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*Full Length Research Paper*

# Effects of different rhizosphere ventilation treatment on water and nutrients absorption of maize

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**The objective of this study was to explore the effects of different rhizosphere ventilation treatment on water and nutrients absorption of maize. The pot experiment was conducted using three methods: no ventilation, two day ventilation and four day ventilation, under conditions of the different levels of irrigation methods. As such, the influence of rhizosphere ventilation treatment on the physiological, water and nutrient absorption of maize was studied. Results showed that, with the increase in ventilation frequency, plant height, leaf area and the content of chlorophyll in maize increased to a certain degree. Root activity of once in every four days ventilation was the biggest (8.237 mg/ (g·h)), followed by that of once in every two days ventilation (6.171 mg/ (g·h)), and that of no ventilation was the least (4.940 mg/ (g·h)). Consequently, it increased by 66.7 and 29.9%, respectively. The chlorophyll content experimental results showed that, rhizosphere ventilation treatment does not affect transpiration of potted maize and has no significant difference on the irrigation water utilization rate.**

**Key words:** Potted maize, rhizosphere ventilation, water, nutrients absorption, agricultural water-saving.

## INTRODUCTION

The rhizosphere environment and ventilation have a great impact on the healthy growth crop. In conditions of different rhizosphere ventilation, respiration and nutrients absorption of root cells and structure will be different. Aerobic respiration can form more adenosine triphosphate (ATP) and that will store more energy to provide power for crop to guarantee its normal growth. From the current data, great research of water, nutrients and irrigation method, which can directly enhance crop's growth has been done (Huet et al., 2005; Liang et al., 2006; Li et al., 2006; Liu et al., 2009; Wang et al., 2009), but rarely, a few scholars did the research of rhizosphere ventilation that enhances crop's growth. After irrigation or rain, the void space of root soil is filled with water, causing poor ventilation, thus it inhibits the aerobic respiration in the soil of the root's layer (Sun et al., 2008; Li et al., 2008; 2004; Sun et al., 2005; Arteca and Provaviah, 1982; Heberger et al., 2001). Although venting can change the micro-environment of root soil, it alters rhizosphere ventilation, enhances the aerobic respiration, improves water and fertilizer absorption efficiency and redound water and nutrients' utilization.

As to the effects of rhizosphere environment on crop physiological index, Sun Zhou Ping had done some research showing that, the appropriate $CO_2$ concentration in the root zone promotes potato growth, while overmuch rhizosphere $CO_2$ would markedly inhibit the growth and development of potato plants. The improving rhizosphere ventilation can promote photosynthesis, metabolites and accumulation of photosynthate (Sun et al., 2008; 2005; Li et al., 2008; 2004). Li studied the effects of rhizosphere ventilation environment on potted cucumber growth, by installing breathable plastic pot mendicancy at the different positions of the vessel base. The results showed that the different types of vessel can obviously improve

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**Table 1.** Treatments of experiments.

| CAS | Treatment |
|---|---|
| A2B3 | once every two days ventilation and irrigation 600 ml |
| A2B2 | once every two days ventilation and irrigation 400 ml |
| A2B1 | once every two days ventilation and irrigation 200 ml |
| A4B3 | once every four days ventilation and irrigation 600 ml |
| A4B2 | once every four days ventilation and irrigation 400 ml |
| A4B1 | once every four days ventilation and irrigation 200 ml |
| AnB3 | no ventilation and irrigation 600 ml |
| AnB2 | no ventilation and irrigation 400 ml |
| AnB1 | no ventilation and irrigation 200 ml |

Using ordinary tire pump to supply air, ventilation started on sowing day volume is between of 2.8 to 3.0 L. The amount of initial irrigation of all treatment is equal both were 4 L, all irrigation once every two to three days.

the roots and top growth (Li et al., 2008). The research of Li et al. (2004) also showed that, the improvement of soil aeration increased the ATP content and promoted the ATPase activity in functional leaves and tubers and increased the contents of abscisic acid (ABA) in tubers. As such, all these increased the tuber yield significantly. Arteca and Provaviah (1982) adopted 14C tracer method and found that potato roots can absorb and fix $CO_2$, and these $CO_2$ could be used for leaf photosynthesis. Some researchers studied the effects of rhizosphere ventilation treatments on dehydrogenase activity and nitrogen absorption of barley, triticale and cauliflower. The results showed that, different rhizosphere ventilation can improve dehydrogenase activity, promote the nutrients absorption, help the growth of crop and increase production (Heuberger et al., 2001; Brzezinska et al., 2001a, b; Gibbs et al., 2001; Khan, 2001). Thus, there is little research about the effects of different rhizosphere ventilation treatment on water and nutrients efficiency of maize. However, the objective of this study is to adopt artificial ventilation, thereby setting different ventilation frequency, researching water and nutrients absorption of maize and analyzing the effects of different rhizosphere ventilation on root activity. As such, this will provide the theoretical basis to the improvement of rhizosphere environment.

## MATERIALS AND METHODS

### Tested materials

The experiment was arranged at the experimental field of Arid Agriculture Soil and Water Engineering of Ministry of Education in Northwest of Agricultural and Forestry University, located in the Guanzhong plain. It possesses three sets of the original terrace, partial dry wet areas, average annual sunshine hours (2163.8 h), frost-free period (210 d) and frequent rainfall in August. The tested maize varieties are ZhengDan"968", while air is the experimental material (oxygen content is 21, nitrogen is 78 and others are 1%, respectively). The tested soil was obtained from an arable land surface within 20 cm depth, whereas the total nitrogen content was 0.98 g/kg and the organic matter content was 9.51 g/kg with soil bulk density of 35 g $cm^{-3}$.

