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SHORT COMMUNICATION

EFFECT OF MOISTURE STRESS AT LATE VEGETATIVE GROWTH STAGE ON APICAL DEVELOPMENT OF RICE AND VARIETAL DIFFERENCES

N. SENANAYAKE*[1] and M.T.M.D.R. PERERA[2]

[1] *Regional Agricultural Research Station, Bombuwela, Kalutara.*

[2] *Regional Agricultural Research Station, Angunakolapalessa.*

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Abstract: Physiological and morphological changes in apical development of rice under moisture stress during late vegetative growth state were studied. Moisture stress at this stage reduced the leaf primordia differentiation significantly in At 85-2. Necknode differentiation, panicle initiation, maximum spikelet number stage and flowering were delayed by 5 to 10 d under stress. Exponential spikelets differentiation were reduced in rate and also delayed by about 17 d. The sink size and the percentage spikelet abortion were also reduced under moisture stress. Leaf primordia differentiation of 6 varieties of two age groups also showed significant reduction in leaf primordia number irrespective of age group except two varieties At 354 (which is a saline tolerant variety) and Bg 380.

Key words: Apical development, moisture stress, rice.

INTRODUCTION

Apical development of lowland rice which can be broadly divided into vegetative, reproductive and maturity phases is complex in nature and patterns of development differ between rice varieties and are modified by the environment.[1] Moisture stress among crop production factors is a major constraint for growth and yield of rice. It is generally believed that plants subjected to water stress not only show a reduction in size but also exhibit characteristic modifications in structure, particularly of the leaves, leaf area, cell size and intercellular volume. Moisture stress throughout the crop growth in the variety IR 8 can reduce rice yields to 20-25%.[2,3] Further there is a negative relationship between relative grain yield and the duration of stress period.[4] It is generally believed that the peak water demand of rice is between maximum tillering and the grain filling stage. Morphological changes in plant stature of rice exposed to moisture stress were identified as stunting, reduced tillering and decreased yields.[5] However, adequate emphasis was not paid to study the effect of moisture stress on rice plant development. This paper reports the effect of moisture stress during late vegetative growth period on apical development of the rice variety At 85-2 and the varietal differences.

* Corresponding author.

Present address - Task Force in Rice, Task Force Headquaters, Department of Agriculture, No. 1, Sarasavi Mawatha, P.O. Box 5, Peradeniya.

METHODS AND MATERIALS

Greenhouse experiments (Temperature 35-36°C,R.H.68%) were conducted at the Regional Agricultural Research Station, Angunukolapalessa during Yala 1993. Rice variety At 85-2 which has a growth duration of 105 days was used.

Seeds were soaked for 24h, incubated for 48h and one gram equivalent of ungerminated seeds was sown in plastic pots containing lowland soil to simulate broadcast sown conditions. Each plastic pot (0.3 m^2) , was filled with moist equivalent of 10 kg oven dried soil (Low Humic Gley soils). Thirty pots were used in the experiment. Pots were irrigated to maintain saturated conditions up to 10 days after sowing (DAS) after which fifteen pots were subjected to moisture stress by curtailing the supply of water from 11 DAS to 31 DAS. Rest of the pots were well watered to maintain one inch standing water throughout the growth period. After the treatment, one inch of standing water was always maintained in all pots until maturity. Pots were fertilized with 100:25:20 kg N:P:K/ha; 30 kg N and all P and K were applied at sowing. The remaining 70 kg N was applied 42 days after sowing in both treatments.[6] Pots were arranged in RCB design with three replicates inside the greenhouse and oriented to have the minimum shading effect.

Plant samples were taken from each treatment by selecting random plants (1 plant from every pot at every sampling date). Sampling was done once a week during the vegetative stage and at maturity, but 2 or 3 times a week during the reproductive stage.

Statistical analysis was carried out using the cross over design analysis by considering each sample data as a replication by itself.

