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Research Article

Nutrition and Hormone Content of Rice Stubble According to Recutting Time: A Survey of Four Different Varieties

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Abstract

Analysis of nutrient and phytohormone levels of several rice variety stumps which were re-trimmed at different times and the effects on rice rat sprouts were carried out in Padang City. The study was designed according to a completely randomized design (CRD) factorial pattern with 2 factors and repeated 3 times. The first factor is rice varieties (IR 42, Hipa 5, Inpari 21, and Inpari 12) and the second factor is the time of pruning (0, 3, 6, and 9 days after harvest). The results showed that there were no interactions between varieties with re-pruning time on nutrient and phytohormone levels, growth, and rice rat yield. Still, they were influenced by types characterized by increased levels of nutrients, phytohormones, growth and yield along with the longer plant life except for Hipa 5 hybrid varieties. , with a significant influence on carbohydrate levels, time of budding, percentage of primary shoots, and yield of clump-1 rice. When pruning affects the nutrients and phytohormone, the levels of protein, fat, and Indol Acetate Acid (IAA) and ABA. The best rat growth is IR.42 variety with the fastest shoot time (2.31 days), the highest shoot percentage (18.23%) and maximum sapling 101.20 clumps 1 at the right time of 9 HSP even though it is the same as 0, 3 and 6 days after harvest. The highest yield was Inpari 21 variety (117.32 grams clump $^{-1)}$ but still the same as the IR.42 variety (114.11-gram clump $^{-1}$).

Keyword: *Risk Governance, Local Government, Management, Management Structure.*

I. INTRODUCTION

Seed and Ratun are two sources for the use of the seedling in rice cultivation. Ratun is a sprout that grows on the stumps of rice plants that have been harvested and produce for the second time (Liu et al., 2012). Cultivation of ratun is widely used in several countries, but the production number still low at 40-75% in the main crop (Chauhan et al. n. y; Mareza et al. 2016; Setiawan et al. 2014; Susilowati, 2011). So that the cultivation of ratun is no longer used.

If the production number can be increased, The use of ratum will be useful, efficient and economical because they do not cultivate the soil, do not use seeds because the seeds are expensive, do not need planting, save costs and labour (Dong et al. 2017). Besides, rice from ratum is also sustainable because straw as a source of organic material is not burned (Hee et al. 2016). Ratun maintains the genetic purity of hybrid varieties by vegetative propagation. And alternative rice cultivation increases the annual cropping index, from 1 time to 2 times or from 2 times to 3 times (Santoso, 2014). To improve the yield of the ratum, the thing that needs to be done is to make sure that the ratum shoots emerge from the rest of the stems that are inside and the surface of the ground so that the shoots can bear interest and have new roots. To stimulate the emergence of ratun shoots can be done by low cutting the stems during harvest, laying down branches or trimming the stems after harvest so that it is closer to the ground surface. The result is 3.6 tonnes of MPD/ ha higher than the 20 cm harvest cut from the land surface *(dpt).* Thuamkham (2003), was reported by It turned out that the yield was improved by 5-6 t / ha and the number of tillers increased 2-3 times of the re-trimming effect of stumps. Erdiman et al. (2012), was trimming back harvested stems as high as 3-5 cm from the soil surface *(dpt)* can trigger rat shoots on the remaining stems at the soil surface just like moved seeds with yields increasing to 25% according to the dose of fertilizer added. Ratun can increase grain yield per unit area (Santos et al. 2003).

Several factors influence the growth of ratum shoots likes variety, nutrition and phytohormone, harvest time, irrigation, soil fertility, fertilization. It has been proven that hybrid varieties have higher vigority and potential rat (Susilowati, 2011). Cisokan varieties that are derived give almost the same results as the seedlings sown (Syarif, 2016). Nutrition, water, and phytohormones are essential for the growth of shoots. The shoots are part of the plant as a sink that was strong that it requires many assimilations for the development (Wareing & Phillips, 1970). The shoots will dry and die when it does not contain enough nutrients. IAA and ABA fitohormones play a role in plant growth and dormancy. The rest of the plants that have been harvested are high dormancy stumps. IAA can suppress high ABA levels in dormant stumps. Pruning will remove the stems that contain a lot of ABA and trigger IAA to stimulate lateral shoots or its calles ratun (Schell et al. 1993).

But, there have been no reports of the effect of varieties and time of pruning on nutritional levels and phytohormone of ratun rice stumps. So, in this report will analyze nutrient and phytohormone levels in several varieties by re-pruning and linking them to the growth and yield of rice rats (Uphoff et al. 2009).

