Study on high-yielding cultivation model for *Brassica Napus* L.

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Abstract

By adopting the design of orthogonal rotation combination, study on the best combination of planting density, sowing date, nitrogen, phosphorous, and variety for high-yielding cultivation model of *Brassica Napus* L. was conducted under field grown condition. The result showed: 1. Sowing date, nitrogen, phosphorous and the interaction of sowing date and planting density impacted the yield significantly. 2. Rapeseed yield would decrease as the postponing of sowing date and rise as the increasing of nitrogen application amount. 3. The yield would be the highest at early sowing with low planting density, but the lowest either at late sowing with low planting density or early sowing with high density. 4. The best combination for achieving the yield of over 3000kg/hm^2 varied from varieties.

Key words: *Brassica napus* L., high yield, cultivation model

Introduction

Oilseed rape is the second largest oil bearing crop in the world next to soybean. Yangtze River valley is the main production region of rapeseed in China and also in the world which takes 80% of the total production and one forth of the total growing areas respectively.

Rapeseed yield is affected by various factors. However, a lot of researches studied the effect of those factors separately. This paper is going to pursue the comprehensive impact of different factors under the ecological condition of Yangtze River stream to provide a suitable cultivation model of high yield rapeseed for the farmers.

1. Materials and methods

1.1 Design

Orthogonal rotation combination design was employed with 5 factors and 5 levels for each factor shown as table 1.

Table1 Code levels of Experimental factors

Factors	Range	Levels and code				
		-2	-1	0	1	2
Density(10^4P/hm^2)(χ_1)	4.5	12	16.5	21	25.5	30
Sowing date(m/d)(χ_2)	7d	9/16	9/23	9/30	10/7	10/14
Nitrogen(N) (kg/hm^2)(χ_3)	60	0	60	120	180	240
Phosphorus(P_2O_5) (kg/hm^2)(χ_4)	45	0	45	90	135	180
Varieties(χ_5)		HZ6	HZ10	HZ8	HZ9	HZ11

According to the design, 36 plots were needed at least to ensure the correctness and justice. The plots of 13m^2 (6.5m*2m) each was arranged randomly in the field and 7 rows were sown in each plot. Potassium (K_2O) of 90kg/hm^2 and boron of 15kg/hm^2 were applied to each of the plots. All the fertilizers were applied to the plots before sowing except nitrogen which was 70% and the rest 30% was applied at elongation stage.

1.2 Yield calculation

On harvesting, 3 rows of rapeseed plants in the middle of each plot were cut and put into a nylon net bag and weighed after having got dried. The seed yield of each plot was calculated from it.

1.3 Statistics

SAS software was employed to establish the simulation formula of yield (y, dependent variable) to the factors (χ, variable), to each of the factors and also the optimum combination of the factors to the yield.

2 Results and analysis

2.1 The comprehensive effect of 5 factors on rapeseed yield

As shown in Table 2, it was clear that χ_2 (sowing date), χ_4 (phosphorus), and χ_1*χ_2 (density and sowing date) were significantly correlated to the yield, and χ_3 (nitrogen) was extremely significantly correlated to yield, but all the others were not correlated to yield by T-test.

Table 2 Coded regression formulas and its statistical analysis

Variable	Coefficient	T-value	P-value	variable	Coefficient	T-value	P-value
int.	1995.31	22.14	<0.0001	$\chi_1*\chi_2$	171.75*	2.38	0.0312
χ_1	-19.00	-0.32	0.7518	$\chi_1*\chi_3$	0.75	0.01	0.9919
χ_2	-161.63*	-2.74	0.0152	$\chi_1*\chi_4$	8.25	0.11	0.9106
χ_3	356.00**	6.04	<0.0001	$\chi_1*\chi_5$	69.38	0.96	0.3521
χ_4	135.25*	2.29	0.0367	$\chi_2*\chi_3$	-26.81	-0.37	0.7157
χ_5	-27.25	-0.46	0.6507	$\chi_2*\chi_4$	-17.81	-0.25	0.8086
χ_1^2	-57.66	-1.13	0.2768	$\chi_2*\chi_5$	-53.44	-0.74	0.4709
χ_2^2	18.84	0.37	0.7174	$\chi_3*\chi_4$	81.56	1.13	0.2766
χ_3^2	-60.09	-1.18	0.2578	$\chi_3*\chi_5$	30.19	0.42	0.682
χ_4^2	-49.97	-0.98	0.3435	$\chi_4*\chi_5$	42.94	0.59	0.5612
χ_5^2	87.66	1.72	0.1068				

