PATH-COEFFICIENT ANALYSIS OF DIRECT-SEEDED RICE YIELD AND YIELD COMPONENTS AS AFFECTED BY SEEDING RATES

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ABSTRACT

Understanding relationships among rice yield and yield components is critical to utilizing them effectively. Interrelationships among rice yield and yield components for direct seeded rice cultural systems using path-coefficient analysis that describes a cause-and-effect relationships have not been shown. To study these relationships as affected by seeding rates, our experiments were seeded at 50, 100, 150, 200 and 250 kg ha^{-1} in 1997-98 dry season and at 25, 50, 100, 150 and 200 kg ha^{-1} in 1998 wet season with two rice groups (very-early and early growth duration). As seeding rates increased, panicles per square meter (sqm) significantly increased, and filled grain per panicle significantly decreased, this indicated an indication of the compensatory nature between these two traits. Path-coefficient analysis revealed that filled grains per panicle had the positive direct effect on rice yield and compensated for decreasing panicle density. Grain weight was a varietal trait and was of secondary importance in determining rice yield. Unfilled grain percentage was affected by season. Considering good field management, the seeding rate of 100 kg ha $^{-1}$ should be recommended and to achieve optimum rice yield and grain quality in direct-seeded cultural system, adequate panicles per sqm of uniform maturity must be obtained.

Key words: direct-seeded, path analysis, seeding rate, yield components

INTRODUCTION

Optimizing yield is one of the most important goals for most rice growers and, consequently, most rice research programs. Plant populations is necessary to obtain optimum rice yield are influenced by varieties and seeding rates. In water-seeded rice, Miller et al. (1991) reported that panicle/m^2 was important component of yield, accounting for 89% of the variation in yield. Similar results were reported by Yoshida et al.(1972) for transplanting rice. Wells and Faw (1978) showed that yield compensation for "Starbinet" was accounted for increased panicle density and decreased grains per panicle as seeding rate increased. They also reported that a positive, non-significant correlation between rice yield and panicle density, and a negative non-significant correlation between yield and total spikelets per panicle.

Information obtained from correlation coefficients can be augmented by partitioning the relationships into direct and indirect effects for a given set of a prior cause-and-effect interrelationships. In such situations, the correlation coefficients may be confounded with indirect effects due to common association inherent in trait

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interrelationships. Path-coefficient analysis has proven useful in providing additional information that describes a priori cause-and-effect relationships, such as rice yield and yield components (Vlek et al. 1979).

The literature on rice yield and yield component response to seeding rate is extensive for direct-seeded cultural systems. However, only a few studies have reported relationships between traits, but these relationships have not been subjected to path-coefficient analysis. So the objective was to study rice yield and yield component relationship for semi-dwarf rice varieties under varying seeding rates in a direct-seeded cultural system through the use of path-coefficient analysis.

MATERIALS AND METHODS

Field experiments were conducted in dry season 97-98 and wet season 1998. They were laid out in a split-plot design with three replications. Main plot was five seeding rates: 50,100, 150, 200 and 250 kg ha^{-1} (DS 97-98) and 25, 50, 100, 150 and 200 kg ha^{-1}. Subplot was two variety groups: very-early (OMCS) and early rice (IR64).

The experiments were fertilized with 100-50-50 kg ha^{-1} (N-P_2O_5-K_2O). Nitrogen was applied in 3 splits: 30 kg N ha^{-1} at 1week after sowing (WAS), 30 kg N ha^{-1} at 3 WAS and 40 kg N ha^{-1} at 6 WAS. 50 kg ha^{-1} P_2O_5 and 25 kg ha^{-1} K_2O were applied at 1 WAS, and 25 kg ha^{-1} K_2O was applied at 6 WAS. Weeds were controlled before rice emergence and fertilization.

SPAD reading, plant height and tiller numbers were measured every week beginning from three weeks after sowing. Yield components were measured from sample area of 1m^2 in each plot, then taking the sub-sample of 30 grams to count filled grains/panicle, unfilled grain percentage and 1,000-grain weight after oven-dried at 70 ^oC in 3 days. Grain yields were estimated independently from the yield components. Five m^2 area plot were sampled.

The data were analyzed using the ANOVA procedure and path-coefficient analysis to estimate the direct and indirect effects of seeding rate and variety on yield and yield components.

