TILLER DYNAMICS IN INDICA AND TROPICAL JAPONICA RICE FROM TRANSPLANTING STRESSED SEEDLINGS UNDER IRRIGATED CONDITIONS

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Abstract

An experiment was conducted at JICA, Tsukuba, Japan from April to October 2009 to elucidate the effect of transplanting stress on the growth and development of two rice varieties; IR – 64 (Indica) and a Tropical Japonica (Demadola). Four different transplanting options and the two varieties were tested in a factorial experiment of randomized complete block design with 3 replicates. Tiller production was higher for Indica varieties. It was also evident that though total tiller production was high for the different stress levels for the Indica variety; tiller mortality was also high; resulting in slightly higher effective tiller numbers compared to the normal planting. Stem elongation or rhizomes with multiple nodes were observed in Indica seedlings that were severely damaged thus resulting in higher production of tillers. The increase in the production of high effective tiller number could increase the yield of rice for farmers who apply very little or no inputs at all in their rice production.

Key words: *tillers, tiller numbers, effective tillers, non-effective tillers, rhizomes*

Introduction

Rice *(Oryza sativa L)* has many advantages over most of the traditional staple food crops in the Pacific Region. Rice is easy to store, does not perish during transportation to distant locations, consumption of small volumes is enough to satisfy the human appetite compared to the traditional root crops and is considered a novel food (Malangen and Komolong, 2007). It has great potential for food security for these Island countries where the population is expanding with high urban migration and rapid genetic erosion on traditional staples.

In Papua New Guinea (PNG) rice is predominantly cultivated as a subsistence crop under upland conditions (Sajjad, 1995 and 1998). The commonly grown rice varieties are Indica and Javanica commonly referred to as Tropical Japonica FAO (2009) are directly dibbled into the field amongst other crops or planted as a mono-crop in small to medium plots. The yields are generally low due to poor germination, soil fertility, and competition from weeds.

Rice yields can be increased in many ways. The two main ways are by planting improved high yielding varieties and by adopting proper agronomic practices to achieve their potential yield. Generally the yield of hybrid rice varieties is 10% - 15% more than the improved inbred varieties (Alam, *et al* 2009). Proper planting is an important management practice which can increase the yield of rice. Some farmers in PNG have adapted to transplanting seedlings under upland rain fed conditions due to better competition against weeds and their high survival rate. Mitchell *et al* (2004) found that rice transplanted produce 6% more yield than rice direct seeded. The International Rice Research Institute (IRRI) also reported that transplanted rice generally produce more tillers than direct seeded crops IRR1 (2009).

Studies have shown that Indica rice varieties tend to still grow even if their seedlings are slightly damaged during transplanting compared to the Japonica and Tropical Japonica formerly known as Javanica varieties. While a study by Urayama *et al* (1989) found that Traditional Indica Varieties when exposed to stress at transplanting produce higher tillers numbers than the improved Indica varieties. The production of high tiller numbers could increase the yield of rice for farmers in PNG who apply no or very low inputs in rice production.

This study was planned to determine whether transplanting stressed seedling increases tiller production in Indica and Tropical Japonica rice varieties.

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Materials and Method

Design of Experiment

This experiment was conducted at the Tsukuba International Center (TIBC) Ibaraka in Japan in a glass house from April to October 2009. Two rice varieties, an Indica (IR- 64), and a Tropical Japonica (Demadola) rice variety denoted as V_1 and V_2, respectively were used in this experiment.

Thirty day old seedlings (4-5 leaf stage) were transplanted on the 15th of April into pots filled with mountain soil. The two varieties were planted under 4 different stress levels (treatments). The 4 stress levels are 1: Planted upright (Control), 2: Planted horizontal to the soil surface. 3: Planted with stem completely bent at 90 ^{0}C and 4: planted with stem completely snapped: denoted as (T_1), (T_2), (T_3) and (T_4), respectively. Each treatment has 6 pots transplanted with a single seedling. The experimental design is a two-factor experiment in Randomized Complete Block (RCB) with 3 replications.

