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EFFECTS OF RIDGE-PLANTING PATTERN ON AGRONOMIC TRAITS, QUALITY AND YIELD OF SWEET CORN IN SOUTH CHINA

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Abstract

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As a method to avoid waterlogging, ridge planting is widely adopted in sweet corn (*Zea mays saccharata* Sturt) cultivation in south China. The effects of ridge-planting pattern on agronomic traits, quality and yield of sweet corn were studied in 2012. Sweet corn Jinyutian No. 1 hybrid (sh_2) and four ridge-planting patterns were used, and the experimental was designed as a randomized block with three replications. The results showed that ridge-planting pattern almost had no effect on leaf number and chemical properties (moisture, total sugar and starch content) of sweet corn. Although the physical properties (fresh- and husked-ear weight, ear length, kernel rows, kernels per row, ear diameter, kernel depth and 100-kernel weight) of Pattern 3 were higher than other three patterns, the plant density and agronomic traits (leaf area per plant, leaf area index, plant and cob height) of Pattern 1 were higher and the corn stalk rot mortality of Pattern 1 was lower than other three patterns, and the fresh-ear weight of Pattern 1 was higher than Pattern 2 and Pattern 4 all the time, and was lower than Pattern 3 significant only at 21 DAP. As a result, the yield of Pattern 1 was higher than other patterns significantly all the time.

Key words: sweet corn; ridge planting; agronomic trait; yield; quality

Introduction

As an important vegetable crop, sweet corn (*Zea mays saccharata* Sturt) is attractive to consumers for its soft kernels, high sugar content and flavor (Oktem et al., 2003). The research of sweet corn has begun since the 1960s in China, and the greatest part of the production was sold for fresh market as fresh ears corn. Since the beginning of this century, more and more Chinese knew about this tasteful corn and enjoyed it with the rapid economic growth of this country. As a result, the production of sweet corn, especially in south China increased quickly (Yao et al., 2011).

However, the rainfall always exceeds the demand of sweet corn during the growing period in south China. Thus, ridge planting system is adopted to avoid water logging in this region. It was reported that ridge planting is an extremely versatile system, such as saving of labor, enhancing soil fertility, increasing soil temperature, water management, erosion control, multiple cropping, enhancing soil depth and pest management (Lal, 1990; Radke, 1982). Among these advantages, water management is an important factor for farmers both in wet and dry region to adopt ridge planting system. In higher rainfall or poorly drained areas, ridge planting system facilitates the water to drain away, and provide a well-aerated seedbed for crop. On the contrary, in dry land or rainfed farming, ridge planting improves water conservation (He et al., 2010).

In practice, different ridge-planting patterns were adopted in south China. Most farmers grow sweet corn with two rows on a ridge, but fewer farmers grow sweet corn with four rows or one row on a ridge, even some farmers grow two rows together on a ridge. The objective of this study is to identify the effects of ridge-planting pattern on the agronomic traits, quality and yield of sweet corn in south China.

Material and Methods

Site description

The field experiment was carried out from March to June of 2012 in the experimental field of Wenzhou Vocational Col-

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lege of Science and Technology (latitude 28°09′N, longitude 120°52′E, 9 m above see level). The location has a warm humid climate with the average temperature 17^0C, rainfall 1800 mm. The soil type was silty clay with PH 5.67, organic matter 34.7 g/kg, total N 2.18 g/kg, valid-P 38.0 mg/kg and valid-K 79 mg/kg.

Experimental design

The experiment was designed as a randomized block with three replications. According to the practice (namely peasants' habit), four ridge planting patterns were used (Figure 1): (1) two rows on ridge 1 m wide with row space 0.7 m and plant space 0.36 m, with the plant density about 46000 plants/ha (P1); (2) two rows on ridge 1 m wide with the row space 0 m and plant space 0.45 m, with the plant density about 37000 plants/ha (P2); (3) one row on ridge 0.8 m wide with plant space 0.32 m, with the plant density about 31000 plants/ha (P3); (4) four rows on ridge 1.8 m wide with row space 0.5 m and plant space 0.5 m, with the plant density about 40000 plants/ha (P4). Each ridge was 10 m long and 0.2 m high, the furrow was 0.2 wide. Six rows were planted around the blocks as protective belt, and open pollination was permitted.

