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Relationship of Physiological, Growth and Yield Contributing Parameters of LockLodged Rice Ratoon Crop

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Abstract: The rice ratooning practice is unfamiliar in the farming community. It need to be introduced for achieving yield targets, because neither the vertical nor the horizontal increase of rice production could keep pace with this thrust even if the yielding ability has more or less reached in the plateau. Locklodged rice ratooning in this regard might be an alternative approach. With minimum care, no land preparation and transplanting, it can yield at least half of the main rice crop. The attempt was made to exploit the relationship of yield contributing characters and physiological parameters with each other to understand the mode of relationship with yield attributes, which could be guideline for breeders, agronomists and plant physiologists. The study envisaged that the locklodged rice grain yield was associated with all the agronomic and physiological traits including plant height, leaf dry matter, total dry matter, leaf area index, relative growth rate, crop growth rate, biomass duration, 1000 grain weight, seed length, panicle length, number of panicles per plant, tiller number at harvest, and ratoon rating. Whereas, the grain yield showed non-significant relationship with net assimilation rate. These all the growth, yield and physiological parameters were also associated with each other except net assimilation rate of the crop.

Key Words: Locklogded Rice Ratoon, Correlation, Growth, Yield

Introduction

Rice ratooning offers an opportunity to increase cropping intensity per unit of cultivated area because a ratoon crop has the shorter growth duration than main crop (Samson, 1980). In addition, ratoon crop may be grown with 50-60% less labor, neither land preparation nor planting is needed and the crop uses 60% less water than the main crop (Zhang Jing-guo, 1991; Oad and Pompe, 2001). Ratoon yield was recorded as high as 4.0 $t.ha^{-1}$ (Tripathi and Pandya, 1988); Zhang Jing-guo, 1991; and is achievable by 50% of the main crop (Srinivasan, 1988). It is suggested that under most conditions, a ratoon is more cost-effective than double cropping at both micro and macro level. Zhang Hongsong and Gou Xiaohong (1990) estimated that rice production from 2.0 million hectares of rice fields could increase as much as 4.5 million tons, if ratoon rice fields are conservative at 2.2 $t.ha^{-1}$ Considering all these aspects, this research was an attempt to assess the relationship of growth and yield contributing parameters with final grain yield of rice locklodged ratoon crop.

Materials and Methods

Field experiment was conducted under irrigated lowland conditions during wet season (WS) at the Philippine Rice Research Institute (PhilRice) located at Maligaya, Munoz, Nueva Ecija, Philippines. PSBRc8 rice variety, the potential ratooner with high ratoon rating and vigor was taken for growth and yield parameters under Lock Lodged Ratooning (LLR) method. The experiment was laid down in Randomized Complete Block Design and replicated three times.

Making Locklodging and Cultural Practices: The stubbles were braided in pair by bending the straw from each hill forwarded either to the left or right. They were pressed flat to the ground surface. The straw from each pair of adjustment formed an X, as viewed directly from above. The lock lodging process was pursued across the field, permanently locking the straw of each hill into a prone position (Calendacion *et al.*, 1991)

The main crop was harvested 30 days after heading and more specifically at the start of yellowing of culm (Saran and Parasad, 1952; Parago, 1963).

Basal fertilizer for the main crop 40-30-30 kg $NPK.ha^{-1}$ were applied at final harrowing, the remaining 40 $kgN.ha^{-1}$ was top dressed in two splits at tillering and at panicle initiation stage. In ratoon crop, 40 kg $N.ha^{-1}$ fertilizer was applied in two equal splits, one at harvest of main crop as basal N and the other at 20 days after harvest of main crop.

In the locklodged rice ratoon crop the irrigation application was maintained at the depth of one cm or soil saturation condition up to maximum tillering of the ratoon crop. After maximum tillering, flooded condition was maintained in all plots of the experiment.

Computing Correlation Coefficient (r): The correlation coefficient values were calculated by the procedure of Little and Hills (1978). It is customary to consider one of the variables dependent on the other. The choice of which variable to call dependent and which one to call independent is usually obvious. For example, in studying the relation of rice ratoon grain yield to growth and yield contributing parameters, it would be logical to consider yield as dependent on these parameters. Often there is a lapse between the measurement of one variable and the corresponding measurement of the other. In such cases, the first measured variable is called the independent one. It is some times useful to study the correlation between pairs of measurements on the same variable.

There are situations in which we really do not care which variable is designated as dependent variable. We may simply want to describe the joint distribution of two variables where each one is distributed normally. Such a distribution is called a bivariate normal distribution. To describe this distribution we need an estimate of p (rho), which is one of the population parameters. The coefficient (r), is the best estimate of p. Studying the correlation between the grain yield and plant parameters would be an example of the situation where it would make no difference which variable was called dependent. A simple observation that two variables seem to be related does not tell us much. We need answers to two important questions: how closely are the two variables related and is the relations real or could it have been accident due to chance?. To answer first question we need a definite measure of the closeness of the relation between two variables. The measure is called coefficient of correlation, designated by the symbol r. The answer to the second question may be obtained by referring to the appropriate probability tables.