For soil fertility, NPK (6-9-6) fertilizer was applied at a rate of 100kg ha^{-1} of Nitrogen split application (60 kg at basal and 40 kg top dressing). Phosphorous (P_20_5) (0-17.5-0) and Potassium (K_2O) (0 -0-60) fertilizer was applied at a rate of 100 kg and 110 kg ha^{-1} respectively

Data Collection and Statistical Analysis

Growth Observation.

Days from transplanting to ripening stage, plant height (cm), number of tillers, leaf area (cm^2) (measured with leaf meter, AAM-8 Hayashi Co. Ltd Japan), Chlorophyll content or SPAD value (measured with a Chlorophyll meter, Minolta Co., Ltd) and Dry matter content (after drying plants sample at 80 ^{0}C for 48 hours) were determined.

Yield Observations

In each replication 3 pots were used for yield analysis. Harvesting date varied according to treatments. Grains were selected using salt solution of 1.06, specific gravity and grain weight per pot was determined at 14% moisture content. Panicle number, average spikelet number per panicle, ripening ratio (%) and 1000 grain weight (g) were used to calculate the yield per pot.

Statistical Analysis

Analysis of variance (ANOVA) was performed using Excel for each treatment and means were separated using Least Significant Difference (LSD).

Results.

Though both growth and yield observations were made, only the growth observations results is presented and discussed specifically on tiller production in relation to stress.

The average heading dates of the 2 varieties were similar at days after transplanting (DAT) but within the treatments their heading dates varied accordingly. V_1T_2 and V_2T_2 have the same heading date at 99 (DAT) as V1T1 and V_2T_1. Followed by V_1T_3 and V_2T_3 at 101 (DAT) and V_1T_4 and V_2T_4 at 114 (DAT) respectively. T_4 took longer to heading because of the stress. The more severe the stress the longer the crop takes to heading. (Table 1)

V_1 is the shorter of the two varieties with an average height of 111.84 cm while V_2 is a tall variety with an average of 167.76 cm at harvest. V_2T_4 was shorter in height at all stages of growth (DAT) (Fig. 1) compared to the other treatments in V_2 due to the serve stress. Tropical Japonica Varieties are generally tall in height compared to Indica varieties. Therefore in this trail, V_1 is shorter in height as it is an improved Indica variety.

