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Patience with density and reasonable use of different plant types in maize hybrids

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Summary The appropriate density of the hybrids with different plant morphotypes and grain yield of main maize hybrids in Henan province under different conditions and in different places have been studied for many years. The results indicalte that all the light intensity in middle and low part of the plant, the single leaf weight (SLW) and the photosynthetic intensity decrease remarkably with the increase of plant density and leaf area index (LAI), and that all the characters of the sirgle plant yield become inferior with different magnitudes. But the seriousness is slighter for compact type hybrids than that for spread ones. Under high yield condition, the desirable density is 4250 to 5000 plants per *mu* (666.67m^2) for compact maize hybrids and 3300 to 3500 plants for spread ones. The yield differences between the two kinds of hybrid vary with the yield levels.

Key words maize, hybrid, density, plant type

Introduction

The high yield research and production practice both in our country and abroad (Dong, 1988, 1989;Cardwell, 1982) have proved that the yield of compact maize hybrid is remarkably higher than that of spread one under high yield condition. But there are no enough explicit and sysmatic studies about the specific applying scopes of the two kinds of hybrid. This study aims at further analysing the yield of the main maize hybrids in Henan province under various yield levels and their suitable densities, and therefore providing theoretic proofs and concrete methods for bringing the yield potential of different kind hybrids into full play and improving maize yield significantly.

Materials and methods

This experiment was conducted in 1990 and 1991. In 1990, a two-way split-plot experiment with four repetitions was made in the surburbs of Zhengzhou. The maize hybrids were taken as whole unit and densities as subunit. Four widely popularized maize hybrids in Henan province, Yuyu 5, Yedan 13, Danyu 13 and Shendan 7, were used. The former two are compact hybrids and the latter two are spread ones. Five density levels (B1, B2, B3, B4, and B5) were set for both kinds of hybrid, 3500, 4250, 5000, 5750 and 6500 plants per *mu* (666.67m^2) for compact hybrids and 2000, 2750, 3500, 3750 and 5000 for spread ones. From 1991 to 1992, we made a randomized complete block experiment with three repetitions and four-rowed plot. It was carried out in different ecological places such as Nanyang, Fangcheng, Xiping, Pingdingshan, Zhecheng and Puyang. Ten excellent hybrids such as Yedan 4, Yedan 12, Yedan 13, Yuyu 5, Yu 1332, 90—1, Danyu 13, Shendan 7 were taken as experimental materials. The most appropriate density and quantity of

fertilizer were matched with every hybrid. We investigated the development phase, and at tassel-shooting time, tested leaf area, single leaf weight, photosynthetic intensity and other characters. When the corn riped, we harvested the two middle rows of each plot to calculate grain yield and to investigate the ear characters. The data were calculated with GW286 computer.

Results

Influence of density upon photosynthetic characters and yield component factors

The results (Table 1) of the correlation analysis show that the density significantly correlates with the LAI and the positive correlation coefficients range from 0.98 to 0.99; but the correlations with SLW and photosynthetic intensity are significantly negative, the coefficients varying from-0.84 to -0.94 and -0.95 to -0.98, respectively; the correlations with the yield component factors such as ear length, ear diameter, grain numbers per row and kernel weight are negative in different degrees.

Table 1. The correlation coefficients of density with SLW, photosynthetic intensity, LAI and yield component factors

Hybrid	SLW (mg/cm^2)	Photosynthetic intensity ($mg \cdot cm^{-2} \cdot h^{-1}$)	LAI	Ear length (cm)	Grain numbers per ear	Ear diameter (cm)	Grain numbers per row	Kernel weight (g/1000 grains)
Yedan 13	−0.90	−0.98	0.98	−0.60	−0.85	−0.40	−0.91	−0.84
Yuyu5	−0.88	−0.98	0.99	−0.41	−0.87	−0.62	−0.67	−0.89
Danyu 13	−0.94	−0.96	0.99	−0.96	−0.98	−0.99	−0.99	−0.95
Shendan 7	−0.84	−0.95	0.98	−0.33	−0.98	−0.92	−0.91	−0.98

