International Journal of Agricultural Technology 2015 Vol. 11(7):1687-1705
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Lodging Resistance and Agro-Morphological Characteristics of Elon-Elon and Palawan Red Sprayed with Paclobutrazol

Ariel, G. M.* and Canare Jr., J. G.

Department of Soil Science, College of Agriculture Central Luzon State University Science City of Muñoz, Nueva Ecija 3120 Philippines.

Ariel, G. M. and Canare Jr., J. G. (2015). Lodging resistance and agro-morphological characteristics of Elon-elon and Palawan red sprayed with paclobutrazol. International Journal of Agricultural Technology 11(7):1687-1705.

Abstract An experiment was conducted during the wet season of 2010 to determine the effects of paclobutrazol on the lodging resistance, agro-morphological characteristics and yield performance of Elon-elon and Palawan red. Paclobutrazol was effective in shortening the length of the lower internodes which resulted to shorter plants but with increased lodging resistance. There was a reduction of 12.42 % on culm length and 9.59 % on plant height of the two varieties sprayed at 1000 ppm compared to the untreated plants. Lodging resistance increased with increased concentration of paclobutrazol and lodging index was described by the equation $Y = -0.007x + 7.234$. At all concentrations of paclobutrazol, Palawan red had the longest first and fourth internodes, heavier 1000 grain weight and higher leaf area index but with more unfilled grains per panicle than Elon-elon. On the other hand, smaller stem diameter, more productive tillers per hill and longer panicle length were obtained from Elon-elon than Palawan red. Application of increasing concentrations of paclobutrazol did not affect the chlorophyll contents of the leaves at 15, 30 and 50 DAFS. The percentage filled grains/panicle, number of spikelets/panicle, weight of 1000 grains, dry matter yield, harvest index and grain yield were likewise unaffected owing to lodging at later stages of rice maturity.

Key words: Lodging resistance, Paclobutrazol, internodes, lodging index, stem elongation

Introduction

Traditional rice varieties are generally tall with good eating quality and high resistance to diseases. Inspite of their good traits, adoption remained low due to susceptibility to lodging that reduces the yield. Berry *et al*. (2004) reported that yield losses can be up to 80% and can cause severe knock-on effects, including reduced grain quality and greater drying cost. Early lodging in rice decreases yield as shown in the experiment conducted in IRRI (2005), the unlodged plants had 26% higher grain yield than those that lodged early (at 10 DAF).

* **Corresponding author**: Ariel, G., M.;**Email:** ariel_mactal@yahoo.com

Lodging in rice usually results from the bending or buckling of the two lowest internodes, which have elongated more than 4 cm. The strength of the elongated internodes is affected by the mechanical strength, chemical composition and plant nutritional status. Physically, lodging can be examined in terms of the bending moment and the breaking strength of the culm and sheath. The bending moment is the product of shoot weight and the height of the main axis (culm height). If other things are equal, a tall variety would have greater bending moment than a short variety because it would have greater culm height (Yoshida, 1981).

The use of growth promoters or retardants to manipulate the growth and development of plants may solve the problem on lodging and height characteristics of traditional varieties, however, only limited studies have been conducted.

There were reports showing that exogenous application of paclobutrazol increases yield and lodging resistance of rice and wheat. Fang and Zhao (2005) showed that soaking the seeds and spraying in jointing stage with 50 mg/kg and 200 mg/kg, respectively, paclobutrazol increased the yield and 1000 grain weight of wheat and rice.

In the light of these developments and the threats confronting rice production, a study on the effects of paclobutrazol on traditional rice varieties under Philippine condition was undertaken.

Objectives

The study was conducted with the following objectives:

1. determine the effects of different concentrations of paclobutrazol on stem elongation of two traditional varieties and ultimately on various agronomic characteristics;
2. evaluate the resistance to lodging of two traditional rice varieties applied with paclobutrazol;
3. determine the interaction effects of different concentrations of paclobutrazol and variety on lodging resistance and yield of two traditional rice;
4. determine the relationships between the different concentrations of paclobutrazol and yield of rice; and
5. establish the relationship between chlorophyll content and yield, stem elongation and lodging, and lodging index and yield.