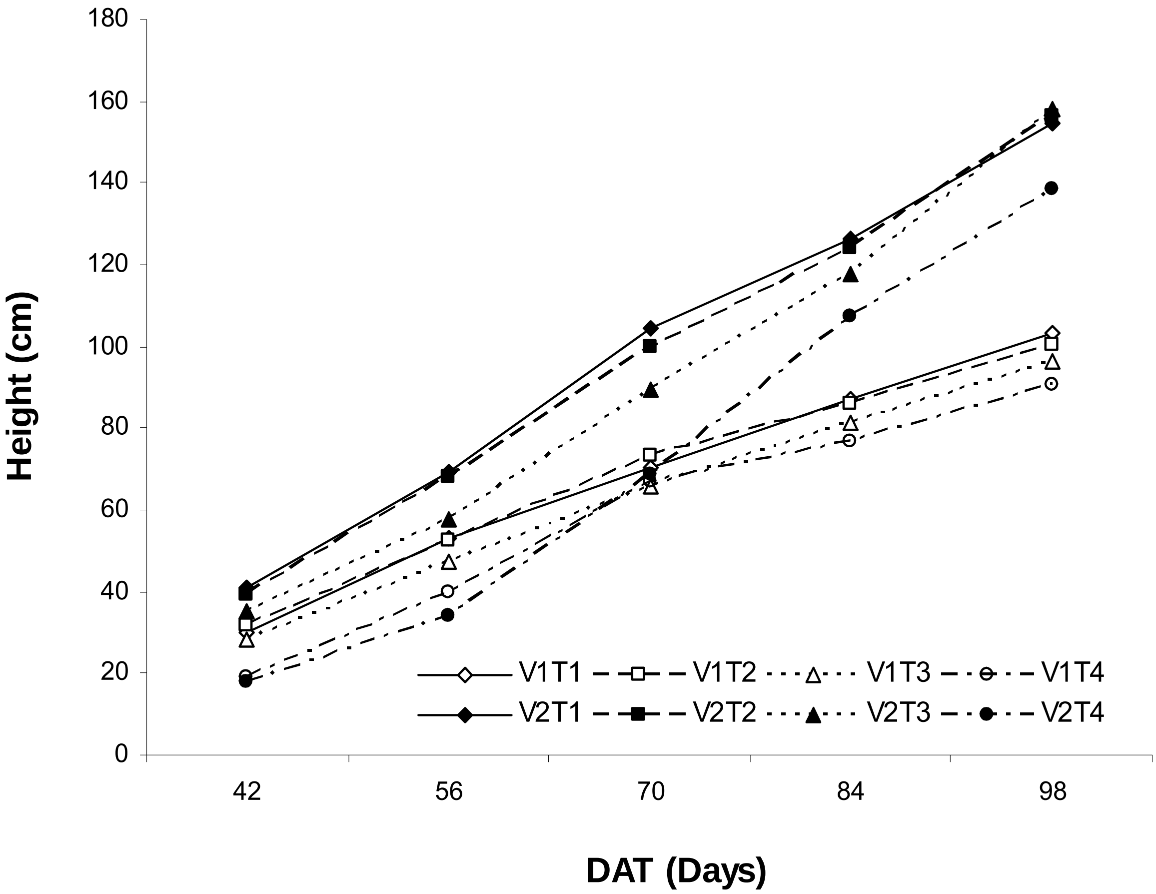
As for the chlorophyll content (SPAD values), there was a significant difference at 42 DAT (Fig. 2). V_2T_4 has a lower SPAD value than all the other treatments (Fig. 2). But at 84 (DAT), it has the highest value until harvest. V_2T_4 was

Table 1. The 80%-heading dates of the two varieties under the different stress levels

V_1				V_2			
T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
22/08	22/08	26/08	6/09	22/0	22/08	26/08	6/09

Date of transplanting was on the 15th of May.
V_1 = IR-64: V_2 = Demadola, T_1 = control, T_2 = planted horizontal to the soil surface,

Fig. 1: Plant height at days after transplanting (DAT)



V_1 = IR-64: V_2 = Demadola, T_1 = control, T_2 = planted horizontal to the soil surface,
T_3 = Planted with stem completely bent at 90 ^{0}C, T4 = planted with stem completely snapped

heavily stressed; therefore it took longer to recover as evident from delayed heading date and as a result its SPAD value was low before 70 DAT. At 84 DAT has recovered and was in its peak stage of growth while the other treatments have reached their peak of growth 70 DAT and their SPAD values were decreasing.

Tiller Number Hill $^{-1}$.

The two rice varieties showed significant difference in tiller production at 70, 84, 94 and at harvest (DAT) which ranged from 1 to 36 tillers number hill^{-1} (Table 2). Tiller number increased sharply with age reaching maximum at 84 DAT and then decreased irrespective of variety. The rate of increase, however, varied depending on variety, treatment and the stage of growth (Figure 2). The maximum tillering occurred during 56 to 84 days DAT. Variety V_1 produced the maximum number of tillers in all stages of DAT. The lowest number of tillers was observed for V_2. It also produced the lowest tiller number hill $^{-1}$ in all stages (DAT). It was revealed that tiller mortality of V_1 was high (Fig. 2), even though it produced higher number of tillers at harvest. Tillering capacity differs in different cultivars, even within sub species level, Japonica, Tropical Japonica. Therefore in this experiment a significant difference in the tiller capacity was observed.