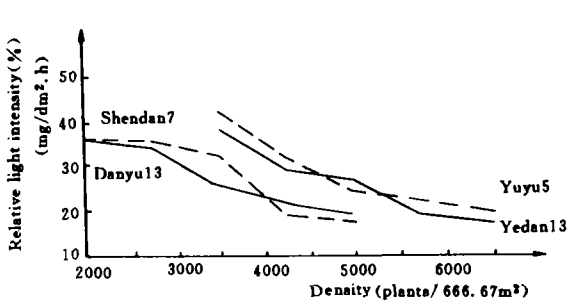
In a certain range, photosynthetic area becomes greater with the increase of density. But at the same time, light intensity at the middle and low parts of the plant decreases noticeably (Fig. 1), and so do single leaf weight and the photosynthetic intensity (Fig. 2). All the grain numbers per row, kernel weight and other yield characters become inferior in different degrees. The grain yield per unit area begins to decrease when the positive effect on yield, which is caused by the increase of ear number per unit area as density increases, is smaller than the negative effect on yeild caused by the degeneration of the ear characters. At this time, the density is the maximum or the most suitable one. Only by suitably thick planting can the solar energy be harnessed maximumly and the high yield potential of every excellent hybrid be fully explored.

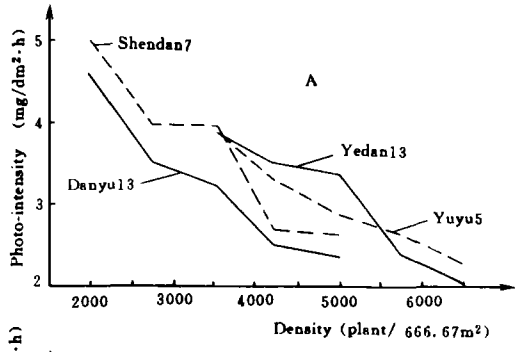
Table 2. The regression analysis of the characters on density

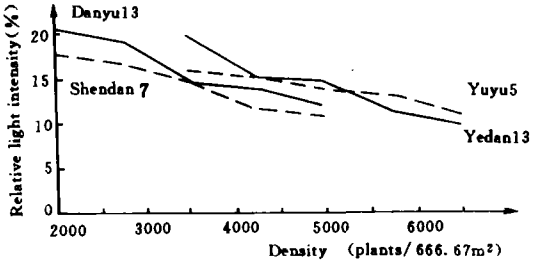
Characters	Hybrids			
	Danyu13	Shandan 7	Yedan 13	Yuyu 5
Ear length (cm)	−0.00231	−0.00208	−0.00030	−0.00031
Grain numbers per ear	−0.08410	−0.07129	−0.04247	−0.01495
Ear diameter(cm)	−0.00019	−0.00019	−0.00008	−0.00007
Grain numbers per row	−0.00572	−0.00355	−0.00201	−0.00097
Kernel weight (g/1000 grains)	−0.02131	−0.01059	−0.00090	−0.01685
SLW	−0.00020	−0.00021	−0.00017	−0.00015
Photosynthetic intensity	−0.00074	−0.00081	−0.00068	−0.00052

The patience with density and the density determination of maize hybrids with different plant types

The sensitivity to density varies greatly among hybrids because of the different plant mor-







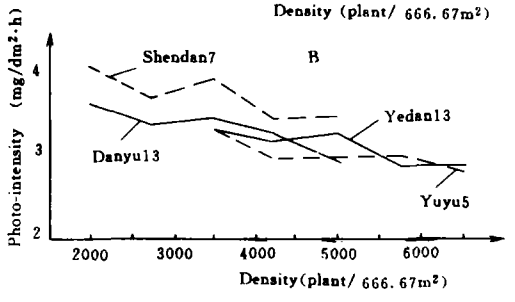


Fig. 1 The solar energy distribution in the population (at tassel-shooting time)
A At the height of 120cm over the ground ;
B In the surface of the ground

Fig. 2 The variation of SLW and photosynthetic intensity under the condition of various density levels
A Photosynthetic intensity; B SLW

photraits of them. The result of regression analysis of density to SLW, photosynthetic intensity and ear characters indicates that (Table 2) the patience with density of spread hybrids (Danyu 13 and Shendan 7) is inferior to that of compact ones (Yuyu 5 and Yedan13). The patience with density of compact hybrids is strong and they are suitable for growing in quite high density level. Therefore, their grain yields can be raised remarkably through reasonable thick planting and strengthening the management of fertilizer and water.

