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Developing an Improved Strip-intercropping System for Maize and Chinese Cabbage in the North China Plain

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Introduction

The North China Plain (NCP) is located in the eastern part of China, covering an area of more than 300.000 km². It is an important agricultural region, contributing about 20 % to China's total food production. Continues degradation of arable land along with a growing population with increasing living standards endanger food security. To meet the demand production intensities are very high, which results in severe resource degradation. The production of vegetables, which increased tremendously in the last decade, demands even a higher amount of external inputs. Water is a key issue in the NCP as the precipitation of 550-650 mm is distributed irregularly within a year. About 70% of precipitation occurs within only three summer months. Therefore irrigation is essential to extend the cropping period. This results in water degradation and shortage as well as land degradation (Dazhong et al., 1992).
There is an urgent need to develop cropping systems that are highly productive, sustainable and use local grown crops. Intercropping is a system traditionally practiced in China that often produces higher yields compared to monocropping (Zhang and Li, 2003). Through simultaneous cultivation of two or more crops on the same field environmental resources can be used more efficiently. Benefits are described as increased land use efficiency, higher water use efficiency, reduced erosion and leaching, increased fertilizer use efficiency and a more stable production. Thus intercropping has a great potential to counteract resource degradation.

Material and Methods

To develop an improved strip-intercropping system a field experiment was conducted at Quzhou experimental station, Hebei province in 2008 and 2009. The station is located at 30° 48' N latitude and 114° 57' E longitude at an elevation of 38 m above sea level. The soil is a calcerous fluvisol. By combining maize (*Zea mays* L.), an erectophile monocotyledone plant with Chinese cabbage (*Brassica campestris* L. ssp. *pekinensis*), a planophile dicotyledone plant strong effects on resource capture were ensured. Additionally the desire of examining an intercropping system that is of practical importance in China was met.

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As productivity of strip intercropping systems depends on strip width, it is important to investigate the influence of the distance to the neighbouring crop to find the appropriate strip width. Therefore one strip of maize was planted next to one strip of Chinese cabbage, allowing measurements in different distances to the boarder of the two crops.
In addition two irrigation strategies were applied to investigate the effect of reduced irrigation on growth and development. These were farmers' practice and farmers' practice minus 20% in 2008 and minus 30% in 2009. Irrigation was done individual for each crop, according to demand. A randomized block design with four replications was used. Plots were sized 14m x 30m and rows were orientated in north-south direction.
Various growth parameters like fresh and dry matter of all above ground plant parts, plant height, number of leaves, leaf area and growth stages were measured continuously over the growing season. Additionally solar radiation and soil temperature were measured to determine the effects on microclimate in the system.
Two sets of Chinese cabbage, one in spring and one in autumn were planted next to one set of spring maize within each year. Thus there were two periods of time (May to June and August to September) where crops were exposed to an intercropping situation (Fig. 1).

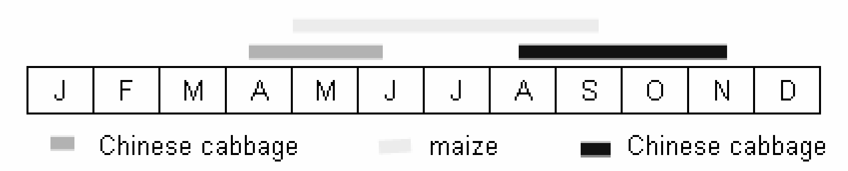


Figure 1: Growth periods of two sets of Chinese cabbage and spring maize over one growing season

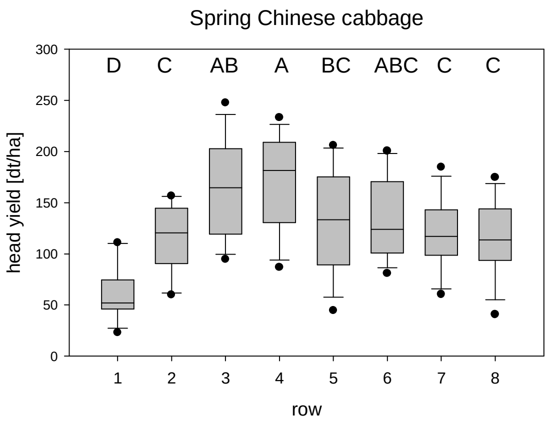
Results and Discussion

At first the influence of irrigation strategy on yield of each crop was evaluated.
In spring Chinese cabbage, reduced irrigation resulted in lower yield. Both, in 2008 with 20% reduced irrigation and in 2009 with 30 % reduced irrigation, the yield of spring Chinese cabbage was lower than 100 % irrigated plants in the respective years.
Spring maize and autumn Chinese cabbage had no significantly lower yield when irrigation was reduced. But data of autumn Chinese cabbage for the year 2009 are outstanding as the last harvest is not yet performed.

The second thing evaluated was the influence of the distance to the boarder on yield. Therefore we analysed the yield of row one to eight. Row one is next to the boarder whereas row eight has the biggest distance to the neighbouring crop being exposed to a monocropping situation.