The formula for the coefficient of correlation can be written in several forms. It is convenient to write these in terms of r^2 first, then find r by taking the square root of the final answer.

$$r^2=[\sum(X-\bar{X})(Y-\bar{Y})]^2 / \sum(X-\bar{X})^2\sum(Y-\bar{Y})^2 \quad (1)$$

Since $\bar{x}$ = X and $\bar{y}$ = Y-Y, we write (1) in abbreviated form:

$$r^2 = (\sum xy)^2 / \sum x^2\sum y^2 \quad (2)$$

While these forms are simple, they usually are not easy to calculate directly because they involve the squaring of cumbersome decimals. To avoid this, we take advantage of the relation.

$$\sum x^2 = \sum (X-\bar{X})^2 = \sum X^2 - \frac{(\sum X)^2}{n}$$

By substituting y for x where necessary, we can rewrite (2) in this form:

$$r^2 = [\sum XY -(\sum X\sum Y/n)]^2 / [\{\sum X^2-(\sum X^2/n)\} \{\sum Y^2 - (\sum Y^2/n)\}] \quad (3)$$

$$r = \sqrt{r^2} \quad (4)$$

Results and Discussion

The introduction of net assimilation rate and plant growth rate, the physiologists have applied them and have found them useful tools in quantitative analysis of plant growth (Blackman, 1919). These techniques, which together have become khown as growth analysis (Watson, 1952) are now also being used by botanists, crop scientists, and agronomists (Muramoto *et al.*, 1965).

Correlation Coefficient Values of Crop Parameters: The correlation coefficients of the locklodged rice ratoon crop were observed from 45 to 60 days after the harvest of the main crop.

Grain Yield: An increase in locklodged rice ratoon grain yield was positively correlated with plant height (r=0.87), leaf dry matter (r=0.67), total dry matter (r=0.91), leaf area index (r=0.85), relative growth rate (r=0.49), crop growth rate (r=0.83), biomass duration (r=0.84), 1000 grain weight (r=0.88), seed length (r=0.68), panicle length (r=0.69), number of panicles per plant (r=0.84), tillers number at harvest (r=0.89), and ratoon rating (r=0.88). Whereas, the grain yield showed non-significant relationship with net assimilation rate by recording r= 0.06 value.

Plant Height: The plant height denotes the tallness and dwarfness of the crop. The plant height of the crop was positively associated with leaf dry matter (r=0.88), total dry matter (r=0.75), leaf area index (r=0.83), relative growth rate (r=0.58), crop growth rate (r=0.77), biomass duration (r=0.66), 1000 grain weight (r=0.92), seed length (r=0.86), panicle length (r=0.76), number of panicles per plant (r=0.64), tillers number at harvest (r=0.77), and ratoon rating (r=0.71). The plant height showed non-significant and negative relationship with net assimilation rate (r= -0.02).

Leaf Dry Matter: Leaf dry matter of the crop was significantly and positively associated with total dry matter (r=0.76), leaf area index (r=0.98), relative growth rate (r=0.59), crop growth rate (r=0.82), biomass duration (r=0.66), 1000 grain weight (r=0.86), seed length (r=0.81), panicle length (r=0.87), number of panicles per plant (r=0.71), tillers number at harvest (r=0.81), and ratoon rating (r=0.79). The leaf dry matter showed non-significant and negative relationship with net assimilation rate (r= -0.19).

Total Dry Matter: It recorded positive and significant correlation coefficients with leaf area index (r=0.77), relative growth rate (r=0.29), crop growth rate (r=0.79), biomass duration (r=0.97), 1000 grain weight (r=0.74), seed length (r=0.47), panicle length (r=0.55), number of panicles per plant (r=0.89), tillers number at harvest (r=0.92), and ratoon rating (r=0.90). The total dry matter of the plant showed non-significant relationship with net assimilation rate (r= 0.11).

Leaf Area Index: Leaf area index is the ratio of assimilatory material per unit of plant material present. It exhibited positive correlation with relative growth rate (r=0.59), crop growth rate (r=0.84), biomass duration (r=0.66), 1000 grain weight (r=0.84), seed length (r=0.76), panicle length (r=0.87), number of panicles per plant (r=0.72), tillers number at harvest (r=0.80), and ratoon rating (r=0.78), however, it was non-significantly and negatively correlated with net assimilation rate (r= - 0.20).