The result (Table 3) of comparison among the yields in various density levels shows that in the yield level of this experiment, B2 and B3 are desirable densities. In other words, the yields of the spread hybrids with density from 3300 to 3500 plants per *mu* (666.67m²) and of the compact hybrids form 4250 to 5000 plants per *mu* (666.67m²) are significantly higher than those of the hybrids with other density levels.

Table 3. The yield in different density

Density level	Grain yield (kg/ *mu*)	Significance 5%	1%
B3	518.74	a	A
B2	511.24	a	A
B1	458.35	b	B
B4	436.81	bc	BC
B5	417.25	c	C

Table 4. Yield comparison in different hybrids

Hybrids	Grain yield (kg/ *mu*)	Significance 5%	1%
Yuyu 5	511.68	a	A
Yedan 13	499.65	a	A
Shendan 7	442.51	b	AB
Danyu 13	419.47	b	B

The yield performance and the reasonable uses of hybrids with different plant types

As the result of the split-plot experiment shows in Table 4, the yields of hybrids experi-

mented vary significantly. More exactly, the yield of the two compact hybrids (Yuyu 5 and Yedan 13) is much higher than that of the two spread ones (Danyu 13 and Shendan 7). But the difference between the hybrids within the same plant types is not significant.

The result of the many-placed experiment also shows that the yield of the compact hybrids is higher than that of the spread ones under high yield condition. But the magnitudes in different places vary significantly. Combining the results in fourteen places, we conclude that the correlation coefficient of the increased percentage magnitude with grain yield is 0.7224. The increased percentage magnitude (Y) can be expressed with the regression equation,

$$Y = -27.238 + 0.0871X$$

where X represents yield level. From the equation, it can be seen that the increasing effect is remarkable when the yield level is higher than 427.5 kg per *mu* (666.67m^2). Generally speaking, when the increasing magnitude is higher than 10%, the higher the yield level is, the greater the increasing effect will be. The main reason for the phenomenon may be that, with the increase of yield level and density, the light scarcity of the leaves in middle and low parts of the plant has gradually become the limited factor to yield instead of fertilizer and water. So under high yield condition, compact hybrids which have strong patience with density should be applied. Under the middle yield condition (312.7—427.5 kg per 666.67m^2), the difference in yield between the two kinds of hybrid is not significant (less than 10%). The spread hybrids such as Danyu 13 and Shendan 7 should be applied when spacely planted in wheat rows. When thickly planted after wheat harvest, the high yield compact hybrids such as Yedan 4, Yedan 12, Yedan 13, Yuyu 5, Yu 1332 and 90-1 should be applied. Under the condition of low yield level (below 312.7 kg per 666.67m^2), the poor soil and the scarcity of fertilizer and water are the major limited factors to yield. Therefore, the spread hybrids should be applied and the yield can be improved by using more fertilizer to promote the soil fertility and strengthening field management.

Discussion

With the increase of density, photosynthetic area enlarges. But at the same time, photosynthetic intensity of the leaves in middle and low parts decreases noticeably, which makes the yield components such as ear rows, grain mumbers per row and kernel weight degenerate in different degrees. Therefore, only by means of reasonable density, can the relationship among the yield components be homonized and high yield be achieved.

The reaction to density is significantly different between the two kinds of hybrids. The magnitude of degeneration caused by high density is less in compact hybrids than that in spread ones in the characters such as single leaf weight, photosynthetic intensity and every ear character. The compact hybrids have strong patience with density. So their appropriate density is relatively high. It is the reasonable density for them to plant 4250 to 5000 plants per *mu* (666.67m^2) under high yield condition.

Under high yield condition, the ability of the corn canopy to capture the solar energy is the key factor to influence the utilization rate of the solar energy and the yield. Therefore, compact hybrids with better density patience should be used, and their yield will be improved with reasonably high density. Under medium and low yield conditions, the scarcity of fertilizer and water is the limited factors to yield. So, applying more fertilizer, improving the irrigation condition and raising soil fertility should be considered as the main methods to improve the yiled.

Only by choising hybrids correctly according to actual yield levels, can their yield potential be fully explored and high yield be gotten.

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