II. METHOD

Surau Gadang Nanggalo was chosen as a research sample cause the farmers used IR 42 varieties which have a long-lived with crop index 2-2,5 in a year. This experiment held from March to November 2014. The experiment design used is completely random (CRD) factorial pattern. The first factors are: IR 42, Hipa 5, Inpari 21, and Inpari 12 varieties and the second factors are a time of pruning in 0,3,6,9 days after harvest the main plant. Analysis of variance used test f with advance treatment DMRT 5%.

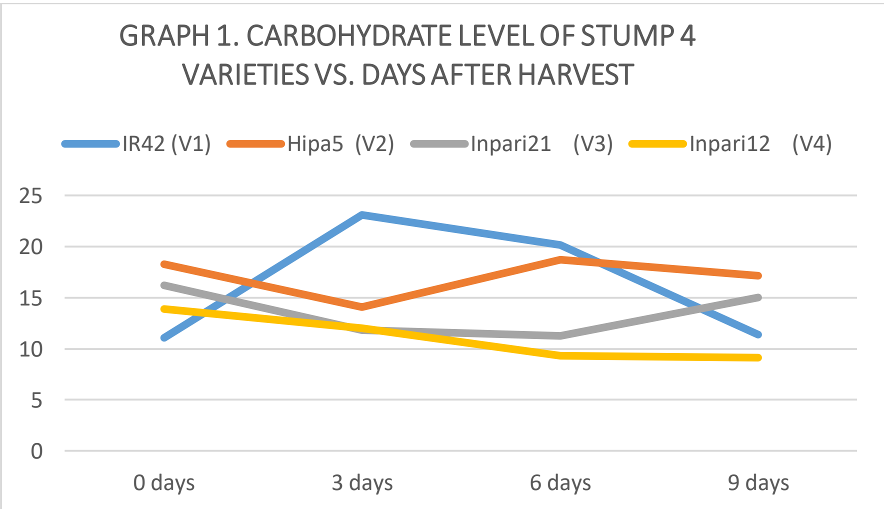
The main crop planting is used SRI (The System of Rice Intensification). Fertilizers which used ini this experiment according to local recommendations per hectare are 150 kg of Urea, 100 kg of TSP, 50 kg of KCl and 16 tons of cow manure. Ratun experiment in a plastic pot with 25 cm of diameter, 40 cm of height, which is filled with 10 kg of dry paddy soil and the wind escapes a 2 cm sieve and cow manure 100 g pot-1. The remaining stems after harvest are trimmed back at the time according to the treatment by leaving the remaining stumps (stumps) as high as 3 cm dpt and then it's transferred to the media pot. Analyzed the nutritional and phytormone level and observed growth. After the plant, the generative phase, which there are symptoms of nutrient differentiation the added Ponska NPK as much as 200 Kg Ha-1. Analysis of Stump nutrient to measures of carbohydrate, protein, and fat (Sudarmadji & Suhandri, 1984). Phytohormone analysis to show IAA and ABA levels (Unyayar et al. 1996). Observation of ratum growth is shoot emergence, the percentage of shoots emergence and the maximum number of tillers. Observation of the results is the percentage of productive tillers and MPD results (Ergün et al. 2002).

III. RESULT AND DISCUSSION.

Harvested rice leaves the stems as in figure 1. Then re-prune according to the specified time and leave a stump 3 cm *dpt*

Picture 1. Stump not yet sprouted (0 Days After Harvest), b. the stump has sprouted 12-13 cm (3 Days After Harvest), c. the stump has sprouted 24-25 cm (6 days after harvest) and d. Stumps have sprouted 30-36 cm (9 Days After Harvesting). (9 HSP).

1. **Carbohydrate Levels**



Graph 1. Carbohydrate level of the stump in rice varieties.