Therefore, the coded regression formula 1 was obtained from table 1 as follows:

$$y=1995.31-19*\chi_1-161.63*\chi_2+356*\chi_3+135.25*\chi_4-27.25*\chi_5+171.75*\chi_1*\chi_2+0.75*\chi_1*\chi_3+8.25*\chi_1*\chi_4+69.38*\chi_1*\chi_5-26.81*\chi_2*\chi_3-17.81*\chi_2*\chi_4-53.44*\chi_2*\chi_5+81.56*\chi_3*\chi_4+30.19*\chi_3*\chi_5+42.94*\chi_4*\chi_5-57.66*\chi_1^2+18.84*\chi_2^2-60.09*\chi_3^2-49.97*\chi_4^2+87.66*\chi_5^2 \quad (1)$$

2.2 Effect of sowing date on yield of different varieties

From formula 1, regression formula of the yield to sowing date was calculated to be sub-formula 2 as follows:

For HZ6, $y=2400.45-54.75*\chi_2+18.84*\chi_2^2$

For HZ8, $y=1995.31-161.63*\chi_2+18.84*\chi_2^2$

For HZ9, $y=2055.72-215.07*\chi_2+18.84*\chi_2^2$

For HZ10, $y=2110.22-108.19*\chi_2+18.84*\chi_2^2$

For HZ11, $y=2291.45-268.51*\chi_2+18.84*\chi_2^2$ (2)

From sub-formula 2, a fig of yield changing with sowing date of different varieties can be drawn as Fig 1. The yield was almost declined linearly with the postponement of sowing dates, however, the decreasing degree was varied from varieties (table 3).

Table 3 Descending degree of yield with the postponement of sowing dates ($kg/hm^2/d$)

Sowing date (m/d)	9/16 -10/14	9/16 -9/23	9/23 -9/30	9/30 -10/7	10/7 -10/14
HZ6	-7.8	-15.9	-10.5	-5.1	-0.3
HZ8	-23.1	-31.2	-25.8	-20.4	-15.0
HZ9	-30.7	-38.8	-33.4	-28.0	-22.7
HZ10	-15.5	-23.5	-18.1	-12.8	-7.4
HZ11	-38.4	-46.4	-41.1	-35.7	-30.3

Table 3 revealed that: 1. the descending degree was lowering with the postponement of the sowing dates; 2. the sequence of descending degree was HZ11>HZ9>HZ8>HZ10>HZ6, resembling HZ11 was very sensitive to sowing date and should be sown early, and HZ6 had a wide range of sowing date.

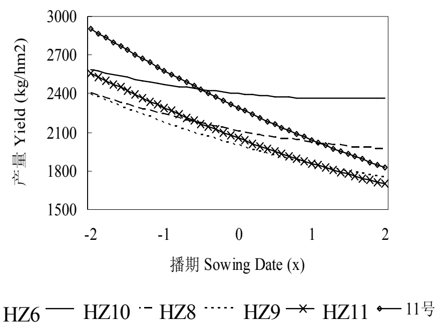

Fig. 1 Effect of sowing dates on yield

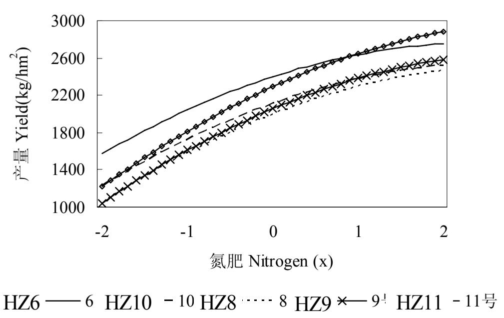

Fig. 2 Effect of nitrogen on yield

2.3 Effect of nitrogen on yield of different varieties

From formula 1, regression formula of the yield to nitrogen was calculated to be sub-formula 3 as follows:

For HZ6, $y=2400.45+298.62*\chi_3-60.09*\chi_3^2$

For HZ8, $y=1995.31+356.00*\chi_3-60.09*\chi_3^2$

For HZ9, $y=2055.72+386.19*\chi_3-60.09*\chi_3^2$

For HZ10, $y=2110.22+325.81*\chi_3-60.09*\chi_3^2$

For HZ11, $y=2291.45+416.38*\chi_3-60.09*\chi_3^2$ (3)

From sub-formula 3, a fig of yield changing of different varieties with nitrogen applying amount was drawn as fig 2. The yield of 5 varieties had a linear rising with the increase of nitrogen applied, meaning that these varieties had a high demand to nitrogen, but the difference between varieties on yield augment existed (table 4).

Table 4 Increasing degrees of yield with the increase of nitrogen applied ($kg/hm^2/kg$)

N(kg/hm^2)	0-240	0-60	60-120	120-180	180-240
HZ6	42.7	68.4	51.2	34.1	16.9
HZ8	50.9	76.6	59.4	42.3	25.1
HZ9	55.2	80.9	63.8	46.6	29.4
HZ10	46.5	72.3	55.1	38.0	20.8
HZ11	59.5	85.2	68.1	50.9	33.7

Table 4 revealed that: 1. the margin yield of nitrogen kept decreasing. 2. the sequence of margin yield of different varieties was HZ11>HZ9>HZ8>HZ10>HZ6, meaning that HZ11 had the biggest demand and very sensitive to nitrogen, but HZ6 had a wide range of nitrogen supply.