Materials and methods

Experimental design and treatments

This study was conducted using factorial in Randomized Complete Block Design (RCBD). The experimental area with a size of 512 m^2 was divided into three blocks and each block was subdivided into eight plots to represent the number of treatment combinations. Each plot had a dimension of 5m x 4m. The blocks were spaced 1m from each other. The treatments were:

Factor A (Variety)	Factor B (Concentration of Paclobutrazol)
A1- Elon-elon	B1 – 0 ppm
A2 – Palawan Red	B2 - 250 ppm
	B3 - 500 ppm
	B4 – 1000 ppm

Seedling establishment

Pre-germinated seeds of the two varieties were sown in a well-prepared seedbed, following the recommended rate of 40 kg seeds per 400 m^2.

Transplanting

Twenty-one-day-old seedlings of the two rice varieties were transplanted into the experimental area immediately after pulling. The seedlings were transplanted at a distance of 25 cm x 25 cm, maintaining two to three seedlings per hill.

Fertilization

The recommended amount of fertilizer was determined through soil chemical analysis. The standard recommendation of fertilizer based on soil test value does not mention traditional varieties and since nitrogen fertilizer is seldom used by farmers in growing traditional varieties due to its sensitivity to lodging, the lowest level of nitrogen was used. The fertilizer rate of 30-60-30 (kg $N\text{-}P_2O_5\text{-}K_2O$) was supplied using urea (46-0-0), ordinary super phosphate (0-18-0) and muriate of potash (0-0-60). The fertilizer materials were applied in two splits; five days after transplanting (DAT) and 30 DAT. The different amounts of fertilizer materials following the above rate were weighed and applied to all plots.

Application of paclobutrazol

Paclobutrazol, with a chemical name (2RS, 3RS)-1-(4-Chlorophenyl)-4, 4-dimethyl-2-(1H-1, 2, 4-triazol-1-yl) pentan-3-ol), at a concentration of 10% (10 WP) was used in this study. It was applied at the stage of growth before the internode elongation. In photosensitive and late maturing varieties, this usually occurs before the panicle primordia initiation (Yoshida, 1981). In this study, paclobutrazol was sprayed at tillering stage or 19 DAT using a knapsack sprayer. To ensure that the applied paclobutrazol adheres to the leaves of the plants, a liquid detergent was used to serve as sticker. However, due to a strong rain that occurred immediately in the afternoon after spraying, application of paclobutrazol was repeated 20 days later using the same rate.

Care and maintenance

The recommended technology for rice production prepared by Philippine Rice Research Institute (PhilRice, 2007) was followed in the proper care and maintenance of the plants. Spraying of molluscide at transplanting, pre-emergent herbicide at 3 DAT, and spraying of insecticides and fungicides were done at 15, 30, 45 and 60 DAT. Water was maintained at a recommended depth of 2 to 3cm at vegetative stage, increasing it to five cm at reproductive stage. Water was withdrawn for about seven days at tillering stage to encourage tiller development. One week prior to harvesting, water was totally withdrawn from the field.

Data gathered

The gathering of data was done following the Standard Evaluation System for Rice (IRTP, 1988), Field Operations Manual (PhilRice, 2007) and the Techniques for Field Experiments with Rice (Gomez, 1972).

1. **Stem diameter (mm).** The stem diameter was taken about 5.0 to 7.5 cm above the base of the plant at flowering stage using Vernier caliper.
2. **Culm length at harvest (cm).** The length of culm was taken from the base of the plant to the panicle necknode. Twelve representative sample hills located at the four corner hills outside the harvest area were measured.

3. **Plant height at harvest (cm).** The height of plants during harvest was taken starting from the base of the plant to the tip of the longest panicle.
4. **Length of internodes (cm).** To effectively measure the lengths of the four lowest internodes, dissecting the plants was done to reveal the nodes.
5. **Lodging incidence.** This was determined by counting the number of tillers that lodged and those that broke at harvest. The scale for lodging incidence (IRTP 1988) is as follows:

Lodging Index	Description
0	no lodging
1	less than 20%
3	20-40%
5	41-60%
7	61-80%
9	more than 80%

6. **Leaf area index.** The leaf area index of the rice plant was measured at flowering stage using leaf area meter.
7. **Panicle length (cm).** At harvest, the length of panicles using twelve representative sample hills were measured from the panicle neck node to the tip of the panicle.
8. **Number of filled and unfilled grains per panicle.** Filled and unfilled grains were separated using a mechanical separator. The number of filled and unfilled grains per panicle from the representative sample plants was counted using a mechanical counter.
9. **Number of spikelets per panicle.** The number of spikelets per panicle from the representative sample plants was determined by taking the sum of the filled and unfilled grains per panicle.
10. **Percent filled grains per panicle (%).** The percentage of filled grains per panicle was taken at harvest.
11. **Weight of 1000 grains (g).** Randomly selected 1000 filled grains were weighed using an analytical balance. The weight of grains was adjusted to 14% moisture content.
12. **Grain yield (t/ha).** The yield was determined using a harvest area of 2m x 3m located at the center of the plots. The grains were sundried, weighed, and the moisture content was determined using a moisture meter and the yield was adjusted to 14% moisture content.