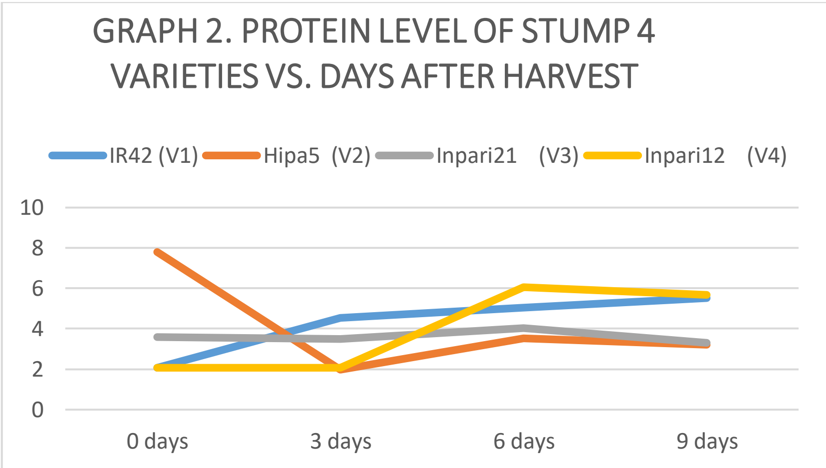
Carbohydrate level in rice stumps at 0 days after harvest is the Hipa 5 variety gets the highest levels with (18.25%), Inpari 21 with (16.23%), Inpari 12 with (13.88%), and the smallest at IR.42 (11.07%). The result shows that in the same line with the Average each yield variety of ton Ha-1 (Hipa.5 with 7.3, Inpari 21 with 6.9, Inpari 12 with 6.0 and IR 42 with 5.0) (Appendix 1). The higher the average yield of a variety so the higher the carbohydrate content remaining in the stump. The newer the variety so the higher the average result. Hipa and Inpari are new types of rice that came out in the 2001s, while IR.42 VUB in 1980 (Gaspar et al. 1996; Suliansyah, 2006).

In 3 days after harvesting, IR42 carbohydrate levels increase rapidly due to the accumulation of assimilates to the point of direct growth, which is reserved as a source of energy for germination of shoots (rats). After that it decreases (6 and 9 days after harvest) due to degradation for rat germination processes while for 3 other varieties decreased towards the turning point (dormancy) to start the accumulation of assimilates at 6 days after harvesting and only experienced the degradation process after 6 which is 9 days after harvesting.

Carbohydrate levels will decrease because there are degraded to metabolic processes until the limit of carbohydrates in old organs not functioning, and new organs have been able to photosynthesize (Setiawan et al. 2014). Large and complex molecular compounds such as starch, protein and fat are broken down into uncomplex and water-soluble so that they are easily transported through membranes and cell walls. Enzyme activities aid this process. The energy produced is used for the formation of components and the growth of new cells (Kingsly et al. 2010; Lombu et al. 2018).

Germination can increase the activity of the α-amylase and β-amylase enzymes which play a role in degradation carbohydrates. The enzyme α-amylase breaks down starch into glucose and dextrin, whereas β-amylase will break down starch into maltose and dextrin, which will later be converted into energy. Germination will break down polysaccharides into simple carbohydrates so that the carbohydrate content decreases.

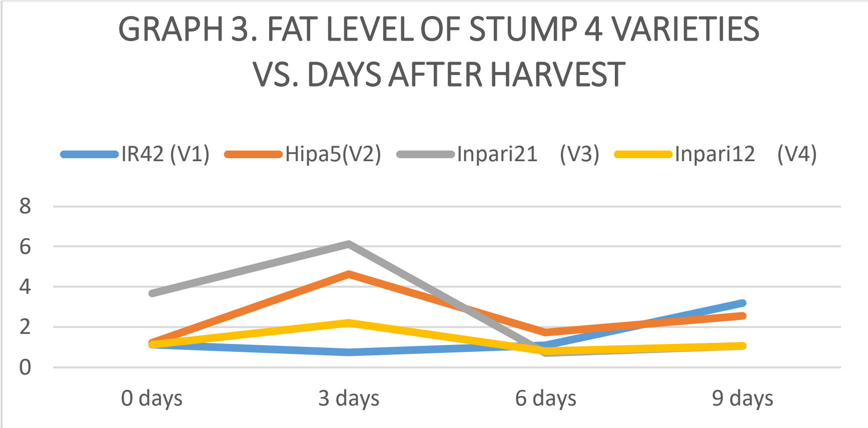
2. Protein Levels



Graph 2. Protein levels of rice varieties.

Like carbohydrates, IR 42 variety at 0 days after harvest is a turning point towards the ratun germination process. Other varieties experienced a turning point at 3 days after harvest and continued to increase up to 6 days after harvest. However, in contrast to carbohydrates, protein levels continue to increase due to the formation of essential amino acids and new amino acids that were not previously formed as compounds of proteins (Paredes-Lopez & Mora-Escobedo, 1989; De Ruiz & Bressani, 1990).