The apical development stage was identified under a low power dissecting microscope, using the technique of Kirby & Appleyard [7] and by reference to rice development stages.[8] The number of differentiated primordia were counted at each sampling under the dissecting microscope.

A parallel experiment was conducted up to the panicle initiation stage using 6 rice varieties; At 353, At 354 and Bg 350 of 3.5 month growth duration and Bg 380, Bg 400 and At 402 of 4 month growth duration. Experimental and sampling procedure was similar to the main experiment.

RESULTS

Table 1 shows that the leaf primordia number and panicle primordia number in plants where moisture stress was imposed during the late vegetative phase, reduced significantly and delayed leaf exertion compared to normal plants.

Further, moisture stress delayed necknode differentiation, maximum spikelet number stage (MSN) and even flowering though there is no difference in time to maturity. Maximum spikelet number stage was delayed by about 5d and the maximum spikelet number differentiated was reduced by 29.5% in stress treatment.

Table 1: Apical development , leaf and panicle primordia production under broadcasted normal and moisture stressed conditions in Greenhouse (max.Temp.35-36^{0}C) pot experiment, Yala 1993.

DAS*	No. of leaves		Primordia Number		Development Stage	
	Normal	Stressed	Normal	Stressed	Normal	Stressed
5	1.0	1.0	5.0	5.0		
11	3.0	3.0	7.0	6.5		
19	4.0	3.3	8.0	6.8		
29	5.6	4.0	10.0	8.7	NN	
39	7.0	5.6	11.9	8.8		
42	7.3	6.0	12.2	10.1		NN
45	7.0	6.0	12.5	10.0		
48	8.0	6.3	24.0	10.3		
51	8.0	6.5	48.8	14.6		
53	-	-	77.4	14.8		
56	8.6	6.6	111.4	16.2		
59	9.0	7.5	157.5	23.6		
61	9.0	7.9	138.2	73.0		
63	9.3	8.1	162.3	107.2	MSN	
65	9.0	8.1	140.7	106.0		
68	9.3	8.6	131.0	117.2		MSN
71	9.0	9.0	92.0	115.6	FLW	
75	10.0	9.0	102.0	108.0		
79	10.0	9.0	94.3	82.6		FLW
93	10.0	9.0	83.2	84.2		
96	10.0	9.0	76.2	82.4		
100	10.0	9.0	69.2	80.0	HVT	HVT

DAS - Days after planting
NN - Necknode differentiation
MSN - Maximum Spikelet Number
FLW - Flowering
HVT - Harvesting

Pre flowering spikelet abortion was greatly reduced (from 37.16% in normal plants to 29.82%) whereas post flowering spikelet abortion reached almost zero (32.25% in normal plants to 3.14 %) in stressed plants.

Table 2 shows the leaf primordia production up to panicle initiation stage of the six varieties. It shows that varieties At 353, Bg 350, Bg 400, At 402 differentiated significantly higher number of leaf primordia (Table 3) while At 354 and Bg 380 were not significantly different.

Table 2 : Effect of moisture stress on leaf primordia number and physiological panicle initiation of different rice varieties, Pot experiment (35-36°C), Yala (Dry season) 1993.

Character	Variety					
	At 353	At 354	Bg 350	Bg 380	Bg 400	At 402
1. No. of fully emerged leaves at onset of stress						
a. Normal	3	3	3	4	3	3
b. Stressed	3	3	3	4	3	3
2. No. of fully emerged leaves at PI[a]						
a. Normal	4	5	4	6	6	6
b. Stressed	4	5	4	5	6	6
3. Total No.of Leaf Primordia at onset of PI						
a. Normal	8.4	9	9.8	10.2	12.0	12
b. Stressed	7.6	9	8.8	10.0	11.4	10.2
4. No. of Days to PI						
a. Normal	31-38	31-38	31-38	38-45	38-45	38-45
b. Stressed	40-45	40-45	40-45	>48	>48	>48

[a] Physiological Panicle Initiation.

