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Drough tolerance estimation of several rainfed rice (*Oryza sativa* L.) of lokal veriety using p*olyethilene glycol* (PEG)

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Abstract. The yield of rice crop was highly affected by water availability and drought condition . The effort was done to seek local varieties of rainfed rice which tend to be tolerance to drought condition. This research objective was to seek some local varieties of rainfed rice that tolerance to several drought conditions. This research was conducted at Farm Exprimentation Site of Agrotechnology Study Program, Baturaja University from November 2015 to April 2016. Exprimental design used in this research was Split Plot Design with three replications. The main plot was variety treatments (varieties of Henik, Henik Pisang, Serenik, Remaja, Semester, Selanggar, Duku, Serendah Putih, Agai and Tinta), whereas the subplot was *Polyethilene glycol* (PEG) treatments (concentrations of 0%, 20%, 25% dan 30%). The results showed that varieties of Henik, Henik Pisang, Serenik, Semester, Duku, Serendah Putih and Tinta had produced high yield at drought condition. Rainfed rice could produced high yield at treatments of 20% and 25% PEG, respectively. Treatment combination of Duku variety and 30% PEG had produced the highest weight of unhulled rice/clump and fully unhulled rice/clump, respectively. The highest weight of unhulled rice per 1000 grains was found on treatment combination of Duku variety and 25% PEG.

1 Introduction

Food increment need to be done in accord to the increase of population numbers. The effort to increase food production was done through dry land empowerment. According to Pusdatin (2013), dry land area in Indonesia that was not yet utilized was 14,262,383 ha. This dry land resource has potential to support food self sufficiency. Rainfed rice

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cultivation can be applied at dry land area. Ogan Komering Ulu District of South Sumatra Province had extensive dry land area and local varieties of rainfed rice that have potential to be developed in order to increase food self sufficiency. Danial and Nurbani (2015) had stated that rainfed rice development had received less attention from the government than that of paddy field rice. Productivity of rainfed rice is lower than that of paddy field rice. Yuniarti (2015) had stated that one factor which cause low productivity of rainfed rice is drought condition. According to Rahayu and Harjono (2010), rainfed rice crop that tolerance to drought would have high prolin content in its leaves. The crop height and tiller numbers of rainfed rice will decrease at drought condition.

The growth and yield of rice crop are highly affected by water availability. Unfavourable climate condition due to climatic change has high impact on crop yield or production. Short wet season period coupled with long dry season will results in crop management difficulty due to water availability which solely available from rainfall water. The impact of El Nino phenomenon in 2015 was extreme drought condition and long dry season.

Drought causes accmulation of absisate acid, decrease in transpiration and decrease of CO_2 assimilation (Razak *et al*., 2013). Drought condition will decrease rice yield level (Quampah *et al*., 2011). Drought tolerance characteristics of a rice genotype is always related to the changes of morphology and physiology as adaptation way toward drought condition so that a rice genotype can be classified as drought tolerance. Crop characteristics either morphology or physiology can be used as assessment base of tolerance properties toward drought condition. One of substance that can be used to select drought tolerance rice crop is PEG (*Polyethylene Glycol*). PEG concentration of 18.1% or equivalent to – 6.24 bar of water potential can be used to determine the tolerance of variety to drought stress (Halimursyadah *et al*., 2013). PEG 6000 solution at 25% concentration is relatively effective concentration level to produce drought stress on rice crop. The used of PEG 6000 solution at 25% concentration at seedling phase can detect hybrid rice genotype which tolerance to drough condition (Afa *et al*., 2012).

This research was conducted to analyze the growth and yield of local varieties of rainfed rice originated from Ogan Komering Ulu District, South Sumatra Province, Indonesia at drought condition in order to determine the adaptive local varieties of rainfed rice at drought condition.