Sweet corn Jinyutian No. 1 hybrid (sh_2), which is a widely seeded variety in Zhejiang province, south China, was used in present study. Nutritional bowl seedling in greenhouse was adopted on March 2, and the seedlings were transplanted by hand on April 11. Before transplanting, thoroughly decomposed chicken manure and complete fertilizer (N-P_2O_5-K_2O=18-10-12) were applied at a rate of 7.5 t/ha and 375 kg/ha, respectively. Then the experimental field was plowed, and ridges were built manually according to the design. Seedlings were thinned ten days after transplanting, and one plant was kept at each point. During the completely growing period, the field was weeded by hand.

Measurement

Ten plants in each block were selected randomly, and their leaf numbers were recorded weekly from emergence to silking. Within three days after silking (the last leaf spread), leaf area per plant of three plants were measured using a portable living leaf area meter (Model: YMJ-B), leaf area index (LAI) of each block was estimated as the product of mean leaf area per plant and number of plants per square meter. At the same time, plant and cob height of five plants in each block were measured using a ruler.

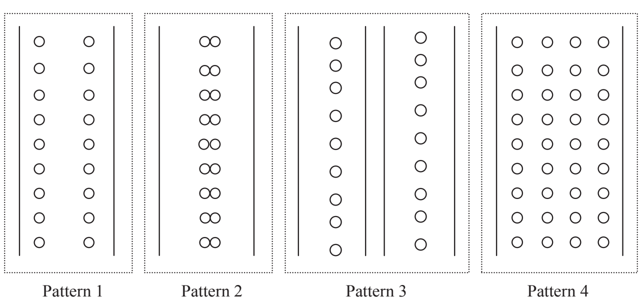

Fig. 1. Four ridge-planting patterns

Three ears were picked randomly in each block at 18, 21, 24 and 27 days after pollination (DAP), respectively. Immediately after harvest, the fresh ears were weighted, husked, the physical properties (husked-ear weight, ear length, kernel rows, kernels per row, ear diameter) were measured and stored at -20^0C for chemical analysis (moisture content, total sugar content and starch content). All the steps must be finished within 2 hours. The moisture content was determined by oven-drying method with the procedure of 105^0C for one hour and 80^0C to the constant weight. The total sugar content and starch content were determined by 3,5-dinitrosalicylic acid method (Yin et al., 2007).

Because some plants were infected with fusarium and died of corn stalk rot before harvest, the mortality of each block was estimated immediately after the ears were harvested at 27 DAP. The yield of each block at each harvest date was estimated by using the following formula:

Yield=Fresh-ear weight × designed density × (1-mortality)

Statistical analysis

Data were subjected to ANOVA procedures using the SPSS analytical software package. The comparison of means was conducted with the Ducan's test, at a significance level P= 0.05.

Results and Discussion

Agronomic traits

Ridge-planting pattern almost had no effect on leaf number (Table 1), with Pattern 1 and Pattern 2 had just a little more leaves than the other two patterns. However, ridge-planting pattern had significant effect on leaf area per plant, LAI, plant height and cob height. Leaf area per plant of Pattern 4 was lower than the other three patterns significantly. On the other hand, LAI, plant height and cob height of Pattern 1 were higher than other patterns, except the plant height of Pattern 2.

Physical properties

All of the physical properties of Pattern 3 were higher than other patterns almost all the time (Table 2, Figures 2-6), and significant differences among ridge-planting patterns were observed for all of the physical properties at least one harvest time (18, 21, 24 and 27 DAP). The fresh-ear weight increased from 18 DAP to 24 DAP, then decreased from 24 DAP to 27

Table 1
Some agronomic traits and corn stalk rot mortality of different ridge-planting pattern

Pattern	Leaf No. (No./plant)	Leaf area per plant, cm^2/plant	LAI, $m^{-2}.m^{-2}$	Plant height, cm	Cob height, cm	Mortality, %
P1	19.89a	4850.30a	2.20a	202.27a	62.60a	1.79a
P2	19.89a	4776.51a	1.74b	200.00ab	58.40b	2.27a
P3	19.78a	4479.97a	1.35b	194.80bc	57.40b	3.75a
P4	19.11a	3860.34b	1.46b	190.43c	57.73b	6.85a

Numbers followed by the same letter in each column are not significantly different at $P<0.05$.

Table 2
Ear length, kernel rows and kernels per row of different ridge-planting pattern

Pattern	Ear length, cm	Kernel rows	Kernels per row
P1	18.04a	13.47ab	37.85a
P2	17.54b	13.17ab	37.97a
P3	18.07a	13.72a	38.66a
P4	17.17b	13.00b	36.03b

Numbers followed by the same letter in each column are not significantly different at $P<0.05$.