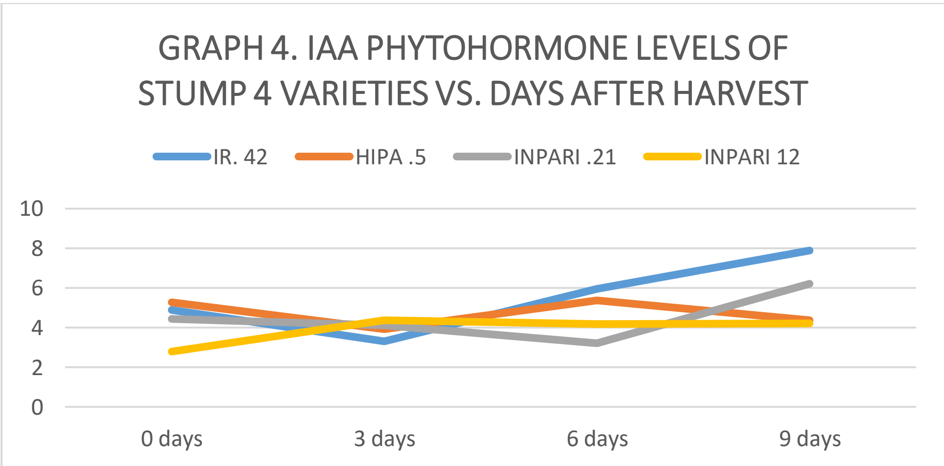
3. Fat Levels



Graph 3. Fat levels of rice varieties.

The fat level at 0 days after harvesting the plant showed that IR 45 variety was a turning point towards the germination process and continued to decrease until the plants were able to synthesize. Protein and lipid levels have increased during the shoots due to the conversion of protoplasm proteins to new shoots (Oomah et al. 1997; Nieva-Echevarria et al. 2019).

4. IAA phytohormone levels

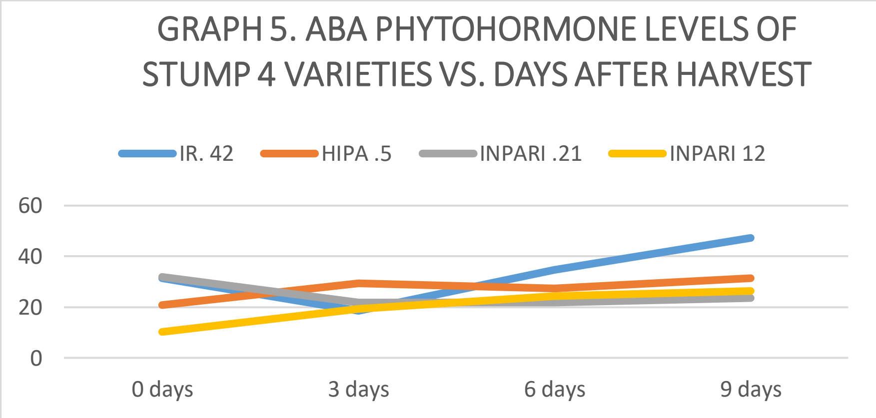


Graph 4. IAA Phytohormone levels of rice varieties

The lowest IAA level is 3 days after harvest. When energy is prioritized to induce budding, IAA plays an active role in stimulating bud formation. The relationship between IAA and protein was explained by (Oomah et al. 1997), that the precursor of IAA formation was tryptophan. Triptopanis a protein in the form of heterocyclic amino acids (Suliansyah, 2006), while ABA plays a role in protein metabolism and amino acid synthesis.

The active IAA content in plants 1-10 ppm while the IAA content in the stumps in this experiment is 2.81-7.88 ppm. These results are in the active range as growth stimulants (Vanderstoep, 1981), IAA helps stem cell lengthening at a concentration of 0.9 g / l if the above concentrations will inhibit stem cell lengthening. High IAA concentrations cause plants to synthesize another ZPT, which is ethylene which has the opposite effect with IAA. In contrast to stem growth, low IAA concentrations in roots (<10-5 g / l) promote elongation of root cells, whereas high IAA concentrations inhibit root cell lengthening. When the concentration of phytohormone has reached a certain level, several inactive genes will begin to express because plant phytohormones are part of the process of adaptation and self-defence of plants to maintain their survival. In this experiment, the IAA content was below 0.9 g / l or 900 ppm, which is the minimum content for IAA to be active.

5. ABA phytohormone levels



Graph 5. ABA Phytohormone levels of rice varieties

At 0 days after harvest, the level of phytohormone and nutrients comes from the rest of the parent plant. At the initiation of the germination 3 days after the harvest, ABA and IAA became active, but carbohydrates and fat became accumulated. At 6 and 9 days after the protein harvest, ABA and IAA return to normal while the fat and carbohydrates are partitioned to the point of growing into energy for germination of ratun.