### Experimental methods

With the method of potted-corn, the inner diameter of the plastic basin is 28.5 cm, baseline diameter is 21.0 cm, high height is 24.5 cm and the tested soil may be from the basin mouth of 2 cm. The experiment consists of nine treatments and eight repetitions, with A2B3, A2B2, A2B1, A4B3, A4B2, A4B1, AnB3, AnB2 and AnB1as the nine treatments and their experimental can be seen in Table 1.

Using ordinary tire pump to supply air, ventilation began on the day of sowing and the volume was between 2.8 and 3.0 L. The amount of initial irrigation for all treatments was equal, while all irrigation done once in every two to three days were both 4 L. In order to ensure airtight, pelvic was not perforated at the same time of installation of soil buried ventilation and irrigation pipe with the diameter of 0.8 and 1.7 m and the length of 75.0 and 22.0 cm, respectively. In order to make water and air evenly distributed in the soil, one end of the ventilation pipe was tied-up to prevent leakage. As such, every 10 cm hit two holes with a diameter of 2 mm, burying into the soil from the pelvic floor (5 cm) in the form of spiral, having 15 cm outside to connect the tire pump. After the ventilation, the outside of the ventilation pipe was clamed immediately to prevent leakage. Two holes were punched into the irrigation pipe at intervals of 3 cm, burying in the central of the basin from the pelvic floor of 5 cm and having 8 cm outside to irrigate and plug the pipe tightly after each irrigation to keep the test environment. In order to make the soil moisture, it is not occupied by water completely, but we often arrange ventilation in the post earlier irrigation. The experiment started on August 4, 2009, where the initial fertilization was equal by 10.71 g urea (46%) (Nitrogen content 5 g). As such, the pots were on lamination after colonization to prevent soil surface evaporation.

### Test items and methods

First, seedling rate of maize and the recorded emergence ratio of maize treatments and their average were calculated, followed by the measurement of the physiological indicators of maize. Afterwards, three repetitions of almost the same growing maize, measurement height, leaf area, chlorophyll content and root activity were selected and then, their averages were calculated. Secondly,

**Table 2.** Effects of different rhizosphere ventilation treatment on emergence ratio of maize.

| Treatment | Emergence ratio | | |
|---|---|---|---|
| | August 8 | August 9 | August 10 |
| A2B3 | 3/4 | 3/4 | 4/4 |
| A2B2 | 2/4 | 3/4 | 3/4 |
| A2B1 | 3/4 | 4/4 | 4/4 |
| A4B3 | 2/4 | 2/4 | 3/4 |
| A4B2 | 3/4 | 4/4 | 4/4 |
| A4B1 | 2/4 | 2/4 | 4/4 |
| AnB3 | 3/4 | 3/4 | 4/4 |
| AnB2 | 1/4 | 2/4 | 3/4 |
| AnB1 | 1/4 | 2/4 | 2/4 |

apparatus of portable SPAD-502 (KONICA MINOLTA SENSING, INC) was used to measure chlorophyll content. The chlorophyll content of all the green leaves in their base, middle and tip (front) site, were measured and their average were calculated automatically in getting the chlorophyll content of different treatments. Calculating the average of three repetitions, TTC method (Zhang, 1982) was used to measure the root activity.

Thirdly, maize was weighed before each irrigation and the cumulated transpiration was calculated with the weight method difference. As such, the cumulated irrigation transpiration was stated in harvest time, while the irrigation water utilization was calculated and the content of nitrate and ammonium nitrogen in soil 9 was measured (Li, 1983). Fresh soil of about 5 g was obtained and KCl solution (25 ml) was added to the concentration (2 mol/l), which was oscillated for 1 h. Afterwards, the filtered supernatant was obtained and the UV spectrophotometer was used to measure the concentrations of nitrate and ammonium nitrogen. Extraction of soil samples were divided into three layers, 0 to 6, 7 to 12 and 13 to 18 cm, respectively.

## RESULTS

### Effects of different rhizosphere ventilation treatment on the emergence ratio of maize

Previous studies showed that, soil moisture and texture is the main external factors that enhance seed germination (Hui et al., 2006; Hou et al., 2006) in the absence of plenty moisture and suitable temperature conditions, but with enough oxygen. Rhizosphere ventilation has changed the soil micro-environment, improved the soil's permeability, increased the proportion of oxygen in the soil and enhanced the aerobic respiration. As a result, these factors stimulated the seed germination. This test recorded the emergence ratio of maize in each treatment. As such, we planted 4 seeds in each pot. Table 2 shows the average emergence ratio of nine deals with eight repetitions. A2B3, A2B2, A2B1, A4B3, A4B2 and A4B1 were vented one time on sowing day (August 4) respectively, then the ventilation frequency was increased once every day and once every other day in A2B3, A2B2 and A2B1 and A4B3, A4B2 and A4B1, respectively, while no ventilation was seen in AnB3, AnB2 and AnB1, in which the ventilation rate was zero. After the completion of the emergence on August 10 (A2B3, A2B2 and A2B1, once in every two days ventilation; A4B3, A4B2 and A4B1, once in every four days ventilation and AnB3, AnB2 and AnB1, no ventilation), there was no additional irrigation during the period of sowing to the emergence completed, whereas the other external conditions were exactly the same. Stating the emergence of maize of nine deals and calculating the average, the results obtained are shown in Table 2. From the table, we can see that the germination date of maize is shortened with the increase in ventilation frequency in the conditions of the initial irrigation that is almost equal, and that marked the emergence ratio of the improved maize. Four days after planting, the emergence ratio of once in every day ventilation, once in every other day ventilation and no ventilation is 66.67, 50.0 and 41.57% respectively, while in the first 5 days and first 6 days, the emergence ratio is 83.33, 66.67 and 58.33% and 91.67, 91.67 and 75.0%, respectively. For the fact that the varieties and probability of emergence of maize is the same, it can be seen that rhizosphere ventilation can promote the germination of corn and improve the emergence rate.