RESULTS AND DISCUSSION

Panicle density significantly increased as seeding rate increased (Table 1 and 2). In contrast, filled grains per panicle significantly decreased as seeding rate increased. This compensatory relationship between two traits is well documented for both direct-seeded, ratoon and transplanting rice (Counce 1987; Jones and Synder 1987a; Jones and Synder 1987b; Wells and Faw 1978; and Yoshida and Parao 1972). Tillering was important increasing panicle density at the two lowest seeding rates (25 and 50 kg ha^{-1}) by comparison of established plant stand (3 weeks after sowing) and panicle per m^2. It appears that filled grain per panicle decreased when panicle density increased, the main stem and its tiller were better able to sustain a greater number of filled grain per panicle. However, if panicles per density is highly dependent on secondary and tertiary tillers, grain maturity differences within the plant may become apparent (Yoshida 1981). Non-uniform maturity can decreased quality due to a mixture of grains at different stages of development and grain moisture (Siebenmorgan and Jindal 1986 and Kocher et al. 1990). Also, if filled grains per panicle exceeds optimum levels, then panicle maturity may become extended, and grain mixtures due to different stages of development will also decrease grain quality.

Table 1. Yield and yield components for each seeding rate in dry season 1997-98

Seeding rates (SR)	Established plant stand	Pan./m^2	Filled grains/ Panicle	Unfilled grain (%)	1,000-grain weight (gr.)	Yield (t/ha)
OMCS97-25						
50	277	507	35	34.4	27.7	5.02
100	356	514	35	31.1	27.5	4.88
150	392	515	35	36.2	28.1	5.07
200	415	539	34	33.5	27.5	5.00
250	401	575	30	31.2	28.0	4.85
IR64						
50	218	499	40	19.2	29.5	5.87
100	337	505	37	18.1	29.3	5.51
150	379	512	39	28.5	29.5	6.03
200	403	539	34	27.3	29.5	5.48
250	402	585	32	21.2	29.1	5.48
F (SR)	**	**	*	NS	NS	NS
F (Var.)	NS	NS	NS	**	**	**
F (SR x V)	NS	*	*	*	NS	NS

*** Significant at 0.01 level, * significant at 0.05 level and NS, non-significant as determined from the analysis of variance.*

Yield differences among seeding rates were non-significant in 97-98 dry season because of this compensatory relationship; however, they were not significantly different in 1998 wet season. Beside seeding rate effect, varietal influence on unfilled grain percentage, grain weight and grain yield was also contributed. Path-coefficient correlation revealed this aspect (Table 3).

Table 2. Yield and yield components for each seeding rate in wet season 1998

Seeding rates (SR)	Established plant stand	Pan./m^2	Filled grains / Panicle	Unfilled grain (%)	1,000-grain weight (gr.)	Yield (t/ha)
OMCS95-5						
25	245	331	27	44.8	27.2	2.33
50	313	369	28	45.3	27.6	2.52
100	352	372	26	45.7	27.5	2.36
150	420	405	21	47.1	28.1	2.14
200	490	420	16	48.1	27.9	1.68
IR64						
25	252	361	30	38.3	29.2	3.02
50	316	410	29	39.9	29.4	3.33
100	387	437	27	39.9	29.2	3.29
150	447	453	21	42.9	29.2	2.70
200	562	446	18	45.4	29.2	2.25
F (SR)	**	**	**	**	NS	**
F (Var.)	NS	**	NS	**	**	**
F (SR x V)	NS	NS	NS	NS	NS	NS