DAP overall. However, the husked-ear weight increased all the time from 18 DAP to 27 DAP, which meant the husk weight decreased dramatically from 24 DAP to 27 DAP. Concerning the ear diameter, 100-kernel weight and kernel depth, the differences among the four patterns were significant at 18 DAP, and then the differences became smaller with increasing harvest maturity. On the other hand, ear length, kernel rows and kernels per row were almost not changed from 18 DAP to 27 DAP.

Chemical properties

No significant difference among ridge-planting patterns were observed for moisture content, total sugar content and starch content from 18 DAP to 27 DAP (Figures 7-9), namely ridge-planting pattern almost had no effect on the chemical properties of sweet corn.

The moisture content of Pattern 1 was higher than other patterns during this period (Figure 7). The averaged moisture content dropped rapidly from 81.90% at 18 DAP to 75.73% at 24 DAP, with the loss of 6.16%, or 1.03% per day. Then the trend slowed down, dropped only 0.58% from 24 DAP to 27 DAP, or 0.19% per day. These results were agreed with some former reports that moisture content decreased with the increasing harvest maturity (Szymanek, 2009; Azanza et al., 1996; Wong et al., 1994). Moisture content can be used as an index to evaluate harvest maturity (Szymanek, 2009), and Williams II (2008) reported sweet corn for fresh market could be harvested at the moisture content of 75%±3%. On this point, sweet corn Jinyutian No. 1 hybrid could be harvested at 24 DAP and 27 DAP.

Sweetness in sweet corn is the most important component of flavor (Culpepper and Magoon, 1927), and it is closely relat-

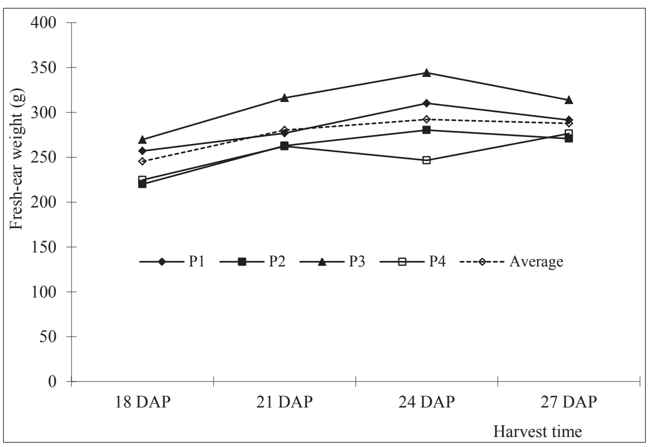

Fig. 2. Fresh-ear weight of different ridge-planting pattern

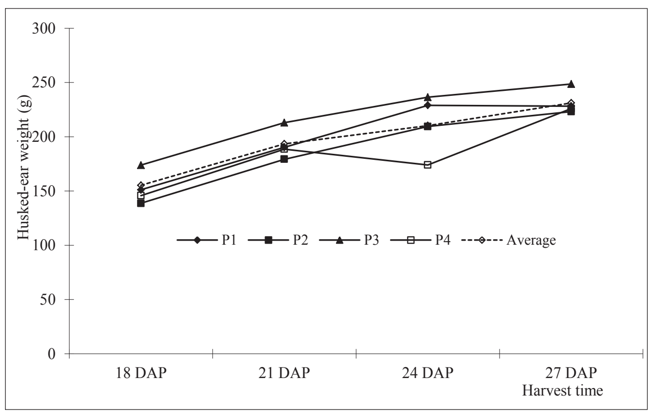

Fig. 3. Husked-ear weight of different ridge-planting pattern

ed to kernel sugar content (Evensen and Yoyer, 1986; Azanza et al., 1994). Sweet corn with higher sugar and lower starch content always shows higher sensory quality, and it is one of the goals for breeders and producers. In present research, the starch content increased all the time, while the total sugar content of all the patterns increased from 18 DAP to 24 DAP, then decreased from 24 DAP to 27 DAP (Figures 8 and 9), namely it was at the peak at 24 DAP. These results were agreed with former reports (Szymanek, 2009; Wong et al., 1994).

Concerning the yield and fresh-ear weight were also highest at 24 DAP, a conclusion could be drawn that it was the optimal time for sweet corn Jinyutian No. 1 hybrid to be harvested at 24 DAP.