2 Material and Method

This research was conducted at Farm Exprimentation Site of Agrotechnology Study Program, Agricultural Faculty, Baturaja University from November 2015 to April 2016. Exprimental design used in this research was Split Plot Design with three replications. Variety treatments as the main plot were consisted of 10 varieties as follows: V_1: Henik, V_2: Henik Pisang, V_3: Serenik, V_4: Remaja, V_5: Semester, V_6: Selanggar, V_7: Duku, V_8: Serendah Putih, V_9: Agai and V_{10}: Tinta). *Polyethylene glycol* (PEG) concentrations as the sub-plot were consisted of four levels as follows: G_1:0%, G_2: 20%, G_3:25% and G_4:30%.

The first activity was planting media preparation in which yellowish red podsolic soil (PMK) was refined and sieved followed by putting it into polybag with size of 5 kg. Soil was then sprinkled with water until field capacity condition and subsequently was left over for one week. The seeds were soaked in beaker glass according to teatments for 12 hours and then were germinated within germination box. The next step was that seeds having 14

days old were transplanted into the previously prepared polybags in which each polybag was contained three stalks of seed. Crop maintenance was consisted of weeds cultivating, watering was done once per day and rice bug pest control was conducted by using demolish spraying. The observed parameters were crop height, crown dry weight, root dry weight, tiller emerging time, maximum tiller numbers, productive tiller numbers, flowering time, unhulled rice weight/clump, fully unhulled rice weight/clump and weight of 1000 grains unhulled rice. Data analysis was done by using Analysis of Variance with statistical package of SAS 6.12. If analysis results were significantly different, then it was followed by Duncan test using 5% level.

3 Results and Discussion

3.1 Results

Results of F-test (Table 1) showed that variety treatments had significant effect on parameters of crop height, crown dry weight, root dry weight, maximum tiller numbers, productive tiller numbers, flowering time, unhulled rice weight/clump, fully unhulled rice weight/clump and weight of 1000 grains unhulled rice. Variety treatments had no significant effect on tiller emerging time. The PEG treatments had significant effect on parameters of crown dry weight, productive tiller numbers and weight of 1000 grains unhulled rice, but had no siginificant effect on other parameters. Treatments interaction had significant effect on parameters of root dry weight, productive tiller numbers and weight of 1000 grains unhulled rice, but PEG treatments had no significant effect on other parameters.

3.2 Growth Parameter

The results of Duncan test showed that crop height of Henik variety (V_1) was not significantly different than that of V_2, V_4, V_7 and V_8. Crown dry weight of V_1 was not significantly different than that of V_3, V_7 and V_{10}. Root dry weight of V_1 was not significantly different than that of V_4 and V_8. Faster emerging time of tillers were found on treatments of V_1, V_3, V_4, V_6 and V_9. Maximum tiller numbers and productive tiller numbers were found on treatments of V_6. Tiller emerging time for V_3 treatment was faster than that of other varieties (Table 2). The comparison of PEG treatments and without PEG treatment (G_0) showed that G_3 treatment had taller crop height, tiller emerging time was not significantly different than that of G_1 and G_2 treatments as well as had faster flowering time. The G_1 treatment showed better results in increasing of crown dry weight, root dry weight, maximum tiller numbers and productive tiller numbers (Figure 1 to Figure 3). Results of treatment combination of variety and PEG showed that the highest values of crop height, crown dry weight and root dry weight were found on $V_{10}G_3$ treatment combination. The fastest tiller emerging time was found on V_9G_1 treatment combination. The highest values of maximum tiller numbers and productive tiller numbers were found on V_6G_3 treatment combination than that of other treatment combinations (Table 3).