### Effects of rhizosphere ventilation treatment on corn plant height, leaf area and the chlorophyll content

Plant height and leaf area of maize is a growing form of response under different ventilation conditions which has a macroeconomic performance by the impact of the permeability of the crop rhizosphere. Table 3 is the test data of effects of different ventilation treatments on the various growth stages of corn plant height, leaf area and chlorophyll. As can be seen from Table 3, when the irrigation frequency and irrigation are the same, with the ventilation frequency increased, plant height of corn basically showed an increasing trend. Among them, the impacts of aeration of the rhizosphere on plant height at maize

**Table 3.** Effects of different rhizosphere ventilation treatment on plant height, leaf area and the content of chlorophyll.

| Item | Height (cm) | | | | Leaf area ($cm^2$) | | | | Content of chlorophyll (mg/g) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | SS | ES | HS | MS | SS | ES | HS | MS | SS | ES | HS | MS |
| A2B3 | 68.7 | 115.4 | 143.0 | 146.6 | 136.5 | 1993.4 | 3111.9 | 2653.8 | 33.9 | 35.7 | 45.1 | 35.6 |
| A2B2 | 62.3 | 116.7 | 131.0 | 132.8 | 123.1 | 1960.2 | 2775.3 | 2179.6 | 30.8 | 33.0 | 45.0 | 33.4 |
| A2B1 | 57.1 | 110.8 | 137.2 | 140.0 | 111.5 | 1848.2 | 2170.4 | 1867.6 | 31.2 | 32.3 | 43.0 | 30.5 |
| A4B3 | 62.5 | 125.7 | 141.9 | 147.2 | 141.6 | 2202.6 | 2912.8 | 2367.2 | 34.5 | 36.1 | 44.6 | 34.1 |
| A4B2 | 63.7 | 128.9 | 135.7 | 138.0 | 122.6 | 1856.0 | 2601.0 | 2278.8 | 31.5 | 32.7 | 43.5 | 32.3 |
| A4B1 | 55.8 | 117.0 | 132.9 | 135.9 | 119.8 | 1697.0 | 2091.6 | 1990.1 | 33.0 | 33.8 | 43.3 | 30.5 |
| AnB3 | 61.1 | 123.0 | 136.5 | 139.4 | 129.0 | 1826.5 | 2538.6 | 2335.7 | 33.3 | 34.2 | 40.7 | 32.3 |
| AnB2 | 58.6 | 108.1 | 131.9 | 135.9 | 124.5 | 1756.0 | 2425.4 | 2194.1 | 31.5 | 32.1 | 39.4 | 31.1 |
| AnB1 | 57.0 | 102.9 | 128.2 | 130.4 | 118.6 | 1458.5 | 2183.3 | 1797.9 | 30.9 | 31.8 | 35.2 | 28.7 |

SS, Seeding stage; ES, elongation stage; HS, heading stage; MS, maturity stage.

seedling stage and jointing stage is relatively small, but the effects are more significant on plant height at heading stage and grouting maturity.

Meanwhile, as can be seen from Table 3, when the irrigation frequency and irrigation are the same, with the ventilation volume and ventilation frequency increased, the entire growth process of the corn leaf area showed an increasing trend. Effects of different ventilation on corn leaf area at jointing stage, heading stage and grain filling and maturity are much more significant and the impact on leaf area at seeding stage is relatively small.

Chlorophyll is the product of photosynthesis, which may be an alternative method in evaluating the absorption of crop nutrients' status under the status of ventilation in the rhizosphere. Effect of different aeration on the relative content of chlorophyll in maize is shown in Table 3. As can be seen from Table 3, when the ventilation rate and ventilation frequency is constant, with the irrigation increasing, the chlorophyll content of maize showed an increasing trend, but the growth showed a lesser extent. Among them, in the entire growth process, when each irrigation was 600 ml, the chlorophyll content all reached the maximum growth. In the seedling and jointing period, under the condition of passing gas once every four days, each irrigation volume of 200 ml (A4B1) chlorophyll content is greater than that of the irrigation of 400 ml (A4B2). This is because the change in chlorophyll content in crops is not only relevant to irrigation water, but also to the factors of crop itself and its external ventilation and light conditions.

## Effects of different rhizosphere ventilation treatment on plant height

Effects of different irrigation on plant height, in conditions of a certain ventilation frequency and ventilation volume, are shown in Figure 1a to c. As shown in Figure 1, when the ventilation frequency and ventilation volume is constant, as the irrigation water increases, the entire growth process of corn plant height increased. However, from seedling stage to jointing stage and jointing stage to heading date, plant height increased rapidly, while from heading to maturity, the growth was relatively slow, that is, it slowed down after the growth trend.