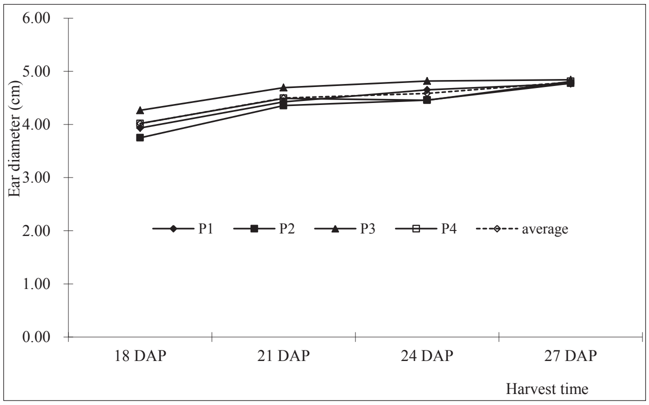

Fig. 4. Ear diameter of different ridge-planting pattern

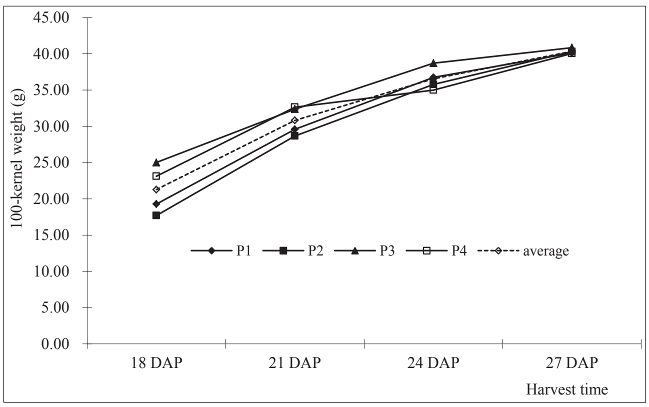

Fig. 5. 100-kernel weight of different ridge-planting pattern

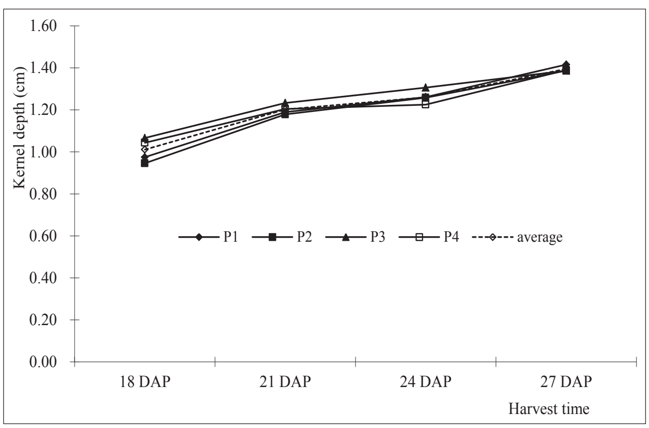

Fig. 6. Kernel depth 0f different ridge-planting pattern

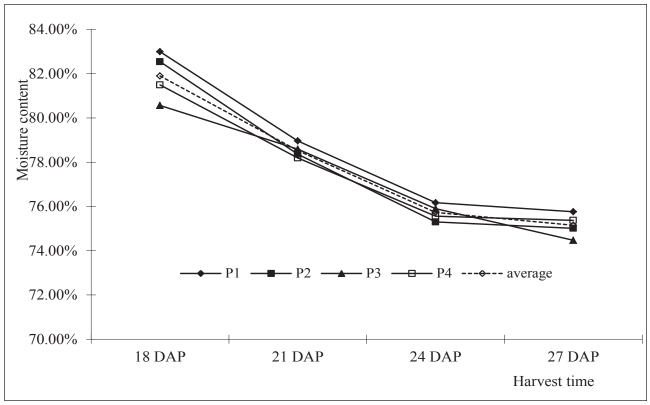

Fig. 7. Moisture content of different ridge-planting pattern

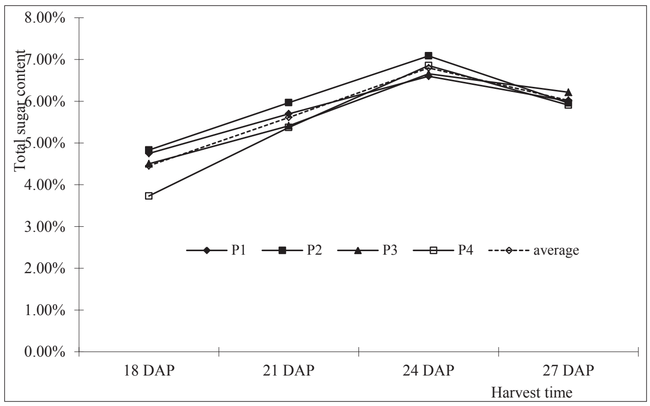

Fig. 8. Total sugar content of different ridge-planting pattern

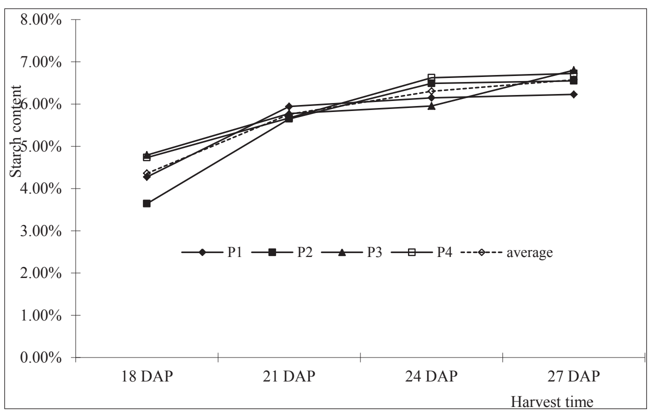

Fig. 9. Starch content of different ridge-planting pattern

Yield

Although Pattern 1 had the highest plant density, the corn stalk rot mortality of this pattern was the lowest (Table 1). On this point, Pattern 1 showed an advantage over other three patterns. On the hand, the fresh-ear weight of Pattern 1 was higher than Pattern 2 and Pattern 4 all the time, and was lower than Pattern 3 significant only at 21 DAP. As a result, the yield of Pattern 1 was higher than other patterns significantly all the time (Figure 10).

As the optimal harvest time for sweet corn Jinyutian No. 1 hybrid was at 24 DAP, the fresh-ear weight of Pattern 1 were 9.86% lower than Pattern 3, and was 9.64% and 20.50% (significant) higher than Pattern 2 and Pattern4 at this time, respectively. All the factors, which included the highest plant density, pretty higher fresh-ear weight and the lowest corn stalk rot mortality, resulted in the yield of Pattern 1 was 27.35%, 26.14% and 33.97% higher than Pattern 2, Pattern 3 and Pattern 4 at 24 DAP, respectively.

