile of vapour pressure in the crop canopy

D. Physiological Maturity

At the physiological maturity vertical profile of vapour pressure as influenced by various heights was observed to be almost similar to those mentioned in 60 DAS and 90 DAS, with minor things which differed at harvest time, is sole chickpea recorded the lowest vapour pressure at the various height of observation as compared to other treatments. The maximum value of vapour pressure observed in all heights of observation in maize + chickpea (1: 1) row ratio. The vapour pressure at 190 cm was noted the same in maize + chickpea (1: 1) row ratio and maize + chickpea (2 : 2) row ratio.

The study mentioned above showed that the vapour pressure was greatest near the ground surface and that height changes above ground caused rapid changes in vapour pressure. Vapour pressure was found to be significantly lower at the top of the plant and higher within the canopy of the plant. It might be because there is a better gas exchange at the top of the plant. According to Rosenberg [10], the profiles of vapour pressure in soybean crop above the ground surface were almost always lapse, with the exception of when condensation was taking place. The concentration of vapour near the surface increases during the day as a result of the increased evaporation or transpiration. Uchijima *et al.* [11] studied the distribution of air temperature and the profile of water vapour in the corn crop canopy, and he observed that the relative humidity and vapour pressure in the microclimatic layers always contributed in controlling the rate of transpiration, in the layers.

4. CONCLUSION

During the early crop growth inversion profile of air temperature was observed because crops canopy was short. Air temperature was lowest at ground level, with increase in height air temperature increase.

During 60 DAS, 90 DAS and physiological maturity crop canopy is fully developed, lowest air temperature was observed at ground, further increase in height air temperature is increase. At upper canopy air temperature is lower than lower canopy because active transpiration by the dense foliage at upper canopy lower down the air temperature. While more wind movement and turbulence at above the canopy led the air temperature to increase.

At 30 DAS highest value of vapour pressure was determined at the ground and the lowest value of vapour pressure was reported at above the canopy. During the early crop growth lapse profile of vapour pressure was observed.

During 60 DAS, 90 DAS and physiological maturity highest value of vapour pressure was observed at the ground, but with an increase in height vapour pressure decreased. The lowest value of vapour pressure was noted above the canopy. In the case of within crop canopy, strong gradient of vapour pressure was observed in upper crop canopy and weak gradient at lower crop canopy.

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