Strategies for High Yield Inferred through Path Analysis of Major Economical Traits in Yongyou 8, a Hybrid Late Season Japonica Rice

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Abstract: In order to further clarify the path to high yield cultivation techniques for Yongyou 8, a hybrid late season japonica rice line, we selected 65 sets of data from 11 sites in Zhejiang and Jiangsu Provinces between 2005 and 2011, analyzed profiles of panicle, kernel and weight in Yongyou 8. Through correlation, regression and path analysis, a technical strategy has been proposed for high yield Yongyou 8 cultivation: appropriate control of the number of effective tillers, focus on large panicles, with appropriate attention to seed setting rate and kernel weight.

Keyword: hybrid rice, Yongyou 8, yield trait, path analysis, technical strategy

1 Introduction

Simple correlation[1-3]or multiple regression[4-7]analysis are often employed to study the relationship between plant main characters and crop yield often using. However, simple correlation cannot fully examine the relationship between variables, so that the results might have a certain one-sidedness (Ref??). Multivariate regression analysis, to a certain extent, can eliminate confusion between variables and reveal the real correlation of the independent variables with their dependent variables. The path analysis is able to effectively demonstrate a direct effect of the relevant variables on the outcome and to find out the indirect effect of casual factors on the affected factors, allowing comparison of the relative importance of various causal factors [8-10]. Such a comprehensive analysis will be a solid ground for improving yield cultivation techniques.

In order to determine cultivation strategies for high yield of intermediate to late season japonica rice, we explored the effect of major economical traits on yield[11-

13]. Yongyou 8 , en elite and late season cultivar, is often used as a three-strain hybrid rice line. In 2012, we collated 55 sets of data from 2005 to 2011 in 9 sites of Zhejiang and Jiangsu Provinces, to determinethe relationships between traits and yield, performed regression, correlation and path analysis [14] for Yongyou 8. Later, we have gathered more economical trait data from various sites, and further analyzed the effects of major economical traits on yield of Yongyou 8.

2 Materials and Methods

2.1 Data Collection

Yongyou 8 is a 3-strain hybrid late season japonica rice line with moderate growth period, can be grown late season in areas where rice is harvested once or twice a year. Yongyou 8 has loose tillers, moderate tillering capability, high panicle bearing rate, large spikes, high seed setting rate, moderate lodging resistance. The quality of rice meets the national standard of second excellence grade.

Results from analysis of 65 sets of field data for 7 continuous years from 11 sites in the two Provinces (Table 1) indicate that the yield was negatively correlated with the number of effective tillers per unit area, but positively correlated with the number of total kernels, filled kernels per panicle and 1,000 kernel weight. The seed setting rate was the highest in paddies with a yield at 11250 kg/ha, followed by paddies with a yield at 8250 kg/hm^2.

Table 1, Characteristics of Panicle, Kernel and Weight Traits at Various Yield Level

Yield Level(kg/hm^2)	>11250	≤11250—>9750	≤9750—>8250	≤8250
No of Paddies	21	19	17	8
Effective Tillers(10^4/hm^2)	226.97	237.33	240.61	241.86
Total Kernels/Panicle	239.36	229.00	201.58	177.50
Filled Kernels/Panicle	204.85	173.04	155.68	146.64
Seed Setting Rate	85.39	75.83	77.89	83.00
1,000 Kernel Weight(g)	28.28	27.98	27.18	26.56
Mean Yield(kg/hm^2)	12633.09	10303.72	8953.82	8050.31

2.2 Method of Analysis

Sixty five sets of trait data were analyzed for correlation, regression and path to

reveal the cultivation technical strategy to high yield.

3 Results and Analysis

3.1 Regression Analysis among Traits

As shown in Table 2, among five traits, yield is negatively correlated with the number of effective tillers not statistically insignificant though, and positively correlated with the remainder 4 traits very significantly. Further analysis of the five traits revealed that the number of effective tillers was negatively correlated at very significant level with total number of kernels per panicle, filled kernels and 1,000 kernel weight, weakly correlated with seed setting rate. The total number of kernels per panicle was very significantly correlated with filled kernels, 1,000 kernel weight, weakly negatively correlated with seed setting rate. Thus, relationships among the five traits are complex, and their relationships with yield vary even negative. Thus, it is the key to understand how to coordinate traits with yield, how to focus on the main factor to fully explore the traits.

Table 2, Correlation Coefficients for Major Economic Traits

	x_2	x_3	x_4	x_5	Actual Yield
Effective Tillers	−0. 7741**	−0. 7156**	0. 0237	−0. 3460**	−0. 1498
Total Kernels/panicle		0. 8546**	−0. 1880	0. 6262**	0. 4956**
Filled Kernels/Panicle			0. 3390**	0. 5340**	0. 6982**
Seed Setting Rate				−0. 1737	0. 3835**
1,000 Kernel Weight					0. 6378**

Note: * denoted difference at α = 0.05. ** denotes deference at α = 0.01.

