The Effect of Intercropping of Maize and Soybean on Microclimate*

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Abstract. Intercropping induces the diseases decreasing, and yield increasing, may partly due to the improvement of microclimate in fields. In order to understand the mechanism and efficiency of resource utilization in intercropping of maize (Zea mays) and soybean (Glycine max), a field experiment was conducted as factorial on the bases of randomized complete block design of three patterns with three replications. Three cropping patterns were maize monocropping (A), 2 rows maize and 2 rows soybean intercropping (C) and 2 rows maize and 4 rows soybean intercropping (D). Our studies showed that compared with monocropping, the temperature in intercropping was a little higher in the daytime, but in the nighttime, the contrary results were observed; the relative humidity in intercropping was lower in the daytime, but in the nighttime, the contrary results were observed; the light intensity in intercropping was markedly higher than that in monocropping. The yield components of maize in intercropping, including thousand kernel weight, yield per plant and leaf area were increased than that in monocropping. These results imply that microclimate variation of intercropping probably play important role to maize yield increasing.

Keywords: Intercropping, Temperature, Relative humidity, Light intensity, Biological characters.

Introduction

Compared with the monoculture, there may be more effectively utilize the temporal-spatial remainder of intercropping crops growth and development to bring into play the production potential of limited agricultural resources including radiation, fertilizer, water, gas and heat[1-3]. Therefore intercropping plays an important role in agricultural productions.

The microclimate including temperature, relative humidity (RH) and light intensity in farmland is an important factor in the growth and production of crops. Previous studies showed that the relative humidity, which played vital roles in disease injuries of

* Foundation: This work was supported by the National Basic Research Program (2011CB100400).
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D. Li and Y. Chen (Eds.): CCTA 2011, Part II, IFIP AICT 369, pp. 257–263, 2012.

crops, was found to present downtrend and reducing the number of hours per day with relative humidity ≥92% in intercropping[3-4]. And the intercropping can increase the amount of light intercepted of crops in unit planting area so that improve the crop dry matter production, yield and radiation use efficiency[5-10]. So we explore the microclimate change regulation in multi-culture patterns of maize and soybean and compared with monocropping so to discover the mechanism of intercropping.

1 Materials and Methods

Field experiments were conducted at the farm of Yunnan Agricultural University, Yunnan province, China, 25°01′N, 103°E during 2009/05/06 to 2009/10/22. the crops used in the experiment were maize (Yunrui 88) and soybean (Nandou 12), and were sown by north-south rows at the same time. The experiments was made up of three cropping modes, one of which was maize monocropping (A, row distance 40cm), two of which were maize intercropping, viz., 2 maize rows (row distance 50cm) and 2 soybean rows (row distance 50cm) (2:2)- (C) which distance of maize to nearest soybean row is 50cm, and 2 maize rows (row distance 35cm) and 4 soybean rows (row distance 30cm) (2:4)- (D) which distance of maize to nearest soybean row is 40cm. Maize plant distance is 20cm and soybean plant distance is 30cm in all cropping patterns. Experiments repeated 3 times which using two-factor completely block design. Every unit area was 4.0cm ×5.0cm. Full irrigation and fertilizer were applied for every cropping system.

HOBO U12-012 data loggers were put beside maize plants and soybean plants to measure temperature ranged from -20℃ to 70℃, RH ranged from 5% to 95%, light intensity ranged from 1 to 3000 footcandles (lumens/ft^2). The light intensity beyond 3000 footcandles was recorded as the max value. But the light distributing difference between mono-cropping and intercropping focus mostly in the upper, middle and botten part, and the light intensity is usually in the measurement range. The Li-6400 portable photosynthesis was used to measure the photosynthetic rate of maize leaves.

The temperature, RH and light intensity on the position between maize and soybean, above ground 30cm (below the head of soybean canopy) and 70cm (above the head of soybean canopy) of field were measured at maize heading stage in our experiment. The HOBO loggers recorded the data one time every 30 minutes and the average of that during a period was obtained as the daily changes of temperature, RH and light intensity.

2 Results and Discussion

2.1 The Difference of Temperature and Relative Humidity Beside Maize Plant at Heading Stage in the Monocropping and Intercropping

Fig.1-(a) and (b) indicated that the similar trend of the temperature beside maize plants above ground 30cm and 70cm between monocropping and intercropping was observed,

viz., temperature in the daytime was higher than that in the nighttime. Wherever above ground 30cm or 70cm, in the daytime the temperature in intercropping was a little higher than that in monocropping, and the temperature in intercropping D was the most highest, followed by that in intercropping C and that in monocropping A. But in the night time, the contrary results were observed. The temperature in the nighttime in intercropping was a little lower than that in monocropping, and the temperature in intercropping D was the most lowest, followed by that in intercropping C and that in monocropping A. Fig.1-(c) and (d) also illustrated that similar daily change regulation of RH beside maize plants above ground 30cm and 70cm between monocropping and intercropping was also observed as the temperature, viz., the RH in daytime was lower than that in nighttime. Both above ground 30cm and 70cm, the RH in the daytime in monocropping A was the most highest, followed by that in intercropping D and that in intercropping C. But in the nighttime, the contrary results were observed. The RH in the nighttime above ground 30cm in intercropping D was the highest, followed by that in intercropping C and that in monocropping A. Above ground 70cm, the highest RH was found in intercropping D, and the lower one was found in monocropping A and in intercropping C. The results indicated that the microclimate in field such as temperature and RH in the intercropping were improved compared with that in monocropping.