Relative Growth Rate: The increase of plant material per unit time is called as relative growth rate of the crop. It was closely associated with crop growth rate (r=0.79), net assimilation rate (r=0.25), biomass duration (r=0.80), 1000 grain weight (r=0.75), seed length (r=0.75), and panicle length (r=0.79), however, relative growth rate recorded non-significant correlation with number of panicles per plant, tillers number at harvest and ratoon rating.

Crop Growth Rate: This is also the increase of plant material present per unit time. It recorded positive perfect correlation coefficient values with net assimilation rate (r=0.32), biomass duration (r=0.63), 1000 grain weight (r=0.91), seed length (r=0.73), panicle length (r=0.84), number of panicles per plant (r=0.59), tillers number at harvest (r=0.68), and ratoon rating (r=0.61).

Net Assimilation Rate:
It is the increase of plant material per unit of assimilatory material per unit of time. The net assimilation rate exhibited positive and significant relationship only with biomass duration, whereas it showed non-significant relation with all the other crop parameters.

Biomass Duration: It refers the dry matter accumulation per unit time. The biomass duration showed its positive relationship all the crop parameters by recording correlation coefficients of 1000 grain weight (r=0.61), seed length (r=0.32), panicle length (r=0.39), number of panicles per plant, tillers number at harvest, and ratoon rating all recorded the correlation coefficient of r=0.91 respectively..

1000 Grain Weight: 1000 grain weight was positively and significantly associated with seed length (r=0.88), panicle length (r=0.84), number of panicles per plant (r=0.58), tillers number at harvest (r=0.71), and ratoon rating (r=0.63).

Seed Length: It exhibited correlation with panicle length (r=0.86), number of panicles per plant (r=0.33), tillers number at harvest (r=0.49), and ratoon rating (r=0.42).

Panicle Length: The panicle length of the locklodged rice ratoon crop was highly significant with number of panicles per plant (r=0.44), tillers number at harvest (r=0.55), and ratoon rating (r=0.49).

Number of Panicles Per plant: The number of panicles per plant recorded their relationship with tillers number at harvest (r=0.96), and ratoon rating (r=0.93).

Ratoon Rating: Ratoon rating is the scale of productive and vigorous tillers of the ratoon crop. It showed it relationship with tiller number at harvest by recording r=0.96 correlation coefficient value.

Physiological Basis of Ratoon Crop: The ratoon tiller regeneration and growth depends on the buds that remained on the stubbles. The buds exist in various stages of development (Nair and Sahadevan, 1961). Auxiliary buds that develop at those nodes grow into ratoon tillers. In hybrid rice, most of the buds on the second, third and fourth nodes of the stubble are more viable compared to fifth node bud from the base (Sun Xiaohui *et al.*, 1988). The buds grew in different stages of development and no longer at the lowest nodes and were shorter at the upper nodes (Niar and Sahadevan, 1961). Chauhan *et al.* (1985) observed that IR-44's buds were similar in length irrespective of their position on the stubble. However, the length of buds was affected by nitrogen fertilizer application to the main crop as observed by Sun Xiaohui *et al.* (1988) in hybrid rice. Ratoon development began soon after the main crop ripened. In the case of delayed harvesting of the main crop, the culms of the growing tillers became damaged as they elongated under the old leaf sheaths (Szokolay, 1956). In a study on ratoon tiller development of IR-44, the length of the buds at the first, second and third nodes did not vary. Buds grew slowly 40 days after cutting of the main crop. After 5 days, the buds at the first node generally grew faster, followed by those from the second and third nodes. Maximum bud lengths were 74 to 235 mm. The average bud lengths were 17 to 144.45. Eight days after ratooning, the culms began to branch (Chauhan, 1988). Ratoon tillers are characterized by different C:N ratios according to their origin (Iso, 1954). In Kagi Ban2 cultivar, the C: N ratio was 17.0 in tillers from upper nodes, 13.88 in those from the base and 10.80 from those below the soil. Moreover, the tillers from the upper nodes with high C: N appeared like old seedlings, matured faster, and had shorter culm than those tillers emerging from the lower nodes, which behaved like young seedlings (Iso, 1954). Aubin (1979) observed in the D52-37 rice cultivar that the upper node tillers had fewer leaves than the lower node tillers. However, Volkova and Smetanin (1971) reported that different cultivars produced ratoon tillers differently.