3.2 Gradual correlation analysis

We analyzed 65 sets of data for traits by stepwise regression, maximized coefficient. The regression equation is

$\hat{y}$ =-31504.81+34.81 x_1 +46.75 x_3 -38.49 x_4 +810.23 x_5 ±754.78

Where,

x_1 = effective tillers, x_2 = kernels per panicle, x_3 = filled kernels per panicle, x_4 = seed setting rate, and x_5 = 1,000 kernel weight.

Through results of stepwise regression analysis, it can be seen that among the five traits, the total kernels per panicle did not contribute to yield. The ranges of the five traits were 1.7700~3.2850 million/hm^2, 149.60~288.90 kernels/panicle, 114.27~250.74 kernels/panicle, 65.50~89.20% and 25.30~29.32 g for x_1, x_2, x_3, x_4, x_5, respectively. The range of yield (y) was 7665.00~13549.50 kg/hm^2.

Results of variance analysis indicated that the F value for the regression equation was 75.60 with $P < 0.01$. Analysis of partial correlation revealed that filled kernels per panicle (r (y, x3) = 0.7003) had the largest contribution to yield, followed by effectively panicles (r (y, x_1) = 0.6672), weight per thousand kernel (r (y, x_5) = 0.5888) and seed setting rate (r (y, x_4) = 0.2599). But multiple regression analysis revealed the there are dependences among traits. Since there is colinearity between factors, it is hard to accurately estimate the contribution of each trait on the yield. Path analysis could effectively reveal the direct and indirect effect of these traits on the yield. Thus, path analysis was employed to determine the effect of major economic trait on yield.

3.3 Path Analysis

Based on stepwise regression analysis, four main factors were selected for path analysis to further clarify the importance of each trait on yield. Results showed that filled kernels per panicle had the largest effect on yield, followed by effective tillers, 1,000 kernel weight, and seed setting rate (Table 3).

Table 3, Path Coefficient Analysis

Factor	Direct Effect	Through x1	Through x3	Through x4	Through x5
Effective Tillers	0. 6042		−0. 6141	0. 0036	−0. 1435
Filled Kernels/Panicle	0. 8581	−0. 4324		0. 0510	0. 2214
Seed Setting Rate	0. 1503	0. 0143	0. 2909		−0. 0720
1,000 Kernel Weight	0. 4147	−0. 2091	0. 4583	−0. 0261	

The path coefficient due to direct effect of effective tillers was 0.06042. However, effective tillers had a large negative effect through filled kernels per panicle, as much as -0.6141, with small positive effect indirectly through seed setting rate and a small negative effect through the 1,000 kernel weight. The ultimate effect of effective tillers on yield was -0.1498. Thus, the number of effective tillers had a large effect on kernels per panicle. In order to increase the number of filled kernels per panicle, it is

necessary to reduce the number of effective tillers.

The number of filled kernels per panicle had the largest direct effect on yield with a path coefficient as high as 0.8581. However, its negative indirect effect through the number of effective tillers was also as high as -0.4324 while its positive indirect effect through the weight per thousand kernel and seed setting rate was small, respectively being 0.2214 and 0.0510. Thus, the number of filled kernels per panicle has a combined effect 0.6982. Therefore, in high yield cultivation, it is extremely important to control the negative effect of the number of panicles through the number of filled kernels, focusing on produce large panicles.

The seed setting rate had the smallest direct coefficient, being 0.1503. Its positive indirect effect through the total number of kernels per panicle was higher, being 0.2909. Its indirect effects through the number of effective tillers and the 1,000 kernel weight were weak, being 0.0143 and 0.0720. Ultimately, the seed setting rate had a combine effect of 0.3835.

The 1,000 kernel weight had a direct path coefficient 0.4147. Its negative effects through the number of effective tillers and seed setting rate were respectively -0.2091 and – 0.0261, but the positive indirect effect through the number of filled kernels was 0.4583. Therefore, the 1,000 kernel weight had a combined effect of 0.6378.

4 Discussion and Conclusion

Our analysis showed that the number of filled kernels had the greatest direct positive effect. The effect of seed setting rate and the 1,000 kernel weight were exerted indirectly through the positive effect of the number of filled kernels. The number of effective tillers was strongly negatively correlated with the number of total kernels, the number of filled kernels, and the weight of thousand kernels, and negatively correlated with yield. The total number of kernels per panicle was very significantly correlated with the number of filled kernels. Therefore, the technical strategy to high yield cultivation of Yongyou 8 is to appropriately control effective tillers, focus on large panicle, and pay attention to seed setting rate and kernel weight.