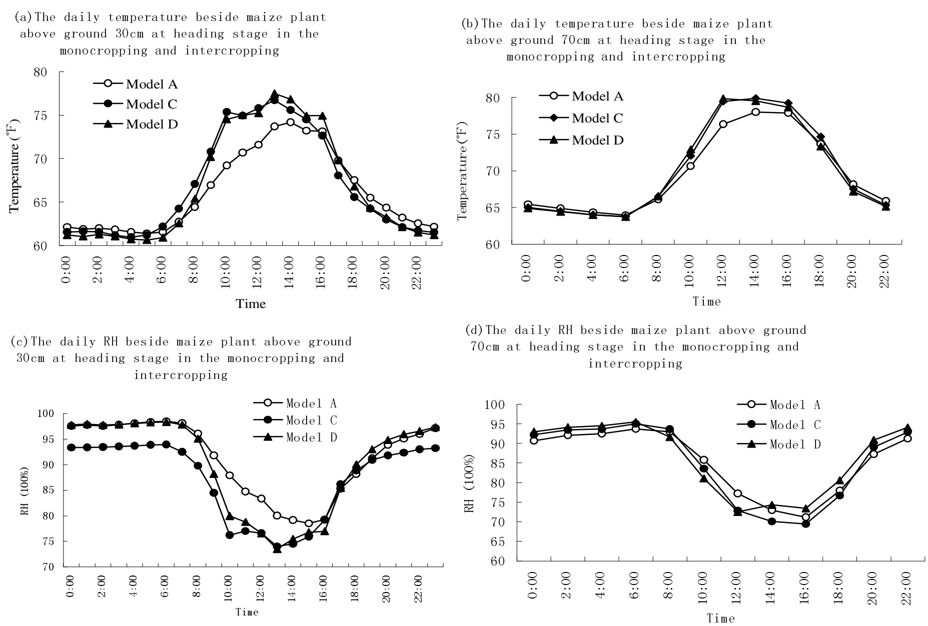

Fig. 1. Daily change of temperature and RH beside maize plants above ground 30cm and 70cm in monocropping and intercropping at heading stage

2.2 The Change of Light Intensity Beside Maize Plants above the Ground 30cm and 70cm in Monocropping and Intercropping at Heading Stage

Fig.2-(a) illustrated the light intensity during July 4th to July 19th, when the head of soybean canopy is below 30cm and the difference of light intensity was presented evident. Fig.2-(a) and (b) indicated that there were similar (parabolic curve) trends of daily light intensity above the ground 30 cm and 70cm beside maize plants in monocropping and intercropping. In other words, the maximum was found in the noon, while the minim was observed in the morning and evening in whatever cropping systems, which were consistent to the rules in meteorology. Moreover, light intensity in intercropping was significant higher than that in monocropping, especially with the increase of radiation angle.

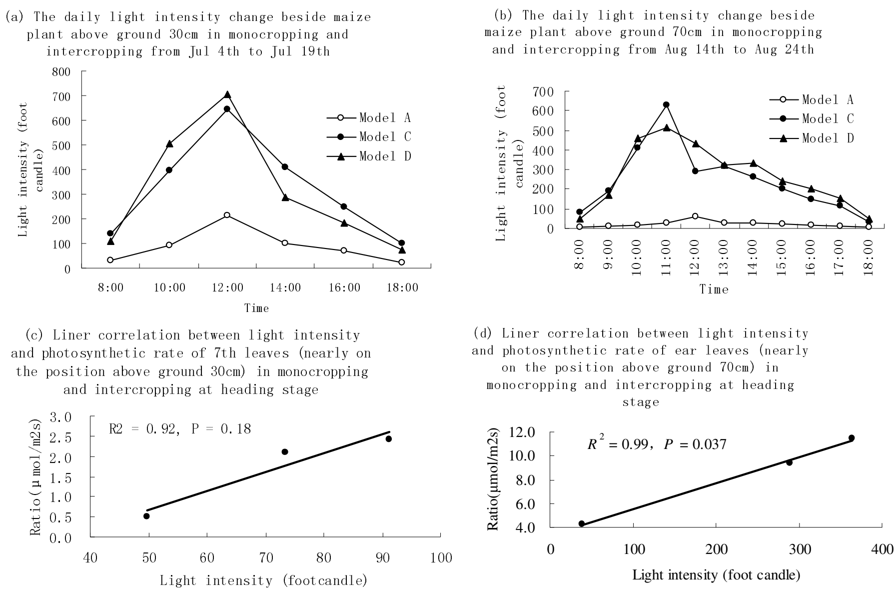

Fig. 2. Daily light intensity change beside maize plants above ground 30cm and 70cm and the relationship between light intensity and photosynthetic rate in monocropping and intercropping at heading stage