3.3 Yield Parameter

Faster flowering time was found on V_6 treatment. Treatment of V_1 had unhulled rice weight/clump that was not significantly different than that of V_2, V_3, V_4, V_5, V_7, V_8 and V_9. Fully unhulled rice weight for V_7 treatment was not significantly different than that of V_1, V_3, V_5 and V_8. The 1000 grains weight of unhulled rice for V_1 treatment was not significantly different than that of V_3, V_7 and V_{10} (Table 2). The G_1 treatment had produced the highest value of 1000 grains weight of unhulled rice. The weight of unhulled rice/clump and fully unhulled rice/clump for G_2 treatment were higher than that of other PEG treatments (Figure 4 and Figure 5). Treatment combination of V_6G_2 had produced faster flowering stage. Treatment combination of V_7G_3 had higher values of unhulled rice weight/clump and fully unhulled rice weight/clump than that of other treatment combinations. The highest value of 1000 grains weight of unhulled rice was found on V_7G_2 treatment combination (Table 4).

Table 1. Variance analysis (F test) of variety treatments (V) and PEG (G)on all variables.

No	Variable	F value V	Pr > F V	F value G	Pr > F G	F value VxG	Pr >F VxG
1	Crop height (cm)	39.38*	0.0001	1.69^{ns}	0.1778	1.00^{ns}	04828
2	Crown dry weight (g)	2.45*	0.0501	5.83*	0.0015	2.34^{ns}	0.0032
3	Root dry weight (g)	7.26*	0.0002	1.86^{ns}	0.1454	1.76*	0.0351
4	Tiller emerging time (dap)	2.14^{ns}	0.0804	1.88^{ns}	0.1426	1.44^{ns}	0.1212
5	Maximum tiller numbers (stalk)	24.65*	0.0001	2.58^{ns}	0.0622	0.98^{ns}	0.5072
6	Productive tiller numbers (stalk)	13.68*	0.0001	9.23*	0.0001	3,17*	0.0001
7	Flowering time (dap)	2.96*	0.0238	1.77^{ns}	0.1626	1.07^{ns}	0.3997
8	Unhulled rice weight per clump (g)	3.99*	0.0060	0.56^{ns}	0.6466	1.37^{ns}	0.1541
9	Fully unhulled rice weight per clump (g)	4.40*	0.0036	0.40^{ns}	0.7510	1.37^{ns}	0.1560
10.	Weight of 1000 grains (g)	2.45*	0.0501	5.83*	0.0015	2.34*	0.0032

Remarks: *= significant; ns = not significant.

Table 2. Average results of variety (G) as the main plot for all variables

No	Variable	Variety										Dun-can Test
		V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	
1	Crop height (cm)	104,2 Ab	104 ab	98.1 bc	110.7 a	99.6 b	63.9 d	108.6 a	109.7 a	91.9 c	100.9 b	57.1
2	Crown dry weight (g)	96.20 a	68.5 b	78.0 ab	75.2 b	61.2 b	62.8 b	77.58 ab	68.83 b	69.92 b	77.75 ab	487.9
3	Root dry weight (g)	31.3 A	23.08 bc	21.58 bc	34.08 a	24.08 b	19.17 bc	24.4 b	31.7 a	21.5 bc	16.9 c	54.1
4	Tiller emerging time (DAP)	17.6	18.5	17.2	17.7	18.0	17.3	18.4	18.3	17.4	19.2	-
5	Maximum tiller numbers (stalk)	11.74 d	13.4 cd	13.94 cd	13.0 cd	13.9 cd	26.4 a	12.1 d	12.1 d	20.7 b	15.5 c	10.7
6	Productive tiller numbers (stalk)	9.02 cde	8.57 cde	11.27 cb	8.08 de	11.8 b	11.2 a	7.4 e	8.6 cde	10.6 bcd	11.2 cb	8.5
7	Flowering time (dap)	95.09 bc	111.94 ab	99.73 bc	101.41 bc	93.18 bc	85.95 c	94.64 bc	94.38 bc	116.09 ab	134.59 a	838.6
8	Unhulled rice weight per clump (g)	37.9 a	26.9 abc	38.4 a	34.9 ab	36.1 ab	16.0 c	39.9 a	37.9 a	37.4 ab	23.4 bc	206.1
9	Fully unhulled rice weight per clump (g)	35.18 ab	23.99 bcd	34.74 ab	31.16 abc	32,75 ab	14.29 d	37.65 a	35.58 ab	31.50 abc	20.55 d	157.9
10	Weight of 1000 grains (g)	96.2 a	68.5 b	78.0 ab	75.2 b	61.7 b	62.8 b	77.6 ab	68.8 b	69.9 b	77.7 ab	487.9