13. **Dry matter yield (t/ha).** Plant samples were cut into small pieces using scissors. The representative sample plants were oven dried at a temperature of 70°C until constant weight was obtained and then weighed to get the dry matter yield.
14. **Harvest index.** Harvest index was derived by getting the ratio of the grain weight to the total dry matter yield.

Results and discussion

Plant height and culm characteristics at maturity

Stem diameter, culm length and plant height at maturity are some agronomic characters that affect the lodging susceptibility of rice plant. Short plants with large stems are generally sturdy and are difficult to lodge despite strong winds. According to Yoshida (1981), if all other things are equal, a tall variety has a greater bending moment than a short variety because it has greater culm height.

Table 1. Plant Height and Culm Characteristics of Elon-elon and Palawan Red sprayed with Paclobutrazol

	CULM LENGTH (cm)	PLANT HEIGHT (cm)	STEM DIAMETER (mm)
Elon-elon	127.97	6.41[a]	103.68
Palawan Red	131.26	6.07[b]	107.65
Paclobutrazol Concentration			
(ppm a.i..)			
0	110.27[b]	133.75[b]	6.24
250	110.70[b]	134.89[b]	6.39
500	105.14[ab]	128.91[ab]	6.22
1000	96.57[a]	120.92[a]	6.12

*means in a column followed by the same letter superscript (s) are not significantly different at 5% level using DMRT

Elon – elon and Palawan red sprayed with 1000 ppm of paclobutrazol were shorter than those applied with low concentrations of paclobutrazol. There was a reduction of 12.42 % on culm length and 9.59 % on plant height of the two varieties sprayed with 1000 ppm compared to the untreated plants. These findings were also consistent with the findings of Im *et al.* (1987), which showed that culm length was shortened by 10-15% due to paclobutrazol application. Ueno and Kohli (1994) mentioned that paclobutrazol is a plant growth retardant and triazole fungicide that is a known opponent of the plant hormone gibberellin. It acts by inhibiting gibberellin biosynthesis by inhibiting oxidation of kaurene. This in turn reduces the rate of cell division, the morphological consequence of being a reduction in stem elongation thereby reducing internodal growth to give stouter stems, increasing root growth, causing early fruit set and increasing seed set in plants such as tomato and pepper.

Elon-elon has bigger stem diameter than Palawan red which is due to the difference in their inherent genetic make-up. However, stem diameter at maturity of Palawan red and Elon-elon were not affected by the different concentrations of paclobutrazol, and their interaction. Culm length and plant height at harvest of Elon-elon and Palawan Red were similar with each other regardless of the concentration of the applied paclobutrazol.

Significant correlation exists between the length of culm and lodging index with a correlation coefficient of 0.4616. This implies that as the length of culm decreases, lodging index likewise decreases.

Length of lower internodes at maturity

Determination of the length of lower internodes is crucial in relation to lodging index. Lodging in rice usually results from the bending or buckling of the two lowest internodes, which had elongated more than 4 cm. The strength of the elongated internodes is affected by the mechanical strength, chemical composition and plant nutritional status. If all other things are equal, a tall variety would have a greater bending moment than a short variety because it has greater culm height (Yoshida, 1981).

Paclobutrazol concentration at higher levels reduces the lengths of the second and third internodes only, while variations between varieties were observed in all the four internodes considered (Tables 3, 4 and 5). Furthermore, paclobutrazol concentration and variety had interaction effects on the length of the third internode.

Significant correlations were obtained between the length of the first internode and lodging index (r=0.4967), second internode and lodging index (r=0.5719), third internode and lodging index (r=0.4273) and fourth internode and lodging index (r=0.4122). These imply that as the length of lower internodes increases, lodging index also increases.

Table 2. Length of first, second and fourth internodes at maturity (cm) as affected by paclobutrazol concentration

Paclobutrazol Concentration (Ppm A.I)	Length Of Internodes (Cm)		
	FIRST	SECOND	FOURTH
0	5.21	10.64[b]	21.28
250	5.44	9.34[b]	22.06
500	4.72	7.65[ab]	19.94
1000	4.09	5.91[a]	17.79

*Means in a column followed by the same letter superscript (s) are not significantly different at 5% level by DMRT

Elon-elon and Palawan red sprayed with 500 ppm Paclobutrazol have shorter second and third internodes. The reduction in length became more evident at 1000 ppm level (Table 2). The length of the second internode was reduced by 44.45%, while the third internode by 28.09 % due to the application of 1000 ppm paclobutrazol compared to untreated plants.