Plant growth and response are the results of interaction or balance between ABA and growth phytohormone, where ABA plays a role in nucleic acid metabolism and protein synthesis. ABA acts as a flowering inhibitor on long-day plants grown on the short-days but induces flowering of short-day plants grown in noninductive conditions. The effect of growth inhibition is to reduce competition in the vegetative part so that the ABA increases as the plant ends its life while the IAA decreases as the plant ends its life. IAA is active in early tissue while ABA is active in aged tissue. Stumps are aged tissue, that's why IAA content is lower than ABA content.

Nutrient levels at IR.42 are high due to high IAA levels, but because ABA levels are also the highest the effects of IAA are weakened so that the energy to form assimilates is reduced. On the other hand, Inpari 21 has IAA levels that are as high as IR.42. Still, due to lower ABA levels, the effect of IAA weakening by ABA is not as strong as the effect of IAA weakening by ABA on IR.42 (Suliansyah, 2006). Plant growth and response is a balance between ABA and fitohormon. The result of growth inhibition is to reduce competition in the vegetative section.

Ratun Rice Growth

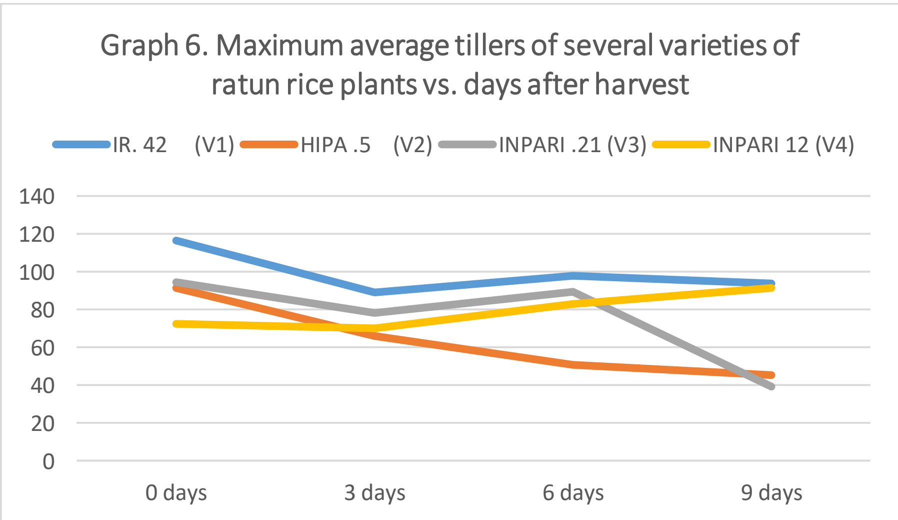
The budding starts from 10 days after planting or 30 days after sowing and a maximum of 50-60 days after planting (Prasetyo, 1996). In Table 3, the emergence of rat rice shoots in this experiment is starting on the 2nd day after harvest because of the seed germination stage, and there are no stems began to grow, so the ratun plants immediately start the budding or breeding phase. Besides, rats cannot improve stagnation because there are not transition from seedlings to nurseries. In this experiment varieties, IR 42 was the fastest buds appeared and followed by Inpari 21, Hipa 5 and Inpari 12.

Table 1. Average growth of several rice varieties

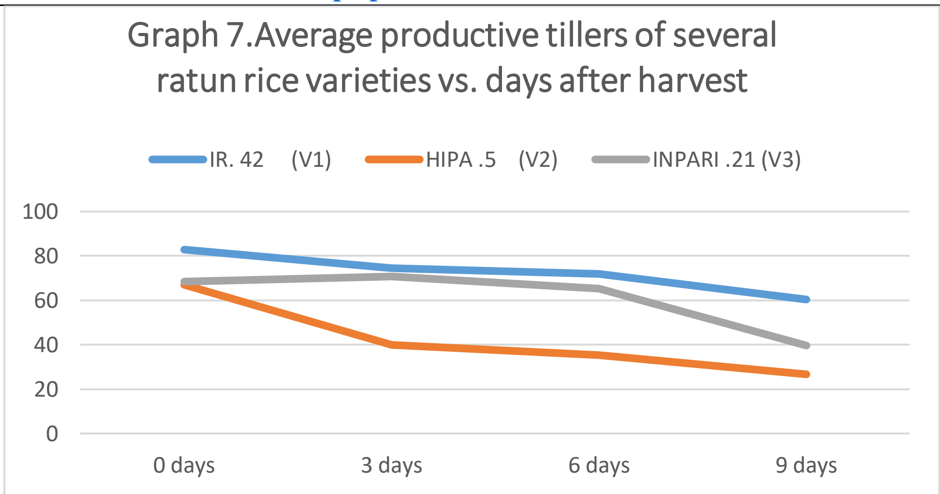
Varietas	Rice Olds (Days)		Shoots appear (Days)	Persentase Shoots appear (%)	Height of Plant (cm)	Maximum tillers (stems)	Grain yield/clump
	Description	Ratun					
IR.a 42	135-145	123,41[a]	2,31[a]	18,23[a]	94,75[a]	101,20[a]	111,25[a]
HIPA .5	114-129	114,83[a]	4,68[b]	16,47[a]	82,37[b]	69,50[b]	85,00 [b]
INPARI .21	± 103	101,89[a]	2,38 [a]	16,52[a]	88,25[ab]	75,47[b]	122,79[a]
INPARI 12	± 99	98,51[b]	5, 39[b]	9,18[b]	92,75[a]	79,25[b]	113,03[a b]