Since the fresh-ear weight and other physical properties of Pattern 3 were higher than Pattern 1, it had the potential to improve the plant population density. However, the improvement of plant population density would cause higher corn stalk rot mortality, poorer agronomic traits and physical properties inevitably, and high yield would not be guaranteed.

Conclusion

Ridge-planting pattern almost had no effect on leaf number and chemical properties (moisture, total sugar and starch content) of sweet corn. Plant density and agronomic traits (leaf area per plant, LAI, plant and cob height) of Pattern 1 were higher and the corn stalk rot mortality of Pattern 1 was lower than other three patterns, while the physical properties of Pattern 3 were higher than other three patterns. The highest plant density, lowest mortality and pretty higher fresh-ear weight of Pattern 1 caused the yield of this pattern was higher than the other three patterns significantly all the time, including the optimal harvest time at 24 DAP. In a word, Pattern 1 had advantages over other three patterns, and it was the reason for most peasants in south China to adopt it.

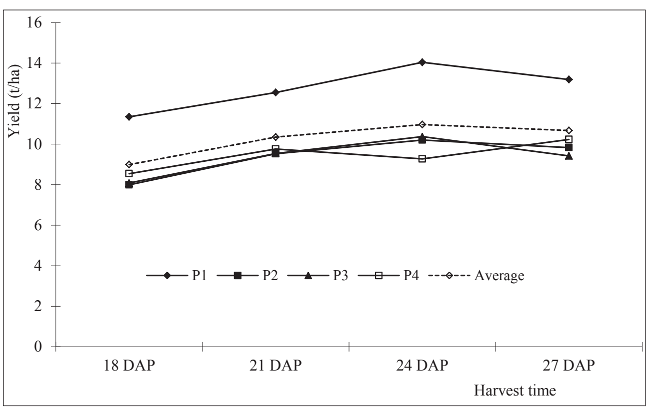

Fig. 10. Yield of different ridge-planting pattern

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