*** Significant at 0.01 level, and NS, non-significant as determined from the analysis of variance.*

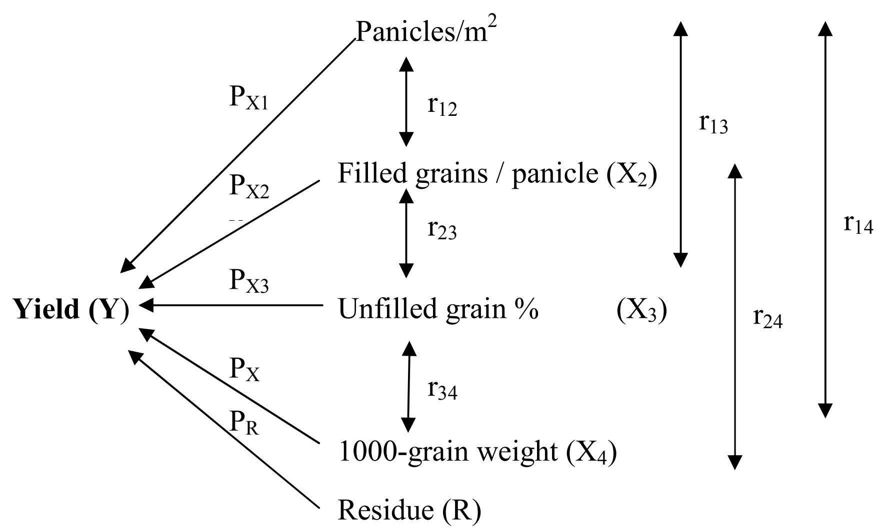

Fig.1: Path diagram showing causal relationship between four predictor variables (panicle/m^2, filled grain/panicle, unfillled grain percentage, and weight of 1,000 grains) and the response variable, grain yield. The residual variable (R) is the undetermined portion.

Path-coefficient analysis requires an implicit, a prior cause-and-effect relationship among traits. In this study, the response variable, grain yield, and the four predictor variables, panicle density, filled grain/panicle, unfilled grain percentage and 1,000 grains weight, were studied (Fig. 1).

Effect of each factor (seeding rate and variety) on yield and yield components were also evaluated with season (Table 3).

Table 3. Coefficient correlation between 2 factors (seeding rate and variety) on yield and yield components

a. DS 97-98

Path coefficient	Seeding rate (kg/ha)	Vars.	Pan. /m^2	Filled grains/ Pan.	% Unfilled grain	1,000-grain weight (gr.)	Grain yield (t/ha)
Seeding rate	**1.000**	0.000	0.918**	-0.739*	-0.644*	-0.010	-0.199
Vars.	0.000	**1.000**	-0.024	-0.480	0.520	-0.971**	-0.891**
Pan. /m^2	0.918**	-0.024	**1.000**	-0.821**	-0.613	-0.068	0.269
Filled grains/Pan.	-0.739*	-0.480	-0.821**	**1.000**	0.385	0.516	0.746*
% unfilled grains	-0.644*	0.520	-0.613	0.385	**1.000**	-0.473	-0.176
1000-gr. Wght.	-0.010	-0.971**	-0.068	0.516	-0.473	**1.000**	0.914**
Grain yield	-0.199	-0.891**	0.269	0.746*	-0.176	0.914**	**1.000**

b. WS 1998

Path coefficient	Seeding rate (kg/ha)	Vars.	Pan. /m^2	Filled grains/ Pan.	% Unfilled grain	1,000-grain weight (gr.)	Grain yield (t/ha)
Seeding rate	**1.000**	0.000	0.759*	-0.949**	0.572	0.147	-0.584
Vars.	0.000	**1.000**	-0.546	-0.174	0.782**	-0.961**	-0.712*
Pan. /m^2	0.759*	-0.546	**1.000**	-0.573	-0.013	0.671*	0.064
Filled grain/Pan.	-0.949**	-0.174	-0.573	**1.000**	-0.708*	0.046	0.769**
% Unfilled grain	0.572	0.782*	-0.013	-0.708	**1.000**	-0.696*	-0.937**
W of 1,000 grains	0.147	-0.961**	0.671*	0.046	-0.696*	**1.000**	0.639*
Grain yield	-0.584	-0.712*	0.064	0.769**	-0.937**	0.639*	**1.000**

Table 4. Path coefficient of seeding rates , varieties and 4 yield components on grain yield

a. DS 97-98

Path coefficient	Seeding rates	Vars.	Pan. /m^2	Filled grains/ Pan.	% Unfilled grain	1000-grain weight (gr)	Correlation coefficient
Seeding rates	**-0.3992**	0.0022	-0.4214	-1.1113	0.5288	-0.0208	-0.199
Vars.	-0.0004	**-2.2346**	0.0110	-0.7218	-0.4270	-2.0215	-0.891**
Pan. /m^2	0.3664	0.0536	**-0.4590**	-1.2346	0.5034	-0.1416	0.269
Filled grains/Pan.	0.2950	1.0726	0.3769	**1.5038**	-0.3162	1.0742	0.746*
% Unfilled grain	0.2571	-1.1620	0.2814	0.5789	**-0.8212**	-0.9847	-0.176
1000-grain wgt	0.0039	2.1697	0.0312	0.4752	0.3884	**2.0818**	0.914**