The figures in the column followed by the same lowercase letters are not significantly different according to DNMRT level of 5%

In this experiment, a linear relationship was found between age, nutrition, phytohormone, and growth in several varieties except in Hipa 5 varieties. The longer the variety age, the nutrient content and phytohormone, the time of rapid shoot emergence and the higher percentage of primary shoots. In this experiment, a linear relationship was found between age, nutrition, phytohormone, and growth in several varieties except in Hipa 5 varieties. The longer the variety age, the nutrient content and phytohormone, the time of rapid shoot emergence and the higher percentage of primary shoots.



Graph 6. Maximum average tillers of several varieties of ratun rice in days after harvest



Graph 7. The average productive tiller of several ratun rice in days after harvest.

Ratun rice plant height is lower than the main plant (parent), but in general, is in the normal range except in Hipa 5 varieties. Plant height and number of tillers were suspected because the fertilizer intake was given homogeneously to all varieties, so the energy needs for Hipa 5 were not adequately. In genetically Hipa 5 was able to pass down the characteristics of the parent through ratun (graph 6). Makarim et al. (Suliansyah, 2006), states that the number of tillers was more influenced by the of nutrients, especially Nitrogen. Hybrid F1 plants are generally plants that need special attention and require more input compared to inbreed plants (Payumo, 1978).

The maximum number of tillers in IR 42 varieties because the early shoots appeared and the longer duration of vegetative growth so that the growth of tillers was more significant. The length of the vegetative phase different for each variety while the duration of the reproductive phase and cooking is relatively the same (Meyer & Anderson, 1952). In terms of pruning time, the highest maximum tillers are at 0 days after harvest (graph 6), as well as nutrition and phytohormone, the stump condition at harvest has a vigoritation from the rest of the parent plant which it has not been utilized for the metabolic process of germination. When the time of pruning is faster than primary shoots will appear faster and more. Slowing the time of pruning will slow down the emergence of primary shoots, even the primary shoots that have appeared (Figure 1) will be pruned which will grow the non-primary shoots (Yoshida, 1981).

Table 2. Average growth and yields of several varieties of rice

Varietas	Percentage of productive tillers		Malai Longs		The amount of grain		Weight of 1000 grain		Grain yield/clump	
IR. 42	75,7	**ab**	25,3	**a**	134,5	**b**	20,58	**b**	111,3	**a**
HIPA .5	68,3	**b**	25,2	**a**	168,8	**a**	23,9	**a**	85	**b**
INPARI .21	85,6	**a**	23,3	**b**	123,7	**b**	21,54	**b**	122,8	**a**
INPARI 12	80,6	**a**	23,3	**b**	123,5	**b**	21,47	**b**	113	**a b**

Tertiary shoots will produce panicles and too] ripe so that they cannot compete with primary and secondary tillers, even though the IR.42 has maximum value shoots and the highest productive tillers of. Still, the percentage of productive tillers is equal to Inpari 21 and Inpari 12. This means that not all tillers produce became productive tillers due to high competition among tillers within the clump. Besides, IR.42 still have grown the tillers and still high even though it has entered the reproductive phase, so that competition between panicle growth and tillers growth is continued, and The effect of that is many tillers losing competitiveness and death.

Hipa 5 is genetically excellent in terms of the number of grains, panicle length and weight of the highest 100 seeds than the other varieties. Still, the lowest is on the plant height, maximum tillers and productive tillers, so yield (table 2) is showing insufficient data. The weight of 100 high seeds indicates of good quality and quantity, because of the low productive tillers, the assimilate partition is more dominant to the fruit; as a result, the grain becomes large, pithy and heavy.