Table 2. Effect of variety and stress on tillers number $hill^{-1}$ at different Days after transplant (DAT).

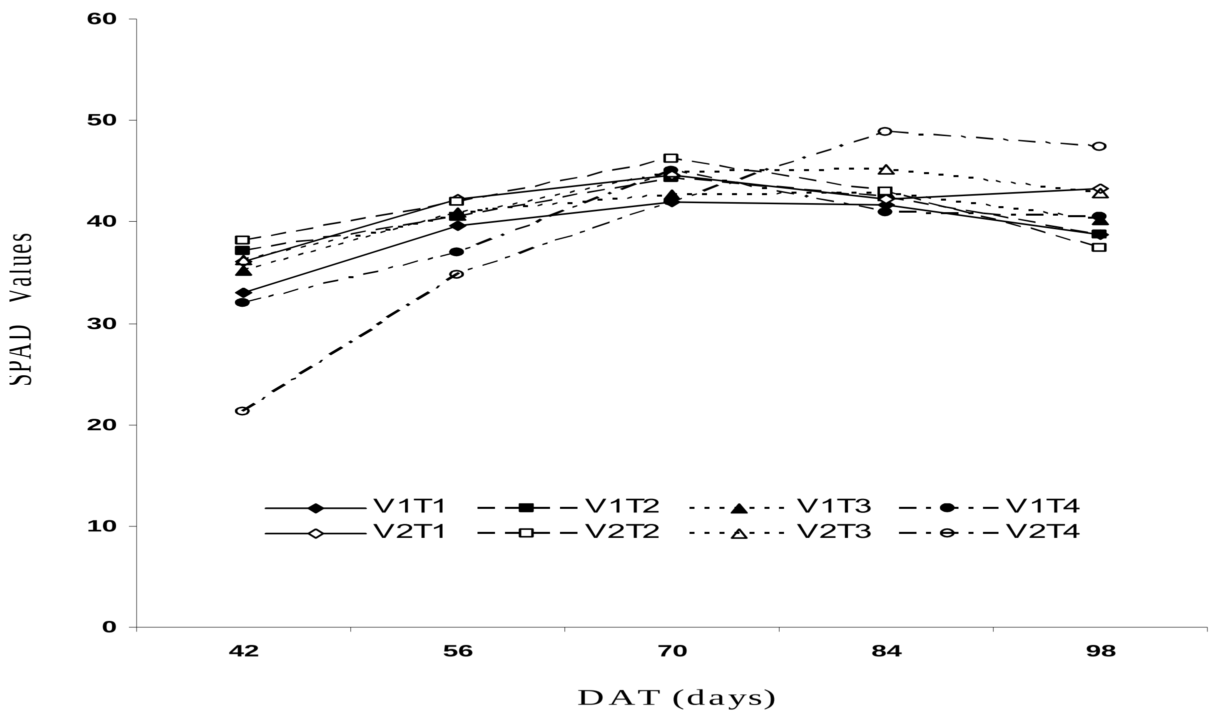
Tillers $hill^{-1}$ (no.) at different DAT							
Treatments		42	56	70	84	98	At Harvest
V1	T1	2	10	24	32	23	24
	T2	3	13	34	37	22	25
	T3	2	7	26	33	24	27
	T4	1	5	20	33	25	27
V2	T1	1	5	15	11	9	9
	T2	2	4	10	12	9	9
	T3	1	3	9	10	8	8
	T4	1	2	7	8	7	7
Variety		ns	ns	**	**	**	**
Stress		ns	ns	*	ns	ns	ns
Variety x Stress		ns	ns	ns	ns	ns	ns

*, ** significant different at p<0.05 and p<0.01 levels respectively.
V_1 = IR-64: V_2 = Demadola, T_1 = control, T_2 = planted horizontal to the soil surface
T_3 = Planted with stem completely bent at 90 ^{0}C, T4 = planted with stem completely snapped.