Remarks: Numbers followed by the same letters are not significantly different.
V_1: Henik, V_2: Henik Putih, V_3: Serenik, V_4: Remaja, V_5: Semester, V_6: Selanggar V_7: Duku, V_8: Serendah Putih, V_9: Agai and V_{10}: Tinta. DAP = Days After Planting.

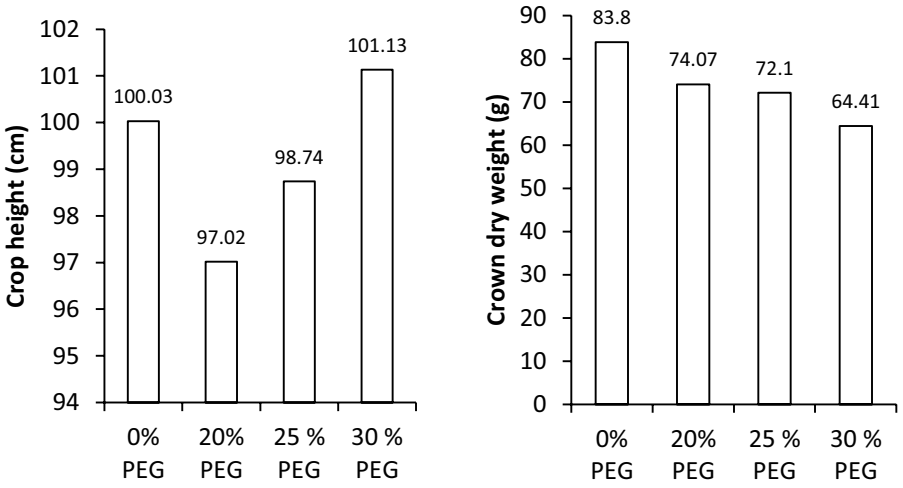

Fig. 1. Average crop height and crown dry weight at PEG treatment.

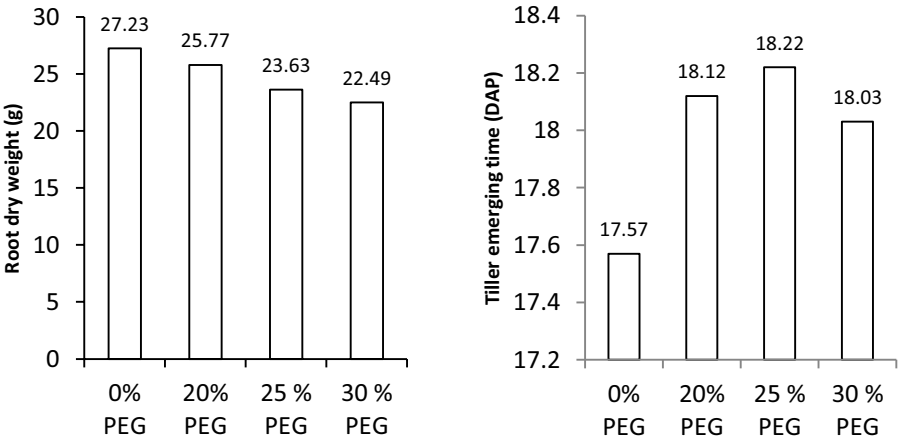

Fig. 2. Average of root dry weight (g) and tiller emerging time (DAP) at PEG treatment.