For spring Chinese cabbage there were no clear tendencies in 2008 due to the occurrence of physiological caused head rot disease. Although this disease also occurred in 2009 it was obvious that the yield was lower in the first row next to spring maize. Therefore we analyzed the data separately for the two irrigation strategies. Within 100% irrigated plots, there was only a significant lower yield of row one compared to row six. But within 70% irrigated plots the highest yield was observed in row four with decreasing yield towards row eight. There was a steep decrease towards the boarder to maize with the lowest yield of spring Chinese cabbage in row one (Fig. 2).

Results of spring maize yield in distance to boarder were completely different compared to spring Chinese cabbage. In 2008 higher yields within the first three rows could be observed. And also in 2009 first rows showed higher cob yields compared to the other rows (Fig. 3).
This is due to higher harvest indices combined with significantly smaller plant height of maize next to Chinese cabbage.



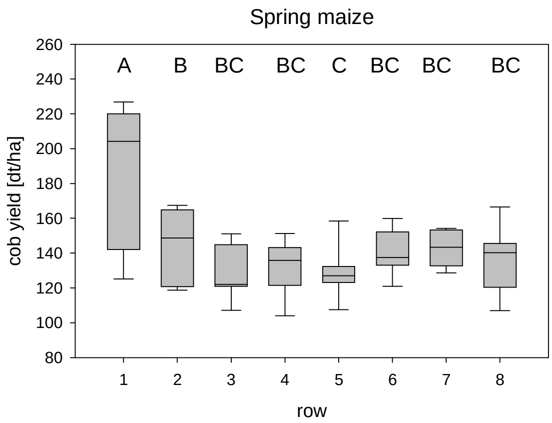


Figure 2: Head yield of 70% irrigated spring Chinese cabbage in 2009

Figure 3: Cob yield of spring maize in 2009

Yield data of autumn Chinese cabbage are only available for the year 2008 as the experiment in 2009 is still ongoing. In 2008 there were slightly higher yields within the first four rows with significantly higher yields in row three and four compared to row eight (Fig. 4).

Even though first rows of autumn Chinese cabbage were shaded significantly by maize, these rows were able to compensate this drawback when maize was harvested.

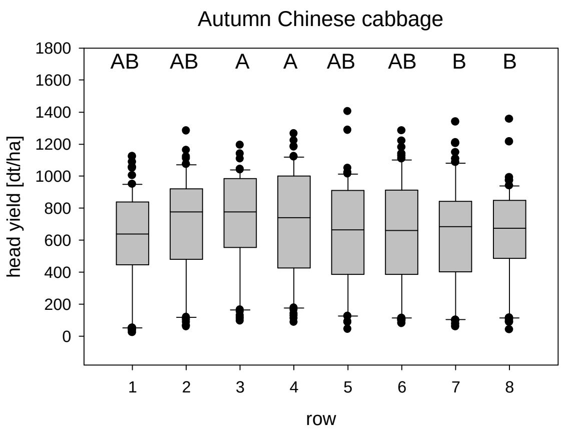


Figure 4: Head yield of autumn Chinese cabbage in 2008

To asses benefits of intercropping the Land equivalent ratio (LER) can be used. The LER is defined as relative land area in pure stands that is required to produce the yields in mixtures. A LER larger than one indicates a benefit of intercropping compared to monocropping.

In this experiment row six to eight was assumed as monocropping and the yield of each row to this 'monocropping' was compared by using the LER (Tab. 1).

For spring Chinese cabbage the LER for the first three rows was lower than one, indicating a disadvantage of intercropping compared to monocropping. But for the other rows as well as all rows of the other crops, the LER was bigger than one. The total LER for all three crops within a year was also bigger than one, indicating a benefit of intercropping compared to monocropping.

Table 1: Land Equivalent ratio of spring maize (SM), spring Chinese cabbage (SCC), autumn Chinese cabbage (ACC) and the whole intercropping System (LER) in 2008

Row	SM	SCC	ACC	LER
1	1.18	0.83	1.06	**1.02**
2	1.25	0.98	1.11	**1.11**
3	1.16	0.98	1.13	**1.09**
4	1.07	1.05	1.13	**1.09**
5	1.06	1.03	1.01	**1.03**
6-8 (monocr)	1	1	1	**1**

Conclusion and Outlook

There is a need for sustainable cropping systems in the NCP to overcome environmental problems.

Strip-intercropping of maize and Chinese cabbage is a possible alternative cropping system which is beneficial compared to monocropping.

This can be observed in higher yields of spring maize and autumn Chinese cabbage within the first three to four rows next to the neighbouring crop. And even reduced irrigation had no significant effect on yield of neither crop. Spring Chinese cabbage in contrast had lower yields at least within the first row, particularly when irrigation was reduced. Therefore 100% irrigation is recommended for spring Chinese cabbage. Additionally it is necessary to determine more suitable Chinese cabbage varieties, crops or irrigation systems for spring time to improve the strip-intercropping system of Chinese cabbage and spring maize in the NCP.

References

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