Interaction Effect of Variety and stress levels:

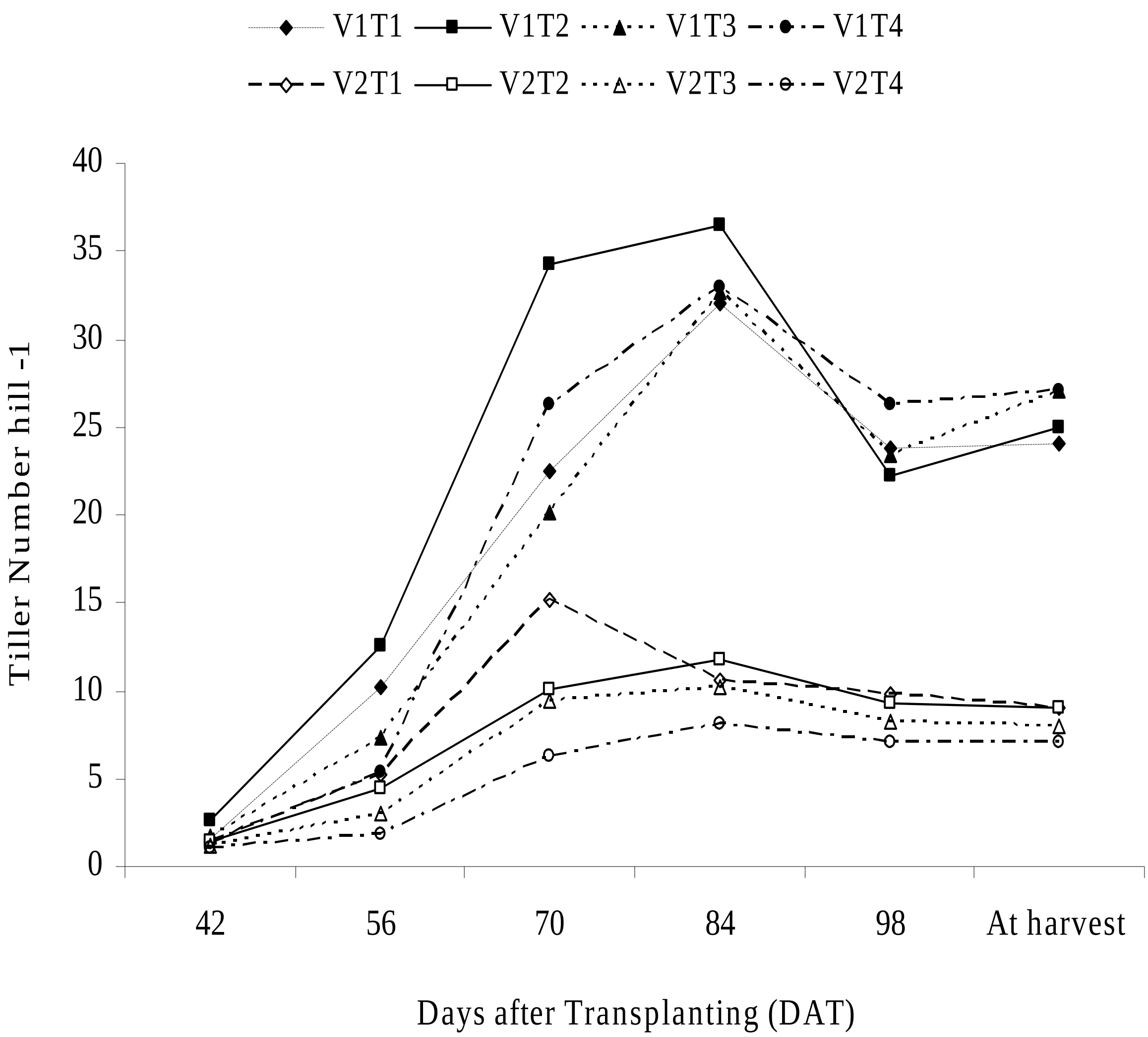
The interaction effect of variety and stress levels showed no significant influence on tiller production at all stages (DAT) though there was significant difference between the varieties. The maximum tiller production for the improved variety V_1, at 84 DAT was in the order, T_2, T_4 and T_3 (Fig, 3) compared to T_1. While for V_2, they were in the order T_2, T_3, and T_4 respectively. T_1 produced higher tiller number than T_4 for V_2. For V_1 there was increase in total tiller production for all the stress levels. V_1T_2 produced (116%), V_1T_3 (103%) and V_1T_4 (103%) more tillers than V_1T_1 respectively. As for V_2 tiller production decreased accordingly to the stress levels. But the total num-