## Effects of different rhizosphere ventilation treatment on leaf area

Effects of different amount of irrigation water on leaf area in conditions of a certain ventilation frequency and ventilation volume are shown in Figure 2a to c. As shown in Figure 2, changes of maize leaf area were in a "single-peak curve" growth trend throughout the reproductive process. In the ventilation volume, ventilation frequency of the same circumstances and the corn leaf area showed a rising trend with the increase in the amount of irrigation. When irrigation is 200 ml in entirety, the corn leaf area was significantly lower than the other two water treatment. As the initial irrigation is the same, the body of young seedling corn plants takes less water, so irrigation water is also less. Thus, when the ventilation frequency and ventilation volume is constant, effects of the irrigation frequency and irrigation on seedling leaf area of maize are relatively small. In the jointing stage, water demand of maize increases gradually along with the growth of plants and as such, the effects of irrigation water on leaf area are gradually increasing. Consequently, the difference of corn leaf area reached the maximum growth. In conditions of passing gas every two days, when irrigation is 600 and 400 ml/time, respectively, the leaf area is 3111.93 and 2775.26 $cm^2$ and it rose to 43.4 and 27.9% than the leaf area (2170.35 $cm^2$) of irrigation in 200 ml/time. In conditions of passing gas every four days, when irrigation is 600 and 400 ml/time respectively, the leaf area is 2912.80 and 2600.95 $cm^2$, respectively, and it increased by 39.3 and 24.4% than the leaf area (2091.61 $cm^2$) of irrigation in 200 ml/time. Without aeration, when irrigation is 600 and 400 ml/time respectively, the leaf

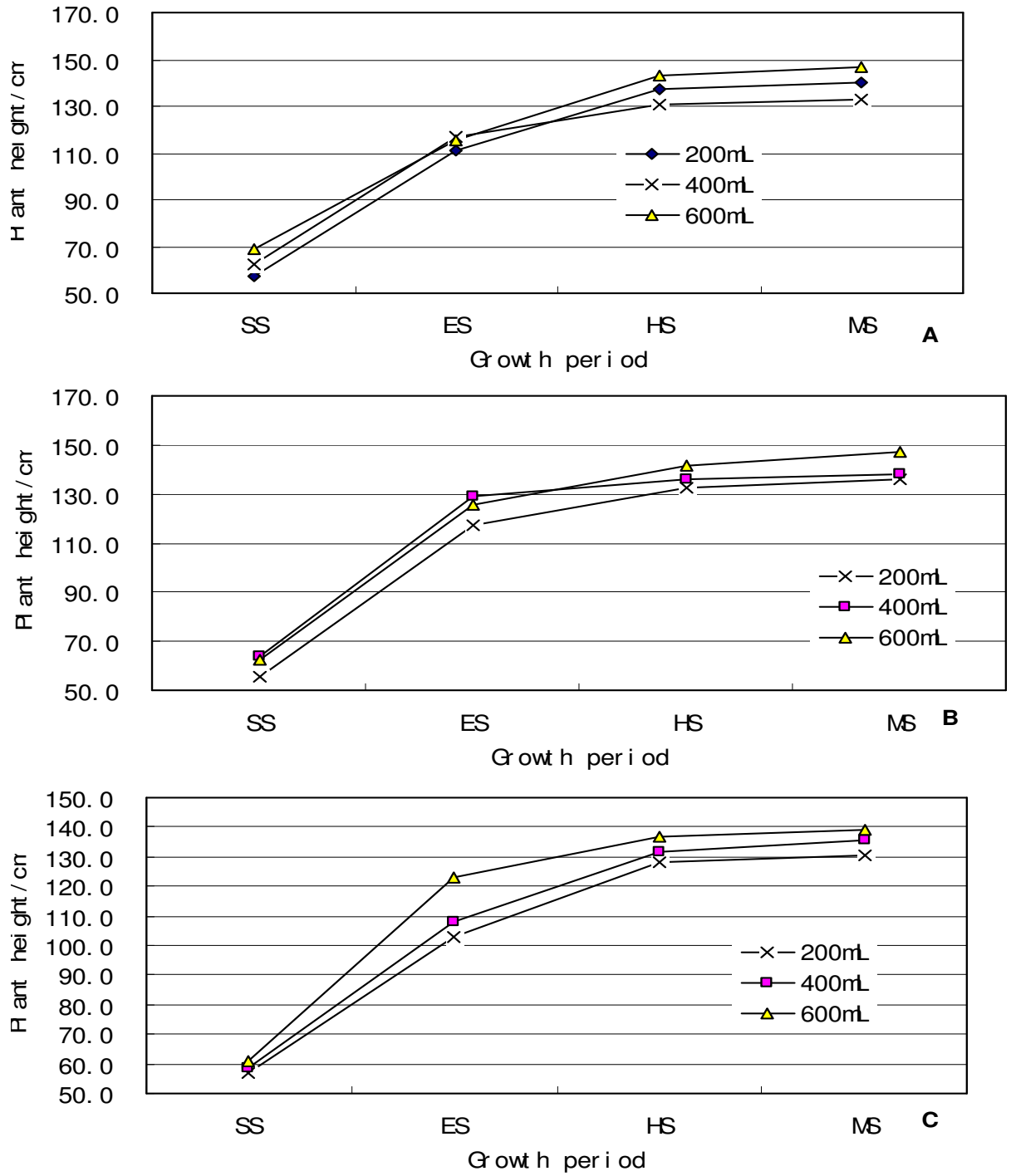



**Figure 1**. Effects of different amount of irrigation water on plant height in conditions of a certain ventilation frequency: (A) effects of different irrigation volume on height of maize in conditions of every 2 days ventilation; (B) effects of different irrigation volume on height of maize in conditions of every 4 days ventilation; (C) effects of different irrigation volume on height of maize in conditions of no ventilation.

area is 2538.59 and 2425.40 $cm^2$ and it increased by 16.3 and 11.1% than the leaf area (2183.26 $cm^2$) of irrigation in 200 ml/time. However, in grouting maturity, leaves of maize began to wither and the leaf area decreased gradually.