2.4 Effect of phosphorus on yield of different varieties

From formula 1, regression formula of the yield to phosphorus was calculated to be sub-formula 4 as follows:

For HZ6, $y=2400.45+49.37*\chi_4-49.97*\chi_4^2$

For HZ8, $y=1995.31+135.25*\chi_4-49.97*\chi_4^2$

For HZ9, $y=2055.72+178.19*\chi_4-49.97*\chi_4^2$

For HZ10, $y=2110.22+92.31*\chi_4-49.97*\chi_4^2$

For HZ11, $y=2291.45+221.13*\chi_4-49.97*\chi_4^2$ (4)

From the sub-formula 4, a fig of yield changing with phosphorus amount of different varieties was drawn as fig 3.

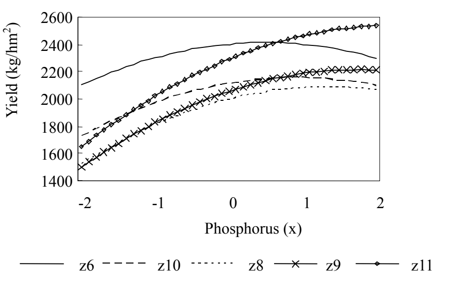

Fig3 Effect of phosphorus on yield

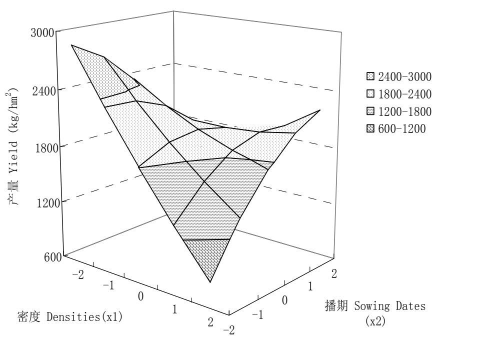

Fig4 Interaction between densities and sowing dates

Fig 3 revealed that the correlation of yield to phosphorus supply was a parabolic curve, that is to say, the yield is climbing up and dropping down after reaching the top with the increase of phosphorus supply. Also, difference of yield response to phosphorus existed among varieties. As the amount of phosphorus applied at the peak yield of each variety was concerned, the sequence was HZ11>HZ9>HZ8>HZ10>HZ6, meaning that HZ11 had the biggest demand and very sensitive to phosphorus, but HZ6 had a wide range of phosphorus supply.

2.5 Effect of interaction of factors on yield

There was only one interaction of each two-factor among the 10 combinations form 5 factors had significant effect on the yield. From formula 1, the interaction sub-formula 5 of density and sowing date was obtained.

$$Y_{1,2}=1995.31-19*\chi_1-161.63*\chi_2+171.75*\chi_1*\chi_2-57.66*\chi_1^2+18.84*\chi_2^2 \quad ⑤$$

Fig 4, drawn from sub-formula 5, revealed that, 1. the highest yield appeared when density and sowing date were both at -2 level and the second highest appeared at 2 level. 2. the lowest yield happend when density was at 2 level and sowing date was at -2 level, or the density at -2 level and sowing date at 2 level. That is to say, high yield could be reached with early sowing and low density or late sowing and high density, but low yield was possible with late sowing and low density or early sowing and high density.

2.6 Optimum cultivation model for each variety

There were 217 combinations screened with 95% probability from $3125(5^5)$ possible combinations based on the standard of yield more than $3000kg/hm^2$ and the optimum measures for different varieties were drawn as table 5.

Table 5 The optimum measures for different rapeseed varieties cultivation

	HZ6	HZ8	HZ9	HZ10	HZ11
Density(10^4p/hm^2)	13.9–15.8	14.1–17.7	16.3–19.9	13.3–16.0	19.8–22.4
Sowing date(m/d)	9/18–20	9/16–19	9/18–22	9/16–19	9/21–25
Nitrogen(kg/hm^2)	189–215	208–233	203–229	189–226	200–217
Phosphorus(kg/hm^2)	102–134	125–161	132–159	117–154	133–150

3 Conclusion and discussion

3.1 HZ11 was very sensitive to sowing date, nitrogen and phosphorus; it had a high demand to nitrogen and phosphorus and should be sown as early as possible to get high yield. But, HZ6 was had a wide range of adaptation to the discussed factors; it could be yielded high with high or low soil fertility and early or late sowing at the scope of tested. The other varieties were between these two.

3.2 The optimum measures drawn from the paper had been practiced in rapeseed production and a positive response was harvested. That looked the prospective adopting of the discussed experiment method to find the optimum combination of cultivation measures effectively and correctly.

References

Omitted.