The morphology of the ratoon plant differs significantly from that of the main crop plant. Usually, plant height (Balasubramanian *et al.*, 1970) is lower and effective tillers are fewer in the ratoon crop than in the main crop (Bahar and De Datta, 1977). However, ratoon crop produced more total tillers than the main crop (Quddus, 1981; Samson, 1980). Stem thickness is correlated with higher carbohydrate content in the stubbles. This could have induced more vigorous regeneration of ratoon tillers, resulting in the production of a larger number of tillers and higher grain yield (Palchamy and Purushothaman, 1988). Ratoon growth of rice depends upon the amount of Total Carbohydrate Content (TAC) in the stem base, at least early growth. The large amount of TAC is required to produce many tillers, and it would be achieved by high cutting of main crop stubbles, because the amount of TAC in the stubbles increases with cutting height (Ichii and Ogaya, 1985). Ratoon growth after the early stage was affected not only by the amount of reserves in the stem base but also by photosynthetic products in the foliage. However, the dependence of photosynthesis in the foliage is far less important in determining tiller number than it is in determining foliage weight, because tiller number became constant far more rapidly than foliage weight after main crop harvest. Ratoon plants should have sufficient tillers in the early stage after the main crop harvest to achieve high yields. Cultivars and cultural practice including cutting height, which provides a large quantity of reserves at harvest, may be advantageous for rice ratooning (Ichii, 1984). Tillers that regenerated from higher nodes formed more quickly grew faster and matured earlier (Prashar, 1970).

The prospect of successful ratoon cultivation depends largely on ratooning of a variety. Among the plant characteristics sought for high yield potential, plant type and nitrogen responsiveness have received extensive consideration (Poehlman, 1976). Lack of acceptance of rice ratooning by commercial farmers has been attributed to low yields, lack of good ratooning varieties, uneven maturity, disease and insect problem, lack of location-specific cultural practices, inferior grain quality and lack of assured return from investment (Chauhan *et al.*, 1985). Ratooning ability has been found to be a varietal character (Balasubramanian *et al.*, 1970; Bahar and De Datta, 1977; Haque, 1975; Nadal and Carangal, 1979). Further, Nadal and Carangal (1979) identified three rice selections without standing tillering capacities and high ratoon yields under varying soil moisture regimes. Haque (1975) found out that IR2061- U23, IR2145-20-4 and IR1924-36-22 possessed high ratooning ability. In India, C3810, Ratna, CR20-66, and CR156-5021-207 showed superiority in ratooning and yield ability (Das and Ahmed, 1982).

Tillering ability is probably the most important genetic factor affecting ratoon performance of grasses. Because there are high and low tillering rice, whereas, ratoon depends to a large extent on the inherit tillering capacity of a cultivar (Plucknett *et al.*, 1984). Different varieties produce ratoon tillers differently (Volkova and Simetanin, 1971). Kuban grew tillers from all nodes of the stubble, whereas Klasnodarskii 424 developed tillers mainly from the third node. Findings indicated that the ratoon crop yields well if main crop stubble is left with 2-3 nodes. Elalaoui and Simons (1988) indicated that the initial tillering variety may be beneficial because it can transport photo assimilates from the non-surviving tillers before they die under dense plant community. In ratoon crop the effective tillers are fewer compared to the main crop. However, the actual number of tillers may be higher in the ratoon crop than in the main crop (Balasubramanian *et al.*, 1970); Bahar and De Datta (1977). Except for seed variability, all other characters (plant height, panicle length, spikelet size, number of productive tillers, and grain setting) were less pronounced in the ratoon crop than in the main crop (Reddy and Pawar, 1959).

Table 1: Correlation Co-efficient Values of the Crop Characters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Grain yield	1.00														
2. Plant height	.87**	1.00													
3. LDM	.67**	.88**	1.00												
4. TDM	.91**	.75**	.76**	1.00											
5. LAI	.85**	.83**	.98**	.77**	1.00										
6. RGR	.49**	.58**	.59**	.29*	.59**	1.00									
7. CGR	.83**	.77**	.82**	.79**	.84**	.79**	1.00								
8. NAR	.06^{ns}	-.02^{ns}	-.19^{ns}	.11^{ns}	-.20^{ns}	.25*	.32*	1.00							
9. BMD	.84**	.66**	.66**	.97**	.66**	.80**	.63**	.30*	1.00						
10. 1000 grain weight	.88**	.92**	.86**	.74**	.84**	.75**	.91**	.22^{ns}	.61**	1.00					
11. Seed length	.68**	.86**	.81**	.47**	.76**	.75**	.73**	.06^{ns}	.32*	.88**	1.00				
12. Panicle length	.69**	.76**	.87**	.55**	.87**	.79**	.84**	.02^{ns}	.39**	.84**	.86**	1.00			
13. Numbe of panicles	.84**	.64**	.71**	.89**	.72**	.12^{ns}	.59**	-.17^{ns}	.91**	.58**	.33**	.44**	1.00		
14 Tillers at harvest	.89**	.77**	.81**	.92**	.80**	.25^{ns}	.68**	-.13^{ns}	.91**	.71**	.49**	.55**	.96**	1.00	
15. Ratoon rating	88**	.71**	.79**	.90**	.78**	.15^{ns}	.61**	-.18^{ns}	.91**	.63**	.42**	.49**	.93**	.96**	1.00

** = Significant at 1% probability level
* = Significant at 5% probability level
ns = Non-Significant

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