Table 3. Length of first, second and fourth internodes at maturity (cm) of Elon-elon and Palawan red sprayed with paclobutrazol

Variety	Length Of Internodes (Cm)		
	First	Second	Fourth
Elon-elon	3.87[a]	6.89[a]	17.62[a]
Palawan Red	5.86[b]	9.88[b]	22.91[b]

*Means in a column followed by the same letter superscript (s) are not significantly different at 5% level by DMRT

The effect of paclobutrazol was further highlighted by the interaction effect on the third internode (Table 4). The length of the third internode of Elon-elon was reduced by paclobutrazol but only at 1000 ppm. However, paclobutrazol did not affect the length of the third internode of Palawan Red.

These results conform to the findings of Im *et al*. (1987) that culm length was shortened by 10-15% by paclobutrazol application.

Table 4. Length of third internode (cm) of Elon-elon and Palawan red sprayed with paclobutrazol

Variety	Paclobutrazol Concentration (Ppm A.I.)				
	0	250	500	1000	MEAN
Elon-elon	13.61^{b}	13.84^{b}	13.04^{b}	6.82^{a}	11.83^{A}
Palawan Red	18.86^{b}	18.26^{b}	12.93^{b}	16.53^{b}	16.64^{B}
Mean	16.23^{X}	16.05^{X}	12.98^{Y}	11.67^{Y}	

*Means in a column followed by the same letter superscript (s) are not significantly different at 5% level by DMRT

Lodging index

Lodging index of elon-elon and Palawan red as affected by increasing concentrations of paclobutrazol is shown in Table 5. Lodging indices of Elon-elon and Palawan red did not vary at all concentrations of paclobutrazol tested.

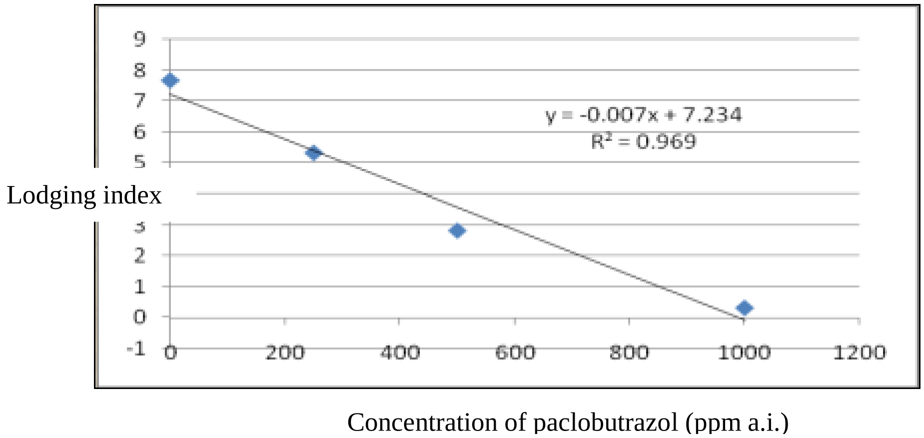
Increasing the concentration of paclobutrazol from 0 to 1000 ppm decreased the lodging index of the two varieties. The general trend is similar to that of the lengths of the second and third internodes, culm length and plant height. This result confirms the findings of Street et al., (1986) that application of 0.28 kg a.i./ha of paclobutrazol two weeks after panicle initiation reduced rice height each year and increased rough rice yield in two of three years. Lodging, which occurred in only one of three years, was significantly decreased with 0.28 kg a.i./ha of paclobutrazol applied either at panicle initiation or two weeks after panicle initiation.

Table 5. Lodging index of Elon–elon and Palawan red as affected by paclobutrazol concentration

Paclobutrazol Concentration (Ppm A.I.)	Lodging Index
0	7.67c
250	5.33b
500	2.83ab
1000	0.33a

*Means in a column followed by the same letter superscript(s) are not significantly different at 5% level by DMRT.

The relationship between paclobutrazol concentration and lodging index are linear. Lodging index is described by the equation $Y = -0.007x + 7.234$ which means that for every unit increase in the concentration of paclobutrazol (ppm), lodging index decreased by 0.007 unit.