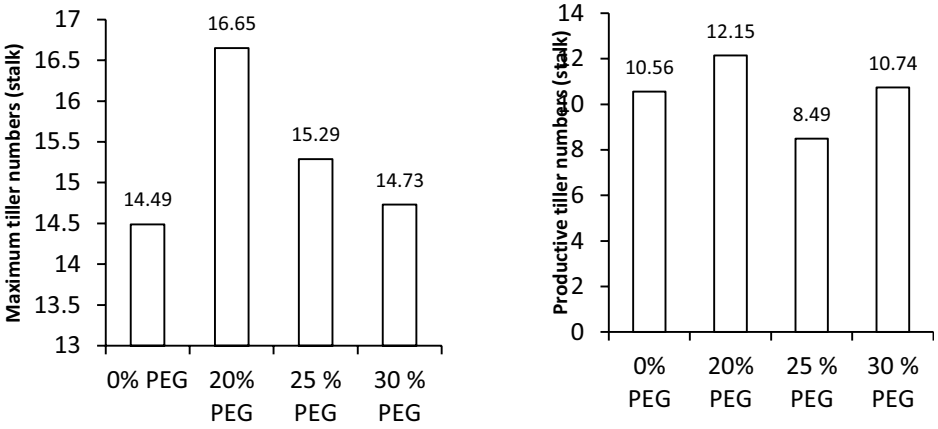

Fig. 3. Average of maximum tiller numbers (stalks) and productive tiller numbers (stalks) at PEG treatment.

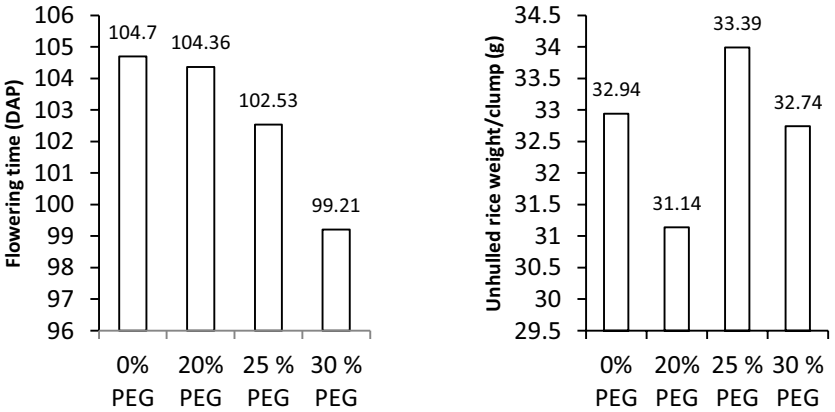

Fig. 4. Average flowering time (DAP) and unhulled rice weight/clump (g) at PEG treatment

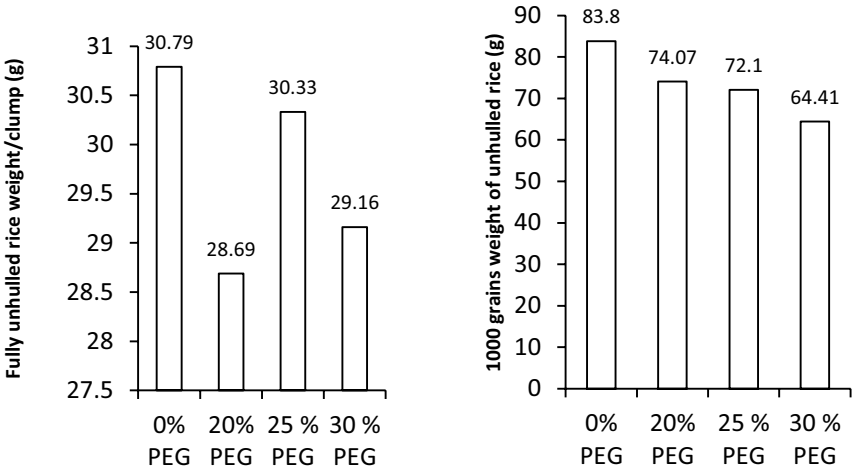

Fig. 5. Average weight of fully unhulled rice/clump (g) and 1000 grains weight of unhulled rice (g) at PEG treatment

Table 3. Average growth and yield of several local varieties of rainfed rice (V) at PEG treatment (G).