Figure 2. Rice shoots of IR varieties. 42

The Average of productive tillers per clump for Hipa 5 varieties are 7-15 stems, IR.42 are 20-25 stems, Inpari 21 are 15 stems, and Inpari 12 are 18 stems (Appendix 1). Still, the average productive ratun tillers (graph 7) is above productive parent plants. This is because the number of stems leftover from the main crop as a source of rat shoots in one clump is large (Figure 2.) for each bar has 3-5 books (Figure 3), and each book has a bud.

Figure 3. Stumps with 3 cm height with 3 - 5 stem^{-1}, each book has 1 bud. There are 22 to 23 stumps of stumps.

In the vegetative growth phase, the most prime variety is IR.42 because of the more endogenous availability of nutrients and phytohormones. After the reproductive phase, the most prime variety is Inpari, although the results are still the same with IR.42. This happens because Inpari's ability to partition assimilates to generative organs is better than IR 42. This is caused by the ability to utilize sinks and source genetically as a characteristic of a new type of rice with prime properties that are far better than new prime varieties.

IV. CONCLUSION

Nutritional and phytohormone levels affect the growth and yield of rats. IR.42 has right in annual shoots and growth, but the ability to partition assimilates has the same as Inpari 21. Hipa 5 can inherit superiority through ratunisasi, but lack of external energy intake to makes growth and the results still lower. The most active shoot response varieties are IR.42 with shoot emergence is 2.331 days after harvest, 18.23% primary shoot percentage and 101.20 maximum number of tillers. The pruning time for each variety was different. Copyright Forms and Reprint Orders.

The best ratun induction budding is IR.42 and more research needs to be done on to found how to suppress the growth of maximal tillers into optimal tillers. If the yield per clump is converted to Ha by multiplying the number of clumps per Ha at a planting distance of 25x25, 16,000 clumps will be obtained so that the bias is very high because the pot experiment gives a relatively wide space and there is no competition. If the yield per clump is converted into the standard number of tillers of the parent plant, the yields range from 4-6 tons/ha, which is the same as the average yield of the local community. Even though the results are the same, they are economically profitable because they are cost-effective (no-tillage, no need for seeds, seedlings and planting, and fast harvest).

REFERENCES

1. Atherton, J., & Rees, A. (2008). Tropical root and tuber crops: cassava, sweet potato, yams and aroids.
2. Chauhan, J. S., Vergara, B. S., & Lopez, F. S. S. (n. y). *Rice ratoonin, no. 102*. https://www.ijab.org.
3. De Ruiz, A. C., & Bressani, R. (1990). Effect of germination on the chemical composition and nutritive value of amaranth grain. *Cereal chemistry*, *67*(6), 519-522.