Fig, 1. Relationship of paclobutrazol concentration and lodging index

Leaf area index

Tables 6 and 7 present the leaf area index (LAI) which indicates the proportion of leaf surface area to the ground area which the plant occupies. A LAI of five to six is necessary to achieve maximum crop photosynthesis during the reproductive stage. During ripening, the LAI will decrease as grain filling proceeds and leaf senescence occurs (Yoshida, 1981).

Table 6. Leaf area index as affected by paclobutrazol concentration

Paclobutrazol Concentration (Ppm A.I.)	Leaf Area Index
0	2.89
250	3.13
500	3.53
1000	2.94

Results disclosed that LAI was not affected by the concentrations of paclobutrazol, while it varies among the two varieties used. As dictated by their genetic make-up, Palawan Red had higher LAI than Elon-elon. The inherent character of Palawan Red of having long and broader leaves caused the significant difference on their leaf area.

Table 7. Leaf area index of Elon-elon and Palawan red sprayed with paclobutrazol

Variety	Leaf Area Index
Elon-elon	2.59[a]
Palawan Red	3.65[b]

*Means in a column followed by the same letter superscript (s) are not significantly different at 5% level by DMRT

Number of productive and unproductive tillers per hill

The number of productive tillers per hill differed among varieties, while the number of unproductive tillers of Elon-elon and Palawan red were comparable. Elon-elon produced more productive tillers than Palawan Red, with an average of 15 and 11, respectively (Table 9).

Table 8. Number of productive and unproductive tillers per hill as affected by paclobutrazol concentration

Paclobutrazol Concentration	Number Of Tillers Per Hill	
(ppm a.i.)	PRODUCTIVE	UNPRODUCTIVE
0	14	1
250	13	2
500	13	2
1000	13	2

*Means in a column followed by the same letter superscript(s) are not significantly different at 5% level by DMRT

Spraying with paclobutrazol did not affect tiller production. In addition, the interaction effects of variety and concentration of paclobutrazol were not significant.As previously hypothesized, early application of paclobutrazol to transplanted rice will result to an increase in the number of productive tiller. The above results did not attain any positive response.

Table 9. Number of productive and unproductive tillers per hill of two traditional varieties

Variety	Number Of Tillers Per Hill	
	Productive	Unproductive
Elon-elon	15[a]	2.0
Palawan Red	11[b]	2.0

*Means in a column followed by the same letter superscript (s) are not significantly different at 5% level by DMRT

Unlike in the study of Wang *et al.* (1988), muti-effect triazole (MET), applied at 300 ppm to the seedlings of late rice at 1-2 leaf stage showed high effectivity in controlling plant height and promoting tillering of rice seedlings. The seedlings sprayed with MET would not fade after transplanting. The plant height was reduced as much as 30%; and the tillers of seedlings increased as much as 50%. Wang (1991) mentioned that soaking or spraying the seeds with 100 to 300 ppm MET was highly effective in retarding plant height and promoting tillering of rice seedling. The above finding suggests that tillering capability of rice is enhanced by paclobutrazol when sprayed at seedling stage. It is worthwhile mentioning that in this experiment, spraying of paclobutrazol was affected by strong rain; paclobutrazol was sprayed in the morning and at four o'clock in the afternoon, there was a strong rain. It is possible that the full effect of the sprayed paclobutrazol was not obtained and resulted to nonconformity with previous studies. Spraying of paclobutrazol at tillering stage needs further study.

Panicle length, number of unfilled grains per panicle and number of spikelets per panicle

The number of spikelets per panicle indicates the yield capacity of rice. When conditions are favorable, those plants with more spikelets have higher yield capacities. Results disclosed that paclobutrazol concentration did not significantly affect the above parameters. Elon-elon and Palawan Red had comparable panicle lengths and number of spikelets per panicle (Table 11). This can be attributed to the difference in their genetic make-up.

Table 10. Panicle length (cm), number of unfilled grains per panicle and number of spikelets per panicle as affected by paclobutrazol concentration

Paclobutrazol Concentration (Ppm)	Panicle Length (Cm)	Number of Unfilled Grains/Panicle	Number of Spikelets/ Panicle
0	23.48	32.6	94.43
250	24.19	27.08	109.59
500	23.77	30.08	113.19
1000	24.35	25.83	98.65

Elon-elon produced an average of 24.71 unfilled grains per panicle (Table 12). This value was lower than the number of unfilled grains produced by Palawan Red with a value of 33 grains per panicle. This result can be explained by the effect of strong rains during the peak of flowering of Palawan Red, which occurred earlier than Elon-elon.