Fig. 2: SPAD value after transplanting (DAT)



V_1 = IR-64: V_2 = Demadola, T_1 = control, T_2 = planted horizontal to the soil surface,
T_3 = Planted with stem completely bent at 90 ^{0}C, T4 = planted with stem completely snapped.

Fig. 3: Tiller numbers hill $^{-1}$ at the different growth stages



V_1 = IR-64: V_2 = Demadola, T_1 = control, T_2 = planted horizontal to the soil surface,
T_3 = Planted with stem completely bent at 90 ^{0}C, T4 = planted with stem completely snapped.

ber of tiller production tends to decrease with the severity of the stress (Fig. 3). Seedlings of Indica varieties slightly stressed at transplanting produces higher number of tillers according to this study.

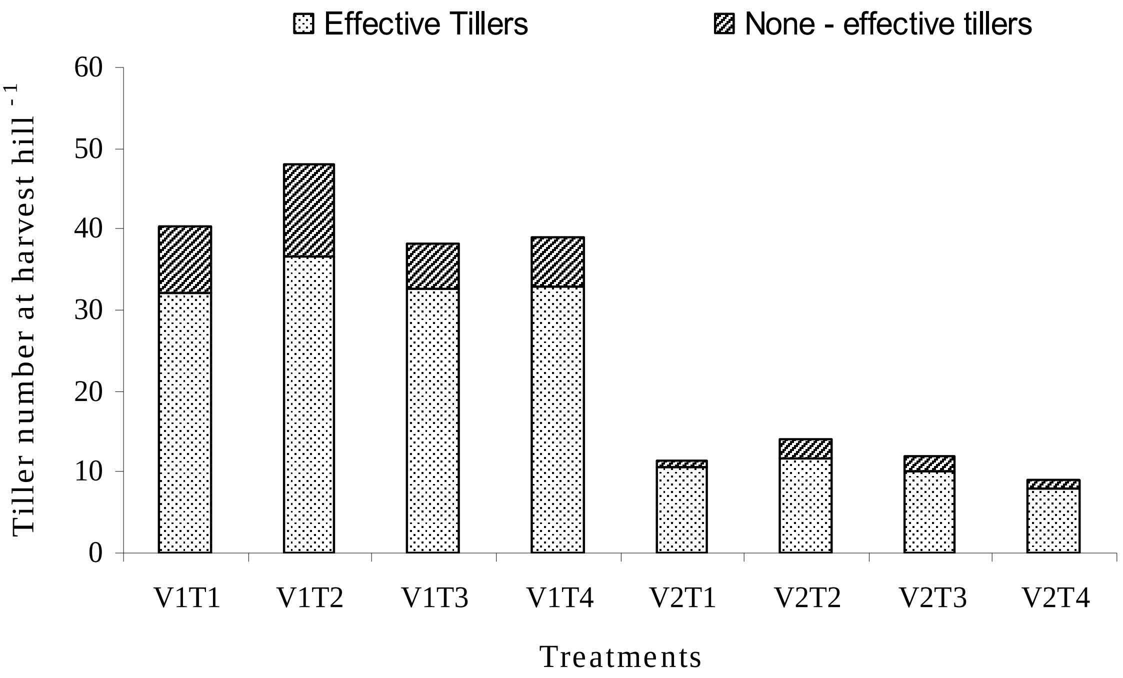
DISCUSSION

The results from this experiment is too preliminary to make any recommendations, because there are no significant difference within the stress levels and the interaction effect. This could be due to the experiment conducted in glass house and the sample size being very small. Seedlings exposed to stress produce higher tiller numbers than severely stressed and the normal method of transplanting. A similar study done by Urayama *et. al* (1989) also found that Indica varieties produce higher tiller when stressed compared to

The climatic condition could have an adverse effect on the tiller production in various conditions and weather patterns. But from this preliminary study conducted under irrigated condition, it is evident that Indica varieties produce high tiller numbers than the Tropical Japonica (IRRI 2009). Tillering capacity differs in different cultivars, even within sub species level, Japonica, Tropical Japonica. Therefore in this experiment a significant difference in the tiller capacity was observed.

It is also evident that stressed seedling produced higher tiller numbers though their mortality rates are high. The numbers of effective tiller numbers produced are high. Severely stressed seedlings produce tillers on multiple nodes due to stem elongation (rhizomes) resulting in slightly higher

Fig. 4: Effective and non-effective tillers at harvest affected by the stress levels.



V_1 = IR-64: V_2 = Demadola, T_1 = control, T_2 = planted horizontal to the soil surface,