Variety	PEG	Crop height (cm)	Crown dry weight (g)	Root dry weight (g)	Tiller emerging time (DAP)	Maximum tiller numbers (stalk)
V_1	G_0	104.67	34.89	11.63	15.3	10.77
V_1	G_1	101.63	33.88	11.29	18.33	11.9
V_1	G_2	101.53	33.84	11.28	18.87	13.2
V_1	G_3	108.9	36.3	12.1	17.97	11.1
V_2	G_0	102.3	34.1	11.37	18.43	12.9
V_2	G_1	99.8	33.27	11.09	19.43	13.9
V_2	G_2	106	35.33	11.78	18.23	12.23
V_2	G_3	110.33	36.78	12.26	18.1	14.87
V_3	G_0	104.13	34.71	11.57	16.97	14.87
V_3	G_1	93.8	31.27	10.42	17.67	12.33
V_3	G_2	100.23	33.41	11.17	16.43	16.13
V_3	G_3	94.33	31.44	10.48	17.67	12.43
V_4	G_0	112.7	37.57	12.52	17.67	14.33
V_4	G_1	111.37	37.12	12.37	17.57	14
V_4	G_2	108.23	36.08	12.02	18.1	11.47
V_4	G_3	110.43	36.81	12.27	17.57	12.53
V_5	G_0	99.57	33.19	11.06	17.67	13.3
V_5	G_1	99.233	33.08	11.02	18.43	14.8

V_5	G_2	101.1	33.7	11.23	18.23	13.9
V_5	G_3	98.57	32.86	10.95	18	13.7
V_6	G_0	64.37	21.46	7.15	17.23	22.1
V_6	G_1	60	20	6.66	17	27.9
V_6	G_2	61.23	20.411	6.80	17.23	25.47
V_6	G_3	70.1	23.37	7.79	18	30.23
V_7	G_0	113.7	37.9	12.63	17.43	12.57
V_7	G_1	106.1	35.37	11.79	18	13.47
V_7	G_2	106.2	35.4	11.8	18.77	11.47
V_7	G_3	108.53	36.18	12.06	19.33	11
V_8	G_0	113.67	37.89	12.63	18.57	10.9
V_8	G_1	109	36.33	12.11	18.8	14.57
V_8	G_2	111.23	37.08	12.36	17.83	10.33
V_8	G_3	104.87	34.96	11.65	18	12.43
V_9	G_0	94.47	31.49	10.49	17	18.77
V_9	G_1	89.87	29.96	9.98	16.13	25.67
V_9	G_2	91.03	30.34	10.11	18.97	20.03
V_9	G_3	92.2	30.73	10.24	17.57	18.2
V_{10}	G_0	90.77	30.26	10.09	19.43	14.37
V_{10}	G_1	99.433	33.14	11.05	19.87	18
V_{10}	G_2	100.57	33.52	11.17	19.53	13.1
V_{10}	G_3	113	37.67	12.56	18.1	16.43

Table 4. Average growth and yield of several local varieties of rainfed rice (V) at PEG treatment (G).