**Influence of rhizosphere ventilation on chlorophyll content of maize**

When the irrigation amount and irrigation frequency is fixed, the ventilation frequency affects the chlorophyll

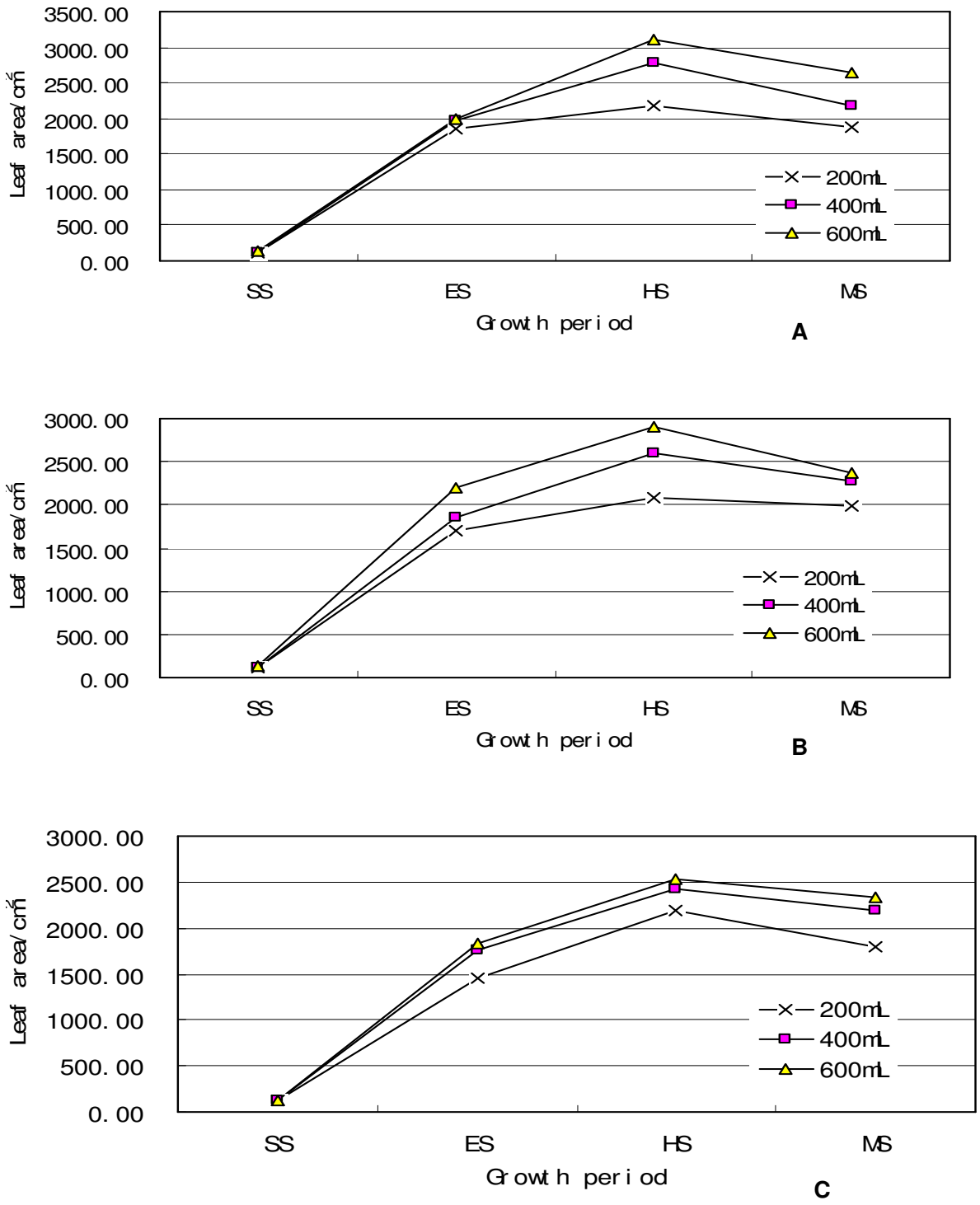
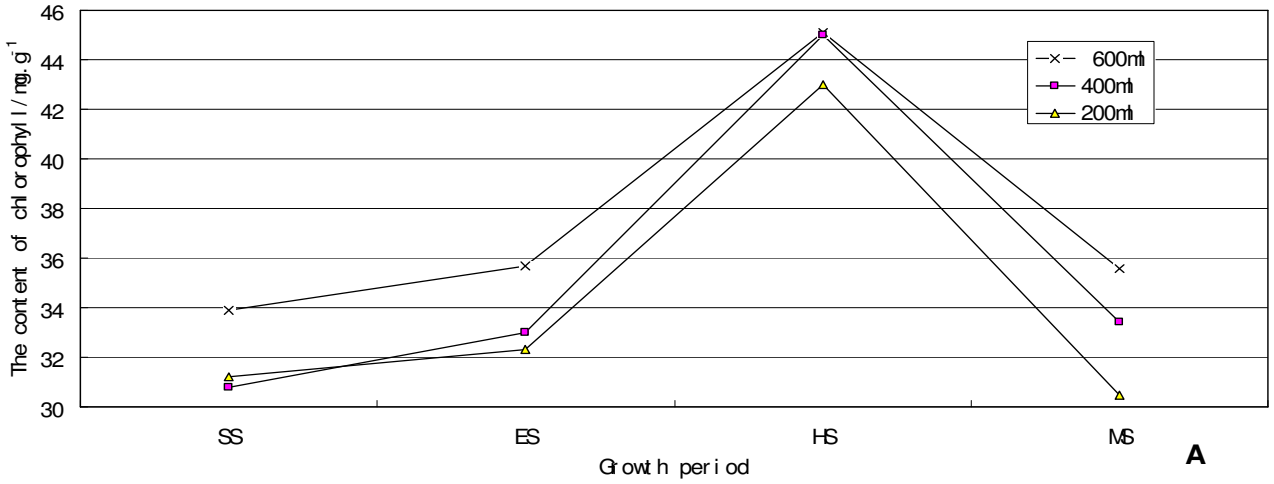
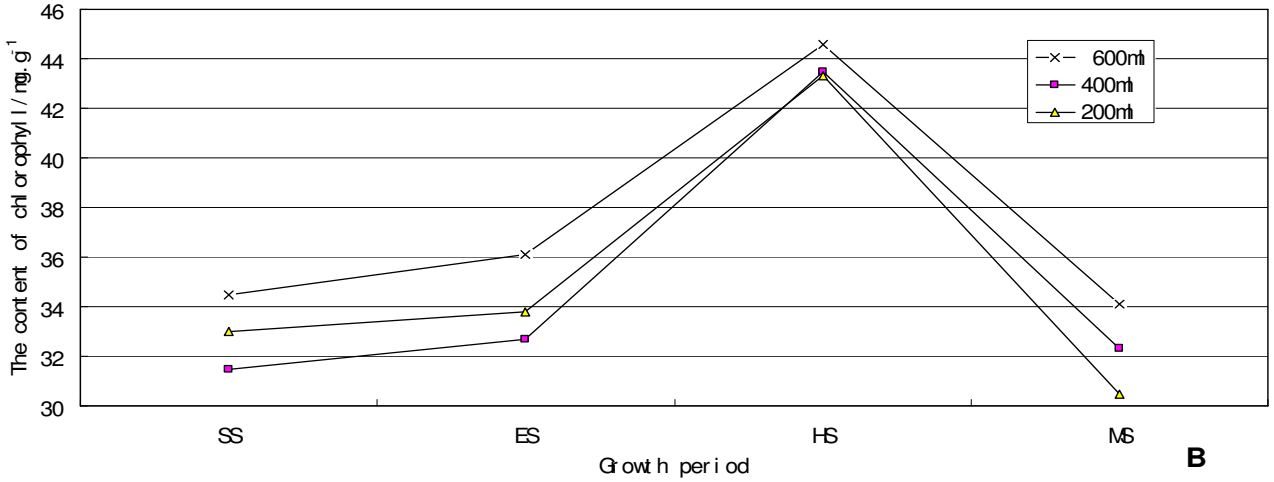