Table 3: Statistical analysis of data on the effect of moisture on leaf primordia number of different varieties in greenhouse pot experiments (35-36°C), Yala 1993.

Variety	Mean Primordia number		Variety mean	Difference
	Normal	Stressed		
At 353	8.4 d	7.6 d	8.0	0.8**
At 354	9.0 c	9.0 c	9.0	0.00 n.s
Bg 350	9.8 b	8.8 c	9.3	1.00**
Bg 380	10.2 b	10.0 b	10.1	0.20 n.s
Bg 400	12.0 a	11.4 a	11.7	0.60*
At 402	12.0 a	10.2 b	11.1	1.80**

** = Significant at 1 % level
* = Significant at 5 % level
n.s= Not significant

C.V. % = 3.9

In a column means followed by a common letter are significantly different at the 5% level by DMRT.

DISCUSSION

Moisture stress results in poor growth, tillering and reduced yields. Few attempts however have been made to study the consequent physiological and morphological changes of the shoot apex. Drought causes plant water deficits that reduce cell turgor causing closure of stomata and reduction in cell enlargement thereby reducing both the leaf surface area and the rate of photosynthesis per unit of leaf area.[9] Water stress thus causes a decrease in crop transpiration which is highly correlated with nutrient uptake.[10] In this experiment moisture stress was imposed from 10-31 DAS. The total leaf number was differentiated 29 DAS in unstressed plants whereas in stressed plants differentiation took 39 DAS. The leaf number was reduced by one.

One of the most sensitive physiological indicators of water stress is expansive growth,[11] a turgor dependant process that is responsive to even mild stress levels .[12,13] Drought damage as manifested by decreased expansive growth also contributed to the low nutrient uptake.[10] Plant metabolic processes are controlled by various growth regulators and under stress conditions production of these growth regulators are reduced.[14-16] Moisture stress also affects the carbohydrate metabolism.[17] Thus the slow growth rate and delayed development stages in stressed plants could be attributed to these factors among others.

Early drought stress had only a small effect on grain yield in improved varieties, in part because it delayed panicle initiation. Further because of insufficient plant development, growth duration is strongly affected and 6 days of early drought increased growth duration by 5d.[18] In this experiment development stages were delayed though growth duration remained unchanged probably because of greenhouse conditions.

After necknode differentiation panicle development occurs in two stages; panicle branch differentiation and spikelet differentiation which normally overlap.[8] Spikelet differentiation is recognized by the exponential increase in primordia number. The exponential growth period was most affected and it shifted from 48-59 DAS in unstressed plants to 59-68 DAS in stressed plants. This delay may be attributed to the low supply of growth regulators and/or source limitations.

Leaf photosynthetic contribution to grain yield was recorded as 51% and 6% from panicles itself.[19] Even though the number of leaves decreased under stress condition, the last four leaves remain photosynthetically active in both treatments. The number of spikelets differentiated was greater in unstressed plants (greater sink) than stressed plants. However increase in leaf area index may not produce an increased grain number because the gap between grain and spikelet number increases.[20,21] In this experiment pre flowering and post flowering spikelet abortion in moisture stress plants were drastically reduced. Thus, greater spikelet abortion under normal conditions with greater sink may be attributed to source limitation. It has also been reported that reducing the sink size by panicle tailoring increased spikelet survival and reduced spikelet sterility.[22]

All rice varieties showed significant reduction in leaf primordia number except varieties At 354 and Bg 380. Salinity tolerant At 354 has a built in mechanism to resist moisture stress. The recovery after imposition of moisture stress is also faster in this variety. Moisture stress at late vegetative stage delayed the physiological panicle initiation by about 5-10 days. A smaller difference in leaf number was observed in 3.5 month duration varieties than 4 month duration varieties even though 4 month varieties had longer time to recover from moisture stress. However the experiment was not conducted up to maturity because the reduction in yield under moisture stress is well known.

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