Variety	PEG	Productive tiller numbers (stalk)	Flowering time (DAP)	Unhulled rice weight/clump (g)	Fullly unhulled rice weight/clump (g)	Weight of 1000 grains (g)
V_1	G_0	8.67	92.33	36.1	33.77	27.32
V_1	G_1	11.37	98.43	42.23	40.6	25.02
V_1	G_2	6.13	98.23	42.63	40.27	25.85
V_1	G_3	9.9	91.37	30.83	26.07	26.02
V_2	G_0	7	115.23	25.23	24	20.27
V_2	G_1	10.9	116.53	24.43	21.6	22.91
V_2	G_2	10.23	106.57	31.6	24.67	22.74
V_2	G_3	6.13	109.43	26.7	25.7	24.66
V_3	G_0	14.7	101.1	42.8	40.03	26.06

V_3	G_1	9.2	102.57	29.07	25.3	23.91
V_3	G_2	11.2	98.9	44.13	43.73	26.73
V_3	G_3	9.97	96.33	37.77	29.9	24.92
V_4	G_0	8.23	100.53	36.87	34.57	25.69
V_4	G_1	9.13	100.1	29.93	27.57	24.35
V_4	G_2	9.2	103.53	39.63	29.67	24.29
V_4	G_3	5.77	101.47	33.03	32.83	23.49
V_5	G_0	12.43	94.13	32.77	30.93	25.74
V_5	G_1	14.57	91.67	42.1	38.27	25.36
V_5	G_2	10.23	92.57	38.83	35.2	25.31
V_5	G_3	10.3	94.33	30.63	26.6	26.24
V_6	G_0	18.63	87.33	30.33	18.43	23.38
V_6	G_1	17.87	86.33	15.7	13.97	21.52
V_6	G_2	16.2	86.47	11.37	9.63	21.05
V_6	G_3	20.3	83.67	16.9	15.13	21
V_7	G_0	5.87	91.77	34.77	33.37	28.24
V_7	G_1	11.13	94.57	37.83	34.5	25.42
V_7	G_2	4.57	94.67	37.63	35.23	27.4
V_7	G_3	8	97.57	49.3	47.5	25.69
V_8	G_0	8.87	98.33	47.67	44.57	28.67
V_8	G_1	9.67	96.2	38.37	37.1	26.75
V_8	G_2	7.97	88.87	30.7	28.07	27.98
V_8	G_3	7.9	94.1	35.37	32.6	27.71
V_9	G_0	8.9	115.67	31.57	28.8	22.78
V_9	G_1	15.2	116.1	30.47	29.77	26
V_9	G_2	1	117.03	32.63	29.63	23.04
V_9	G_3	17.3	115.58	46.88	37.8	25.26
V_{10}	G_0	12.3	150.57	21.6	19.4	23.34
V_{10}	G_1	12.4	141.13	21.27	18.2	22.11
V_{10}	G_2	8.17	138.43	30.8	27.17	20.77
V_{10}	G_3	11.8	108.23	19.97	17.43	23.46

4 Discussion

The results of F-test showed that all varieties used in this study had significant effect on all parameters except for tiller emerging time parameter. This showed that all varieties used in this study had different responses. These different responses were estimated due to

differences in genetic characteristics of each variety. According to Farooq *et al*. (2009), drought tolerance varieties would produce differences in genetic characteristics althouh they are cultivated in the same location. These differences were due to genetic control from each variety.

The PEG treatment had significant effect on crown dry weight, productive tiller numbers and 1000 grains weight of unhulled rice. The effect of PEG on growth and yield was related to crown dry weight in which crown dry weight is the accumulation of photosyntate yield. Interaction of varieties and PEG had significant effect on root dry weight, productive tiller numbers and 1000 grains weight of unhulled rice. The PEG treament had produced drought stress condition in which roots can not absorb more water. Water absorbtion has effect on photosynthesis process of crop. The photosynthesis yield is used for productive tillers development and is accumulated in seeds. Biomass of crop is highly affected by water availability and photosynthesis yield. Ahadiyat (2011) had stated that tolerance of rainfed rice crop at drought stress condition is affected by physiological capability in controlling water distribution during its growth which is tend to be controlled by genetic characteristics. This is in accordance to the statement from Zain et al. (2014) which showed that rice variety that capable to use water efficiently would be more tolerance to water stress condition.