**Figure 2.** Effects of different amount of irrigation water on plant height in conditions of a certain ventilation frequency: (A) effects of irrigation volume on leaf area of maize in conditions of every 2-days ventilation; (B) effects of irrigation volume on leaf area of maize in conditions of every 4-days ventilation; (C) effects of irrigation volume on leaf area of maize in conditions of no ventilation.

content of maize (Figure 2). As it can be seen from Figure 2, during the entire reproductive period, the chlorophyll content of maize changes in a "single peak" growth trend, grows slowly in the stage of seedling and jointing, achieves maximum growth in the heading stage and declines in the milking stage. In the seedling and jointing



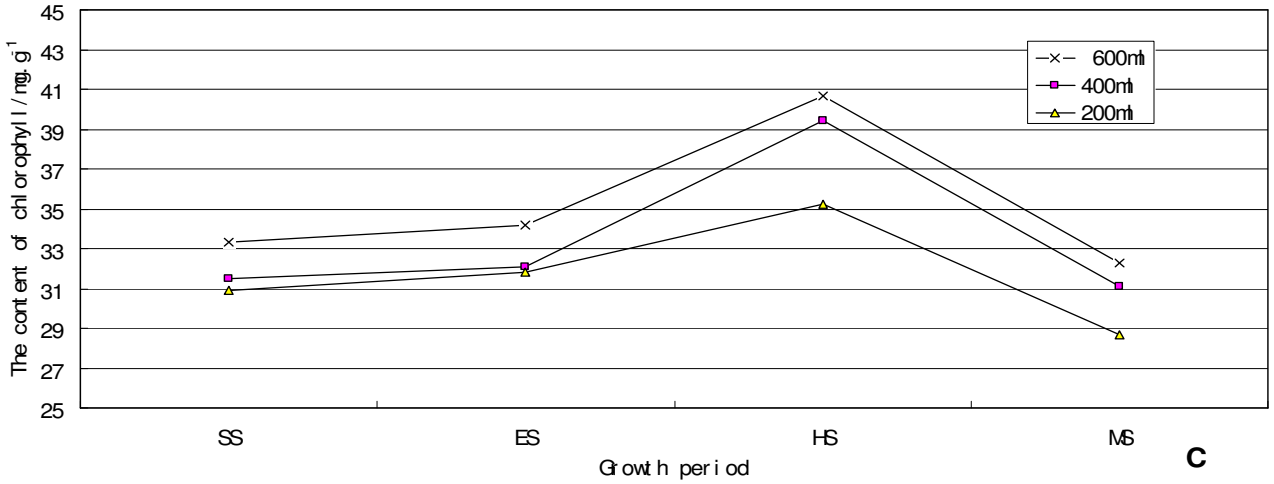




**Figure 3.** Effects of different ventilation frequency on the content of chlorophyll in conditions of a certain amount of irrigation water: (A) effects of ventilation frequency on the content of chlorophyll in conditions of irrigation water (600 ml); (B) effects of ventilation frequency on the content of chlorophyll in conditions of irrigation water (400 ml); (C) effects of ventilation frequency on the content of chlorophyll in conditions of irrigation water (200 ml).