In the current study, results of analysis of five economic traits were somewhat different from previous report, not as previously reported negative correlation [13]. Through stepwise regression analysis, the total number of kernels per panicle fell out to be an important factor. Results of path analysis indicated that yield was affected most significantly by the number of filled kernels per panicle. This is consistent with the previous notion “to appropriate control the number of effective panicle, focus on large panicle and pay attention to kernel weight”. Data for this analysis is more inclusive, containing those collected from more sites, thus is more representative.

Yongyou 8 is an intermediate to late season rice line that can be cultivated in areas where rice is grown once or twice a year. This adaptive line has outstanding performance in Zhejiang and Jiangsu. Zhu has pointed out that Yongyou 8 has displayed a dynamic ultrahigh yield trend of "small at first, stable in the middle and strong at last". An ultrahigh yield can be achieved by stabilizing the panicle number, focusing on large panicle, increasing the pool, strengthening the source, preventing lodging [15]. The current study has found that the large panicle character contributed the largest to ultrahigh yield of Yongyou 8. The number of kernels per panicle had a clear larger contribution to yield than other factors. Because the number of effective tillers was very strongly negatively correlated with the total number of kernels and the number of filled kernels, it is imperative to appropriately control the number of effective tillers.

References

1. Guo Y M, Mu P, Liu J F. Correlation analysis and QTL mapping of grain shape and grain weight in rice under upland and lowland environments[J]. Acta Agronomica Sinica, 2007,33(1):50-56.
2. Zeng X P, Li Q X, Lv J Q. Canonical correlation analysis between quality and yield characters of hybrid rice[J]. Southwest China Journal of Agricultural Sciences, 2006, 19(6): 991-995.
3. Zhang X J, Xu Z J. The correlation of rice yield and its components[J]. Journal of Shenyang Agricultural University, 2003, 34(5)：362-364.
4. Sun C M, Wang Y L. Regressive analysis between leaf characters and yield factors in elongation stage in rice[J]. Journal of Yangzhou University (Agricultural and Life. Science Edition), 2005,26(2):71-73.
5. Zhao Y, Huang F K, Tong X L, Ling B, Pang X F. Secondary compounds in rice varieties resistant to *Nilaparvata lugen*[J]s. Chinese Journal of Applied Ecology, Nov． 2004， l5(11):2161-2164.
6. Zhang Y F, Wang Y L, Zhang C S, Dong G C, Yang L X， Huang J Y, Chen P F, Gong K C. Differences of nitrogen absorption and utilization and their influences on grain yield of conventional *Indica* rice cultivars[J]. Jiangsu Journal of Agricultural Science, 2006, 22(4): 318～324.
7. Guo L B, Luo L J, Xing Y Z, Xu C G, Mei H W, Wang Y P, Yu X Q, Ying C S, Shi C H. Genetic analysis and utilization of the important agronomic traits on Zhenshan97×Minghui 63 recombinant inbred lines(RIL) in rice (*Oryza sativa L.*) [J]. Acta Agronomica Sinica, 2002, 28(5): 644-649.
8. Li P F, Yang S Q, Zhang Y H, Tian H P. Analysis of main agronomic characters of rice in

Ningxia[J]. Acta Agriculturae Boreali-occidentalis Sinica, 2007, 16(2): 33-36.
9. Cheng Y S, Liao Y P, He X Y, Chen Z M, Chen Y H. Relevance and path analysis on harvest index and single yield and its composition factors of rice[J]. Guangdong Agricultural Sciences. 2006(9):36-38.
10. Wang H Z, Luo W X, Wang Y B. Correlation and path analysis of economic characters of hybrid rice[J]. Seed, 2004,23(12):55-57.
11. Liu W M. Correlation, Multiple Regression and path Analysis between Yield Traits and Yield on Intersubspecific Hybrid Rice[J]. Chinese Agricultural Science Bulletin，2009, 25(01): 70-72.
12. Liu W M.Analysis of high yield and efi ciency technique in intersubspecific hybrid rice[J].Journal of Agricultural Science and Technolog ,2009,3(11):43-46
13. Liu W M. Study on the High Yield and High Efficiency Cultivation Technique of Indica-japonica Intersubspecific Hybrid Rice as Single-cropping Late Rice[J]. Hubei Agricultural Sciences, 2011(50): 18, 3684-3686.
14. Liu W M. Analysis of High Yield and Efficiency Technique on Yongyou 8 Hybrid Rice[J]. Hybrid Rice,2013,28(2):40-42
15. Zhu Y Y,Sha A Q,.Fan B G. Formation Rule of Super-high-yielding and Cultural Techniques for Yongyou 8[J].Jiangsu Agricultural Sciences,2012,40(2):45-47.