Results of further test by using Duncan test showed that V_1 (Henik), V_3 (Serenik), V_5 (Semester), V_6 (Selanggar), V_7 (Duku) and V_{10} (Tinta) were varieties that capable to increase growth and to produce high yield at PEG treatments of G_1 (20% PEG) and G_2 (25% PEG). Treatment combinations that had produced high yield were V_7G_2 (Duku +25 % PEG) and V_7G_3 (Duku + 30% PEG). There was six varieties that gave high yield at drought stress condition out of ten varieties tested in this study. These varieties had different characteristics and can be adaptive to water shortage environment. Adaptive capability from each variety is controlled by internal properties. The adaptive and tolerance variety is the one that capable to increase water use efficiency.

Treatment of 20% PEG was capable to increase crown dry weight, root dry weight, maximum tiller numbers, productive tiller numbers and 1000 grains weight of unhulled rice. The highest weight values of unhulled rice/clump and fully unhulled rice/clump were found on treatment of 25% PEG. This was estimated that rainfed rice at drought condition could still absorb water which was subsequently used for growth and production, whereas rice crop no longer could absorb water at 30% PEG condition. According to Afa *et al*. (2012), the higher the PEG concentration results in higher decrease of water potential so that water can not be absorbed by crop. The 1000 grains weight of unhulled rice for 20% PEG treatment was higher than that of 25% PEG treatment which was estimated due to water availability factor. Water availability is highly affected by soil temperature and soil water content. According to Ji et al. (2012), water is the main factor that affect rice production. Water shortage affects stomata closure and subsequently impede photosynthesis process.

Treatment combinations of variety and PEG which capable to increase rice growth was found on $V_{10}G_3$, V_9G_1, V_6G_2 and V_6G_3. Treatment combinations of V_7G_2 and V_7G_3 were superior in increasing rice production than that of V_9G_3. The capability of V_6 (Selanggar), V_7 (Duku), V_9 (Agai) and V_{10} (Tinta) varieties in increasing average values of growth and production parameters were lower than that of control treatment (G_0: without addition of PEG). Selanggar, Agai and Tinta varieties had capability in absorbing water and they could only used water to increase the growth, whereas Duku variety was more efficient in utilizing water and this water could be used to increase rice production with average value

higher than that of control treatment. The weight of unhulled rice/clump for V_7G_0 was 33.37 g and for V_7G_3 was 47.50 g, respectively. The weight of fully unhulled rice/clump for V_7G_0 was 34.77 g and for V_7G_3 was 49.30 g, respectively. Agai variety also had higher average values in term of weight of unhulled rice/clump (V_9G_3:46.88 g) and weight of fully unhulled rice/clump (V_9G_3: 37.8 g) than that of control treatments (V_9G_0: 31.53 g and V_9G_0: 28.8 g, respectively).

Duku and Agai varieties in combination with PEG 30% had higher yield than that of other treatment combinations. These varieties were more tolerance to drought stress than that of other varieties. Duku variety was capable to cope with critical period during seedling phase which was shown by higher value of crown dry weight found in combination treatment of Duku variety and PEG than that of combination treatment of Agai variety and PEG. However, average value of crown dry weight found in these two treatment combinations was not significantly different than that of control treatment. This showed the capability in coping with critical phase so that crop can absorb water and nutrients which were important for the on-going of photosynthesis process. Results of the study by Akram *et al*. (2013) showed that drought stress could decrease the crown dry weight of crop.

5 Conclusion

The results showed that varieties of Henik, Serenik, Semester, Selanggar, Duku and Tinta were capable to produce high yield at drought treatment condition. Treatment of 20% PEG and 25% PEG had significant effect on growth and yield of rice crop. Treatment combination which had high yield was Duku +25 % PEG and Duku + 30% PEG, respectively.

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