4. Dong, H., Chen, Q., Wang, W., Peng, S., Huang, J., Cui, K., & Nie, L. (2017). The growth and yield of a wet-seeded rice-ratoon rice system in central China. *Field Crops Research*, *208*, 55-59.
5. Erdiman, Nieldalina, & Misran. (2012). Increased Land Productivity through Development of Salibu Rice Technology. *Final Report of the West Sumatra BPTP Research Team*.
6. Ergün, N., TOPCUOĞLU, Ş. F., & Yildiz, A. (2002). Auxin (Indole-3-acetic acid), gibberellic acid (GA_3), abscisic acid (ABA) and cytokinin (Zeatin) production by some species of mosses and lichens. *Turkish journal of botany*, *26*(1), 13-18.
7. Fasidi, I. O., & Bakare, N. O. (1995). Distribution of food reserves in Dioscorea dumetorum (Kunth) Pax tubers during sprouting. *Food chemistry*, *52*(4), 423-426.
8. Hee, S. J., Sang, K. K., & Park, S. G. (2016). Effects of Stubble Height, Irrigation and Nitrogen Fertilization on Rice Ratooning in Korea. *Journal of the Korean Society of Crop Science,* 60(4), 431-435.
9. Joshi, P., & Varma, K. (2016). Effect of germination and dehulling on the nutritive value of soybean. *Nutrition & Food Science*.
10. Liu, K., Qin, J., Zhang, B., & Zhao, Y. (2012). Physiological traits, yields and nitrogen translocation of ratoon rice in response to different cultivations and planting periods. *African Journal of Agricultural Research*, *7*(16), 2539-2545.
11. Lombu, W. K., Wisaniyasa, N W., & Wiadnyani, S. (2018). Differences in chemical characteristics and digestibility of corn starch and corn sprouts. 7 (1).
12. Mareza, E., Djafar, Z. R., Suwignyo, R. A., & Wijaya, A. (2016). Rice ratoon yield response to main crops cutting height in tidal swamp using direct seeding system. *AGRIVITA, Journal of Agricultural Science*, *38*(2), 126-132.
13. Meyer, B. S., & Anderson, D. B. (1952). Plant Physiology. D. Van Nostrant Company. *Inc. New York*.
14. Nieva-Echevarría, B., Goicoechea, E., & Guillén, M. D. (2019). Effect of adding alpha-tocopherol on the oxidation advance during in vitro gastrointestinal digestion of sunflower and flaxseed oils. *Food Research International*, *125*, 108558.
15. Onwueme, I. C. (1978). *The tropical tuber crops; yams, cassava, sweet potato* (No. 633.4 O5).
16. Oomah, B. D., Kenaschuk, E. O., & Mazza, G. (1997). Tocopherols in flaxseed. *Journal of Agricultural and Food Chemistry*, *45*(6), 2076-2080.
17. Paredes-Lopez, O., & Mora-Escobedo, R. (1989). Germination of amaranth seeds: effects on nutrient composition and color. *Journal of Food Science*, *54*(3), 761-762.
18. Payumo, E. M. (1978). The potentials of mungbean as a protein supplement for child feeding. In *The 1st International Mungbean Symposium* (No. RESEARCH). AVRDC.
19. Prasetyo, Y. T., (1996). *Gogo Rice Planting without Land Cultivation*. Jakarta. Self-help Spreaders.
20. Schell, J., Koncz, C., Spena, A., Palme, K., & Waiden, R. (1993). Genes involved in the control of growth and differentiation in plants. *Gene*, *135*(1-2), 245-249.
21. Santos, A. B., Fageria, N. K., & Prabhu, A. S. (2003). Rice ratooning management practices for higher yields. *Communications in soil science and plant analysis*, *34*(5-6), 881-918.
22. Santoso, M. B. (2014). Ratun Cultivation. Binuang Agricultural Training Center, 1–7. Retrieved from https://www.bbpp-binuang.info/uploads/files/RatunCultivation.pdf.

23. Setiawan, A., Tyasmoro, S. Y., & Nugroho, A. (2014). Intermittent irrigation and cutting height on ratoon rice (Oryza sativa L.). *AGRIVITA, Journal of Agricultural Science, 36*(1), 72-80.
24. Sudarmadji, S., & Suhandri, B. H. (1984). Analysis Procedures for Food and Agricultural Materials. *Publisher Liberti Yogyakarta*.
25. Suliansyah, I. (2006). Plant Growth Regulatory Substances. *Textbook of Agronomy Study Program Department of Agriculture Budiday Faculty of Agriculture Andalas University, Padang*.
26. Susilowati. (2011). Agronomy of Potential Rice Genotypes for Tidal Land. *Dissertation of Bogor Agricultural Institute Graduate School*.
27. Syarif, A. (2016). *Management of Agroecological Harvesting of Harvest Time with Nitrogen Fertilizer in Efforts to Increase Productivity of the Ratun Rice Field System*. Articles (in the process of publication).
28. Thuamkham, C. P. S. (2003). *Ratoon Cropping of Lodged Stubble*. The Office of Agricultural Research and Development Region 5, Sapaya District, Chainat Province, Thailand.
29. Unyayar, S., Topcuoglu, F., & Unyaya, A. (1996). A modified method for extractio n & identification of IAA, GA3, ABA & Zeatin produced by P. chrysoporium ME446 Bulg. *Journal of Plant Physiology*, *22*, 105-110.
30. Uphoff, N., Anas, I., Rupela, O. P., Thakur, A. K., & Thyagarajan, T. M. (2009). Learning about positive plant-microbial interactions from the system of rice intensification (SRI). *Aspects of Applied Biology*, *98*, 1-27.
31. Vanderstoep, J. (1981). Effect of germination on the nutritive value of legumes. *Food Technology (USA)*.
32. Wang, W., He, A., Jiang, G., Sun, H., Jiang, M., Man, J., ... & Nie, L. (2020). Ratoon rice technology: A green and resource-efficient way for rice production. In *Advances in Agronomy* (Vol. 159, pp. 135-167). Academic Press.
33. Wareing, P. F., & Phillips, I. D. J. (1970). The control of growth and differentiation in plants. *The control of growth and differentiation in plants*.
34. Yoshida, S. (1981). *Chinese Hybrids, Fruit of Perseverance and Patience A Fundamental Research of Crop Science*. IRRI Los Banos Philippines