b. WS 1998

Path coefficient	Seeding rates	Vars.	Pan. /m^2	Filled grains/ Pan.	% Unfilled grain	1000-grain weight (gr)	Correlation coefficient
Seeding rates	**-1.7078**	-0.0022	0.0082	-1.9959	1.6301	0.2893	-0.584
Vars.	-0.0017	**-2.2282**	-0.0054	-0.3659	-2.2286	-1.8911	-0.712*
Pan. /m^2	-1.2963	1.2166	**0.0098**	-1.2051	0.0371	1.3204	0.064
Filled grains/Pan.	1.6208	0.3877	-0.0056	**2.1032**	2.0177	0.0905	0.769**
% Unfilled grain	-0.977	-1.7424	-0.0050	-1.4891	**-2.8499**	-1.3696	-0.937**
1,000-grain wgt	-0.2511	2.1413	0.0066	-0.0968	1.9835	**1.9679**	0.639*

Panicle had a positive correlation r= 0.918** (DS 97-98) and r=0.759* (WS 98) as seeding rate increased while filled grains per panicle significantly decreased, and exhibited through the negative correlation r=-0.739* (DS 97-98) and r=-0.949**(WS 98). Although, the direct effect of panicle density on grain yield was not significant for both season; the indirect effects between panicles/m^2 and filled grains per panicle or with other variables (unfilled grain, grain weight) clearly exhibited.

The direct effect of filled grains per panicle on yield was positive and was the most important as compared to the direct effects of panicle density. Unfilled grain percentage was changed due to dry or wet season. Its direct effects were negative for both seasons and too high in 98's WS. Negative correlation on grain yield (r=-0.937**) and negative path coefficient (P_{X3Y} = -0.8212 (DS97-98) and P_{X3Y} = -2.8499 (WS98) were noticed in unfilled grain percentage. Otherwise, grain weight had a positive correlation on yield and positive path coefficient. The direct effect of variety on grain yield was very significant in both seasons. This relationship indicated a trend for seed size to increase the grain yield. IR64 had a larger size than OMCS.

Path-coefficient analysis results are not only useful to rice breeders but also noticed to all rice researchers. Panicle density and filled grains per panicle were the most important factors and had compensatory nature in producing stable and high yield. The direct effect of filled grains per panicle on grain yield was positive; however, without optimum panicle density of uniform maturity, optimum rice yield cannot be realized.

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TÓM TẮT

Phân tích tương quan hệ số Path năng suất và thành phần năng suất và thành phần năng suất lúa sạ thẳng dưới ảnh hưởng của mật độ sạ

Hiểu rõ tương quan giữa năng suất với các thành phần năng suất lúa là điều rất quan trọng trong việc sử dụng chúng một cách có hiệu quả. Tương quan này mô tả mối quan hệ nhân quả giữa các yếu tố cấu thành năng suất với năng suất lúa dưới ảnh hưởng của các mật độ gieo sạ khác nhau. Hai thí nghiệm thực hiện trong vụ ĐX 97-98 với các mật độ 50, 100, 150, 200 và 250 kg/ha, vụ HT 98 gồm các mật độ 25, 50, 100, 150 và 200 kg/ha trên hai nhóm giống lúa: sớm và cực sớm cho thấy: số bông /m^2 gia tăng khi mật độ sạ tăng trong khi số hạt chắc /bông giảm. Đây là mối quan hệ bù trừ giữa hai đặc tính trên. Phân tích tương quan hệ số path đã tiết lộ số hạt chắc/bông có ảnh hưởng trực tiếp và tương quan thuận với năng suất hạt, bù trừ cho việc giảm số bông/m^2. Trọng lượng 1000 hạt là đặc tính giống và là nhân tố thứ hai trong việc xác định năng suất lúa. % hạt lép chịu ảnh hưởng của mùa vụ. Dưới điều kiện quản lý đồng ruộng tốt, mật độ sạ 100 kg giống/ha được khuyến cáo để nhận năng suất lúa có chất lượng tốt, cũng như đáp ứng đủ số bông/m^2 cho việc chín đồng bộ trong hệ thống canh tác lúa sạ ướt.