T_3 = Planted with stem completely bent at 90 ^{0}C, T4 = planted with stem completely snapped.

effective tiller numbers. Stressed seedlings also took longer time to head, depending on variety and stress levels.

In PNG where inputs into rice yields are very low and with more farmers now transplanting rice seedlings under upland/lowland rain fed conditions, this finding could be further investigated by using the landrace varieties to compare their adaptability to stress and tiller production against the improved varieties in their specific locations. The production of high number of effective tiller would result in higher yield.

Appendix

1. Ryzhome (stem elongation)

2. Tillers from two internodes with heavy root production

Reference

ALAM. M.M, M. HASANUZZAMAN AND K. NAHAR (2009) Tiller Dynamics of Three Irrigated Rice Varieties under Varying Phosphorus Levels. American-Eurasian Journal of Agronomy 2 (2): 89-94,

IRRI (INTERNATIONAL RICE RESEARCH INSTITUTE) (2009) http://www.knowledgebank.irri.org/PlantEstablish/WebHelp/PlantEstablish.doc. 9/15/ 2009 1:55:42 PM

FAO (FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS) (2009)http://www.fao.org/ag/agp/agpc/doc/riceinfo/asia/ASIABODY.HTM.\ 10/15/2009 4:15:27 PM

MALANGEN. S AND NASS-KOMOLONG, B. (2007). Selection of rice (oryza sativa l) varieties for lowlands rain-fed conditions in Papua New Guinea**.** Papua New Guinea Journal for Agriculture, Fisheries and Forestry. Vol. 50. No. 1&2. pp.15-22

Cox. P (2009)
NEW AGRICULTURIST Perennial upland rice takes root.
http://www.new-ag.info/developments/devItem.php?a=798 .11/4/2009 :07:31 AM

SAJJAD, M.S. (1995). Development of modern Upland rice (*Oryza sativa* L) varieties with superior milling & physiochemical traits, for PNG. PNG Journal of Agriculture, Forestry & Fisheries. 38(1): 22-30

SAJJAD, M.S. (1998). Salient features of accomplishments of rice Breeding (Ecosystem-oriented & Agronomic research. A component of Food Management Branch of DAL for the period, 1991 to 1996.

URAYAMA. H, YOSHIRO. H, HIDEKAZU, T AND KIICHI. N. (1989). Effects of transplanting on node part for root and tiller development in Indica type Varieties. Japanese Journal of Tropical Agriculture special Issue Volume 33. issue no.2.