Fig. 2-(a) indicated that above ground 30cm in monocropping only from 11:30 am to 13:30 pm, the light intensity was above the compensation points. But in intercropping (C and D), the light intensity from 8:30 am to 15:30 pm was always above the light compensation points. It was implied that the time length of light intensity above the compensation points was significantly longer (nearly 5 hours) than that in monocropping. Further more, the light intensity was over 400 footcandles in intercropping from 10:00 am to 4:00 pm. Therefore, no matter in the time length and the intensity, effective radiation among the maize canopy above the ground 30cm in intercropping was markedly

higher than that in monocropping during July 4th to July 19th. We conducted a Pearson correlation between daily average light intensity and the photosynthetic rate of 7th leaves (nearly on the position above ground 30cm) during July 20th to July 28th. The results showed that strong correlation (R^2=0.92, P<0.001) can be observed in Fig.2-(c).

Fig.2-(b) indicated that above ground 70cm (beyond the head of soybean canopy) in monocropping, the light intensity was significant lower than the light compensation points, viz., the light intensity was below 100 footcandles. However, in intercropping C and D, the light intensity from 9 am to 5 pm (nearly 8 hours) was above the light compensation points, and from 9 am to 4 pm (7 hours) the light intensity was more than 200 footcandles. Maybe it becaused the canopy above the ground 70 cm in intercropping was not shadowed and can fully accept radiation. In Fig.2-(d) the linear correlation (R^2=0.95, P<0.001) between the light intensity and the photosynthetic rate in ear leaves (nearly on the position above ground 70cm) was also observed in monocropping and intercropping.

2.3 Comparing Biological Characters of Maize in Monocropping and Intercropping

It was easy from above results to see that compared with monocropping, the improvement of microclimate of fields in intercropping cause the raise of the photo-synthetic rate of maize's leaves, which could resulte the improvement of the biological characters of maize.

Table 1 indicated that maize's yield characters in intercropping, including thousand kernel weight, yield per plant and area of ear leaves are all greater than that in monocropping, in which the thousand kernel weight showed D>C>A, yield per plant showed C>D>A, the area of ear leaves showed C>D>A. Accordingly, from the trial results it was seem that the biological characters of maize in intercropping were better than that in monocropping.

Table 1. Biological characters of maize in monocropping and intercropping

Biological characters / Pattern	Thousand kernel weight (g)	Yield per plant (g)	Leaf area(cm^2)
Monocropping	323.8	120.8	626.0
Intercropping 2:2	339.2	167.2	877.3
Intercropping 2:4	344.9	160.7	666.6

3 Conclusions

Intercopping leads to variation of microclimate, especially for light intensity, RH and temperature. Maize and soybean are staple crops in the world, intercropping of the crops have long history in Asian countries, mainly for increasing the yield and nourishing the soil. However, mechanisms and efficiency of intercropping is unclear. It will be the limitation for improving intercropping system. In this study, microclimate of maize field including temperature, RH and light intensity in monocropping and intercropping were continously investigated by using Multi-channel Data Logger (Hobo H8) analyzed and compared. The results show that the microclimate was improved siginificantly.

Firstly, wherever above the ground 30cm or 70cm, in the daytime the temperature in intercropping was a little higher than that in monocropping, but in the night time, the contrary results were observed. Both above the ground 30cm and 70cm, the RH in the daytime in monocropping was higher then that in intercropping, but in the nighttime, the contrary results were observed.

Secondly, from the daily change, no matter in the time length and the intensity, effective radiation among maize plants above the ground 30cm and 70cm in intercropping was markedly higher than that in monocropping. Moreover, a remarkably linear correlation between daily average light intensity and the photosynthetic rate of leaves was observed.

Finally, the yield components of maize in intercropping, including thousand kernel weight, yield per plant and leaf area were increased than that in monocropping.

In summary, our results showed microclimate variation, including increasing the radiation duration and light intensity at different height position in intercropping field significantly, and remarkable correlation between light intensity and photosynthetic rate implied the variation of light intensity play important role for improving the yield component of maize. However, intercropping is a very complex system, biological variation of maize plants play roles for increasing the yield as well. To determine the better combination and more efficiency of resource utilization in intercropping, it is need to understand the biological, physical, chemical and microclimate effectors and their interaction.

Acknowledgemants. The authors would like to thank Project supported by the National Basic Research Program (2011CB100400).

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