Table 11. Panicle length (cm), number of unfilled grains per panicle and number of spikelets per panicle of two traditional varieties

Variety	Panicle Length (Cm)	Number Of Unfilled Grains/Panicle	Number Of Spikelets/ Panicle
Elon-elon	24.28	24.71[b]	99.16
Palawan Red	23.61	33.09[a]	108.78

*Means in a column followed by the same letter superscript(s) are not significantly different at 5% level by DMRT

Number of filled grains per panicle

The number of filled grains per panicle was influenced by the concentration of paclobutrazol and its interaction with variety. Elon-elon responded to paclobutrazol concentration but Palawan Red did not, even at higher concentrations. Without paclobutrazol application, Palawan Red had more filled grains than Elon-elon, implying genetic variation. At 500 ppm level, Elon-elon out-numbered Palawan Red by 23 grains per panicle. This shows that 500 ppm is the best level for Elon-elon as far as number of filled grains per panicle is concerned.

Table 12. Number of filled grains per panicle as affected by paclobutrazol concentration

Variety	Paclobutrazol Concentration (Ppm A.I.)				
	0	250	500	1000	Mean
Elon-elon	51.55^{d}	87.20^{ab}	94.74^{a}	64.31^{c}	74.45
Palawan Red	72.12^{bc}	77.82^{abc}	71.49^{bc}	81.34^{abc}	75.69
Mean	61.83^{Y}	82.51^{X}	83.12^{X}	72.83^{XY}	

*Means in a column followed by the same letter superscript(s) are not significantly different at 5% level by DMRT

The relationship of paclobutrazol concentration and number of filled grains per panicle is presented in Fig. 2. Elon–elon had quadratic relationship which is described by the equation $Y = -0.000x^2 + 0.165x + 52.60$, while Palawan Red is linear and is described by the equation Y = 0.007x + 72.43.

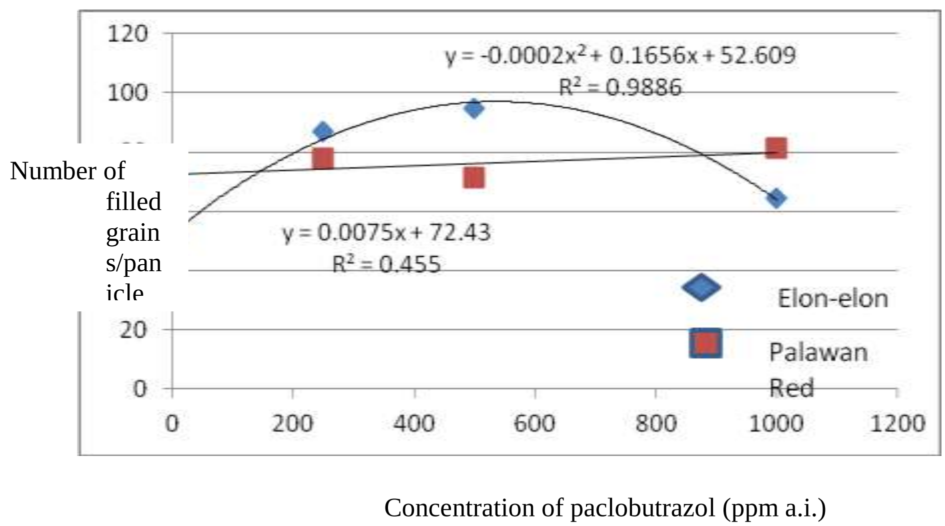


Fig. 2. Relationship of paclobutrazol concentration and number of filled grains per panicle

Percentage of filled grains per panicle

The percentage of filled grains per panicle significantly differed among varieties, concentrations of paclobutrazol and their interaction (Table 14). Application of paclobutrazol increased percent filled grains per panicle in Elon-elon. This is highlighted at 500 ppm level, wherein Elon-elon produced 21.52% higher percent filled grains than Palawan red. It is revealed further that as the level of paclobutrazol is increased, percent filled grains per panicle also increased up to 500 ppm only and then declined at 1000 ppm level using the same variety. Meanwhile, Palawan Red did not show a positive response on the application of paclobutrazol.