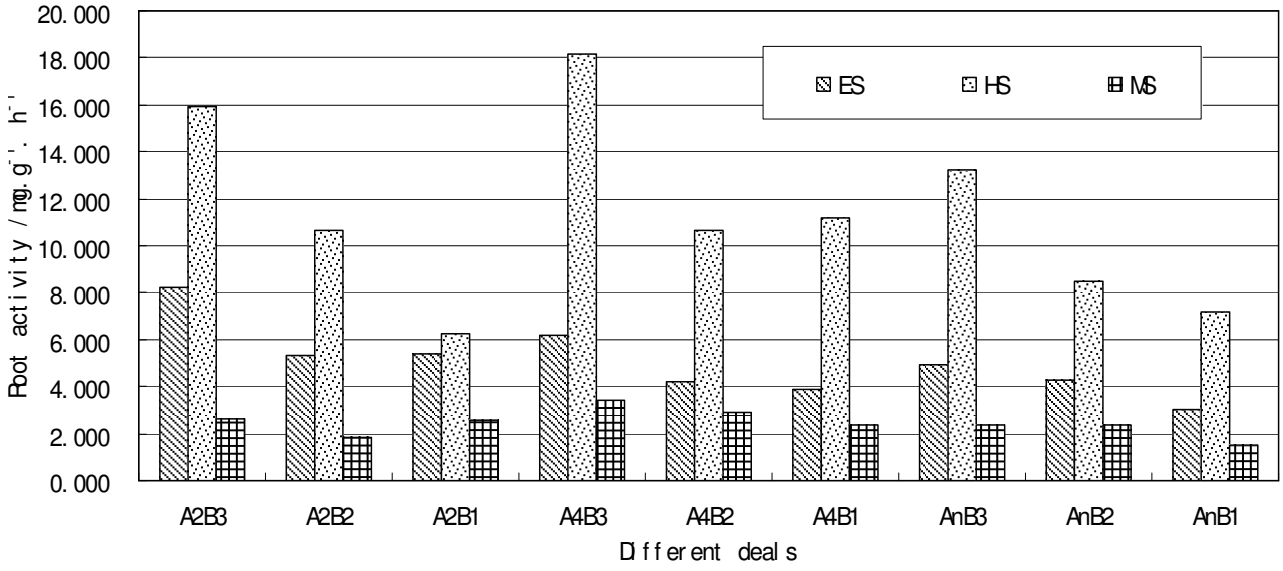



**Figure 4.** Effects of rhizosphere ventilation treatment on root activity.

stage, ventilation treatment on the chlorophyll content of maize has little effect, while from the heading stage, it has a gradually increased effect. Under the three irrigation standards, there is higher chlorophyll content in the ventilation part than the non-ventilation part. At the same time, it can be seen from the figure that, in the heading stage, when each irrigation is 600 ml, the once ventilation in every two days and once ventilation in every four days corn chlorophyll content was 45.1 and 45.0 mg/g, respectively, with each increasing by 4.9 and 4.7% when compared to non-ventilation (43.0 mg/g). When each irrigation is 400 ml, the once ventilation in every two days and once ventilation in every four days corn chlorophyll content was 44.6 and 43.5 mg/g (as previously exemplified), which increased by 3.0 and 0.5%, respectively, when compared to non-ventilation (43.3 mg/g). When each irrigation is 200 ml, the once ventilation in every two days and once ventilation in every four days corn chlorophyll content was 43.0 and 43.3 mg/g (as previously exemplified), and each increased by 22.2 and 23.0%, respectively when compared to non-ventilation (35.2 mg/g) .

## Influence of rhizosphere ventilation on maize root activity

Root activity refers to the strength of the whole metabolism, including absorption, synthesis, respiration, oxidizing power, etc., whereas the size of the root activity is related closely with the life activities intensity of the entire plants which objectively reflects the physiological indices of root activities (Wei et al., 2004; Wang et al., 2006). Figures 1-4 showed the changes of maize under ventilation conditions. As it can be seen from the next figure (Fig.3 and Fig.4), during the entire reproductive period, when the irrigation amount and irrigation frequency is fixed, the ventilation frequency and ventilation volume increases, and as such, the maize root activity showed a significant growth trend and ventilation showed great differences from the maize root activity. In the jointing stage, the root activity of A4B3 (8.237 mg/(g • h)) which was the maximum, was followed by A2B3 (6.171 mg/(g • h)), while AnB3 (4.940 mg/(g • h)) was the smallest under non-ventilation conditions. Under ventilation conditions, each increased by 66.7 and 24.9% when compared to non-ventilation. In the heading stage, A4B3 (18.145 mg/(g • h)) reached maximum growth, followed by A2B3 (15.896 mg/(g • h)), while AnB3 (13.224 mg/(g • h)) was the smallest under non-ventilation conditions. Conse-quently, each increased by 37.2 and 20.2%. This is due to the root ventilation that promotes roots' absorbance of moisture and nutrients (nitrogen) from the soil. While nitrogen is the essential ingredient of the enzyme, suitable nitrogen supply facilitates the formation of these organic materials, thus enhancing crop root activity (Lui et al., 2009). In the milking stage, the difference in maize roots' activity is not obvious, but is maintained at 1.505 mg/(g • h) (AnB1) to 3.397 mg/(g h) (A4B3). This is because during this period, maize has entered into the later stage of growth, where roots activity gradually decayed, and which was affected little by the pervious root soil.