Table 13. Percent filled grains (%) per panicle as affected by paclobutrazol concentration

Variety	Paclobutrazol Concentration (Ppm A.I.)				
	0	250	500	1000	MEAN
Elon-elon	63.58[b]	79.38[a]	80.34[a]	72.81[ab]	74.03[A]
Palawan Red	67.16[b]	71.43[ab]	66.11[b]	74.82[ab]	69.88[B]
Mean	65.37[Y]	75.40[X]	73.23[X]	73.81[X]	

*Means in a column followed by the same letter superscript(s) are not significantly different at 5% level by DMRT

The relationship of paclobutrazol concentration and percent filled grains per panicle is quadratic for Elon-elon, described by the equation $Y = 0.0000005x^2 + 0.062x + 64.53$, while Palawan red is linear and is described by the regression equation $Y = 0.006x + 67.12$ (Fig. 3).

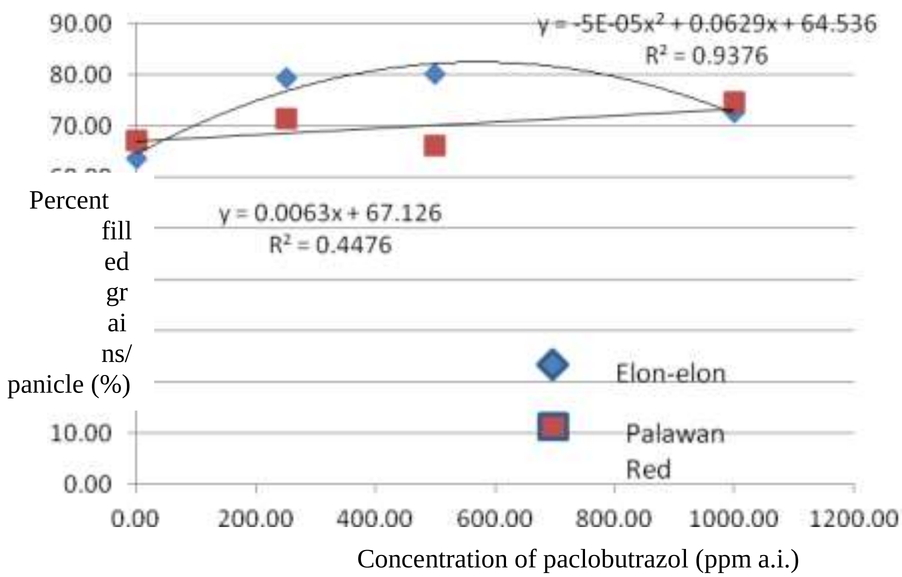


Figure 3. Relationship of paclobutrazol concentration and percent filled grains per panicle

Weight of 1000 grains, grain yield, dry matter, yield and harvest index

The weight of 1000 grains (g), grain yield (t/ha), dry matter yield (t/ha) and harvest index of the two traditional varieties as affected by paclobutrazol concentration are presented in Table 14. Harvest index is the proportion of dry weight of grains to the total dry matter yield. For high yielding varieties, the usual harvest index obtained is about 0.5. This is indicated by the grain to straw ratio of 0.95 to 1.15 in N-responsive varieties (Chandler 1969, as cited by Canare, 1998). The harvest index obtained by the two varieties is 0.34 for Elon-elon and 0.35 for Palawan Red. This indicates that the yield level is low in relation to the amount of straw that was produced. These values, however, are acceptable considering so many factors that adversely affected the growth of the plants as well as the inherent characteristics of traditional varieties of being low yielding.

Results further revealed that the weight of 1000 grains (g), grain yield (t/ha), dry matter yield (t/ha) and harvest index were not significantly affected by paclobutrazol concentration. However, as regards the weight of 1000 grains of the two traditional varieties Palawan Red had heavier 1000-grain weight than Elon-elon with a value of 27.95g and 19.85g, respectively (Table 18). Moreover, the grains of Palawan Red are generally longer and bigger, while Elon-elon are smaller and rounder in appearance, hence, the difference.

It is interesting to note that the incidence of lodging occurred at a later stage of plant growth, that is, when the grains have been already filled with photosynthates. Lodging at this stage may be considered as less critical to yield and though lodging percentage is high on the untreated plants and those that received low levels of paclobutrazol, it has very minimal effect on the yield.

Table 14. Weight of 1000 grains (g), grain yield (t/ha), dry matter yield (t/ha) and harvest index as affected by paclobutrazol concentration

Paclobutrazol Concentration (Ppm)	Weight Of 1000 GRAINS (G)	Grain Yield (T/Ha)	Dry Matter YIELD (T/Ha)	Harvest INDE
0	23.21	3.43	9.62	0.33

250	24.05	3.75	10.2	0.34
500	24.22	3.95	10.39	0.35
1000	24.12	3.61	9.12	0.36

The above result is related to the findings at IRRI (2005), that the unlodged plants had 26% higher grain yield than those that lodged early (at 10 DAF). The severity of yield loss increased from plants that experienced lodging at late flowering stage (30 DAF) compared with those that lodged during early flowering (10 DAF).

Table 15. Weight of 1000 grains (g), grain yield (t/ha), dry matter yield (t/ha) and harvest index of two traditional varieties

Variety	Weight Of 1000 Grains (G)	Grain Yield (T/Ha)	Dry Matter Yield (T/Ha)	Harvest Index
Elon-elon	19.85[b]	3.68	10.08	0.34
Palawan Red	27.95[a]	3.7	9.59	0.35

*Means in a column followed by the same letter superscript(s) are not significantly different at 5% level by DMRT

Summary

In an effort to reduce the height of plants, four concentrations of paclobutrazol were sprayed to 'Elon elon' and 'Palawan red' rice in wet season to determine its effects on lodging resistance and growth and yield performance.

Spraying with 1000 ppm of paclobutrazol was effective in reducing the length of the second and third internodes, culm length and plant height of Elon-elon and Palawan red. Lodging resistance was increased as evidenced by the decline in the lodging index of Elon-elon and Palawan red.

The number of filled grains/panicle, number of spikelets per panicle, weight of 1000 grains, dry matter yield, harvest index and grain yield were unaffected by paclobutrazol. The yield was unaffected since lodging occurred at later growth stage and that is when the grains are already filled with photosynthates.

Regardless of the concentrations of paclobutrazol, Palawan red had the longest first and fourth internodes, more unfilled grains per panicle, heavier 1000 grain weight and higher leaf area index than Elon-elon. Whereas, smaller stem diameter, more productive tillers per hill and longer panicle length were produced by Elon-elon.

Spraying of Elon-elon and Palawan Red with 1000 ppm of paclobutrazol is effective in shortening the length of the lower internodes resulting to shorter plants with increased lodging resistance.

References

Berry, P. M., Sterling, M., Spink, J., Baker, C. J., Sylvester-Bradley, R., Mooney, S. J., Tams, A. R. and Ennos, R. (2004). Understanding and reducing lodging in cereals. Advances in Agronomy 84:217-271.

Canare, J. JR. G. (1998). Fertilizer management of upland rice (*Oryza sativa* L.) grown on lahar deposit. (Doctor of Philosophy's Thesis). Central Luzon State University.

Gomez, K. A. (1988). Techniques for Field Experiments with Rice. Laguna, Philippines: International Rice Research Institute.

Fang, T. and Zhao, W. (2005). Chemical control of the overgrowing seedlings in the continuous cropping of late rice. Effect of MET on the growth and tillering of rice seedling and the yield of rice grain. Retrieved from http://en.cnki.com.cn/Articleen/CJFDTOTAL-XBZW198802000.htm.

Im, I. B., Lee, S. Y. and Lim, M. S. (1987). Growth and lodging of paddy rice as affected by paclobutrazol application under the different level of nitrogen fertilizer. Korean Journal of Weed Science 7:171-178.

IRTP (1988). Standard Evaluation System for Rice. 3rd Edition, Los Banos, Philippines: International Rice Research Institute.

Street, J. E., Jordan, J. H., Ebelhar, M. W. and Boykin, D. L. (1986). Plant Height and Yield Responses of Rice to Paclobutrazol. American Society of Agronomy. Journal of Natural Resources and Life Sciences Education. Retrieved from http://scidirect.com.

Ueno, H., French, P., Kohli, A. and Matsuyuki, H. (1987). Paclobutrazol: control of lodging of rice in Japan. Proceedings of the 11th International Congress of Plant Protection, Manila, 1987, ed. by E. D. Magallona 1:1440-444.

Ueno, H. and Kohli, A. (1994). Paclobutrazol: Control of Rice Lodging in Japan. Paper presented at the 1987 British Crop Protection Conference - Weeds and the 11th International Congress of Plant Protection. pp. 109-118.

Wang, X. I. (1991). Effects of MET on IAA-oxidase and endogenous IAA in Rice. Acta Agricultural University Zhejiangensis 17:60-64.

Yoshida, S. (1981). Fundamentals of Rice Crop Science. Los Banos Laguna, Philippines: International Rice Research Institute.

(Received: 21 September 2015, accepted: 25 October 2015)