## Effects of different rhizosphere ventilation treatment on water absorption of maize

The accumulation of irrigation water lost through the plant body during the entire growth period is shown in Table 4.

**Table 4.** Effects of different rhizosphere ventilation treatment on water absorption of maize.

| Treatment | Cumulated irrigation water | Cumulated transpiration | Irrigation water utilization rate |
|---|---|---|---|
| A2B3 | 10.4 | 8.738 | 0.8402 |
| A2B2 | 8.9 | 7.492 | 0.8417 |
| A2B1 | 7.4 | 6.480 | 0.8756 |
| A4B3 | 10.4 | 8.740 | 0.8404 |
| A4B2 | 8.9 | 7.544 | 0.8477 |
| A4B1 | 7.4 | 6.264 | 0.8465 |
| AnB3 | 10.4 | 8.668 | 0.8335 |
| AnB2 | 8.9 | 7.609 | 0.8550 |
| AnB1 | 7.4 | 6.328 | 0.8551 |

**Table 5**. Effects of different rhizosphere ventilation treatment on Nitrogen-fixing ability of maize.

| Treatment | Distance from face of soil | Concentration of $NH^{4+}$-N ($mg \cdot kg^{-1}$) | Concentration of $NO_3$-N ($mg \cdot kg^{-1}$) |
|---|---|---|---|
| A2B3 | 0~6 | 203.75 | 1254.17 |
| | 7~12 | 292.92 | 1540.00 |
| | 13~18 | 280.42 | 1604.58 |
| A2B2 | 0~6 | 271.25 | 1647.92 |
| | 7~12 | 303.75 | 1816.25 |
| | 13~18 | 298.33 | 1824.17 |
| A2B1 | 0~6 | 289.58 | 1726.67 |
| | 7~12 | 300.42 | 1596.67 |
| | 13~18 | 313.75 | 1760.83 |
| A4B3 | 0~6 | 272.92 | 1297.50 |
| | 7~12 | 267.08 | 1538.33 |
| | 13~18 | 317.08 | 1773.75 |
| A4B2 | 0~6 | 276.25 | 1718.75 |
| | 7~12 | 286.67 | 1384.58 |
| | 13~18 | 277.08 | 1511.67 |
| A4B1 | 0~6 | 176.25 | 1322.50 |
| | 7~12 | 277.50 | 1698.75 |
| | 13~18 | 336.67 | 1816.25 |
| AnB3 | 0~6 | 337.50 | 1677.08 |
| | 7~12 | 294.58 | 1677.92 |
| | 13~18 | 340.00 | 1792.08 |
| AnB2 | 0~6 | 310.83 | 1615.00 |
| | 7~12 | 356.25 | 1883.33 |
| | 13~18 | 355.00 | 1815.42 |
| AnB1 | 0~6 | 352.50 | 1748.75 |
| | 7~12 | 380.42 | 1902.08 |
| | 13~18 | 353.33 | 1847.50 |

As the experiment adopted the method of potted maize in the form of lamination, the soil surface evaporation of water can be ignored and the lost water is transpired in all the plants. The table showed that the differences of transpiration between each deal are small in the entire growth process, and as such, the utilization of irrigation water is also more or less the same. Moreover, this indicates that rhizosphere ventilation does not affect plant transpiration.

## Effects of different rhizosphere ventilation treatment on nutrient absorption of maize

Table 5 shows the effects of rhizosphere ventilation on nitrogen-fixing ability of maize. From the table, we can

see that the soil nitrogen content reduced with the ventilation volume and frequency, which increased in the conditions of a certain amount of irrigation water and frequency. As such, the maize absorbing the nitrogen is increased. This indicates that rhizosphere ventilation reduces the nitrogen-fixing capability of maize, enhances the healthy growth of crops and raises the nutrient utilization on rhizosphere soil (Hui et al., 2006; Hou et al., 2006; Wei et al., 2004; Wang et al., 2006; Lui et al., 2009). However, Table 5 shows the effects of different rhizosphere ventilation treatment on the nitrogen-fixing ability of maize.

## Conclusion

With the increase in rhizosphere ventilation volume and frequency, the height and leaf area of maize showed a steady growth, while chlorophyll content and root activity grew vigorously. As such, this indicated that rhizosphere ventilation had a significant effect on maize. For the fact that rhizosphere ventilation changed soil permeability, increased aerobic respiration and promoted seed germination, when compared with no ventilation, the emergence rate of maize of rhizosphere ventilation increased.

There is a small impact on height, leaf area and chlorophyll content of maize in the early period, but the influence increased gradually during the late growth stage, in which the height, leaf area and chlorophyll content was significantly greater than non-aeration. The effects of rhizosphere ventilation on root activity is most significant, while the root activity of once in every four days ventilation is most dynamic, and as such, it has less effect on moisture absorption.

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