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Alternative Solution to Avoid the Failed Harvest of Citrus "Keprok 55" in Dry Season by Sprinkle Irrigation Design

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ABSTRACT

Batu-Malang Government area is one of central production of citrus in East Java. In dry season, citrus produce low production level, because there is insufficient water in the soil. Based on this facts, some efforts is needed in order to increase the citrus production especially to face the dry season, through sprinkle irrigation system to increase citrus production. Sprinkle irrigation system has been installed on citrus plantation in Selorejo Village, Batu. Randomized Block Design (RBD) with factorial was used in the research. There were two investigated factors, i.e.: 1) height of riser pipe and 2) time of watering. Result showed that based on crown bud produced. There was no differences between factors. In case of amount of blooming flowers and number of fruits, combination of treatment with 150 cm in height of riser pipe and once a week of watering produced 359.667 and 1032.667 respectively as the highest values.
Keywords: Citrus fruit production; dry season; land inclination; sprinkle irrigation system; time of watering.

INTRODUCTION

Construction and technology engineering of sprinkle irrigation system is possible to be adopted by farmer. Whereas the application of sprinkle irrigation system can stimulate to disposal system. In addition, it`s also useful to be applied in the watering, fertilizing methods and reducing the plant pest and disease attacks (Herman, 1991; Merriam, 1991).

As far as now, the citrus production increase on long dry season never be reached by farmer. A main problem, the lack of water on dry season impact to citrus successful plant in Batu. Through technology of sprinkle irrigation system, may boost the horticulture farmer especially to increase citrus production on dry season, until equal to the productivity on rainy season.

Batu is one of central production of citrus "*Keprok 55*" productions in East Java. The citrus is usually planted on area which have some land topography criteria such as phase land, steep declivity, where between the water resources and plantation area have altitude difference. The citrus cultivation needs land and plant maintenance, in order to guarantee the citrus can be harvested twice a year. At the end of rainy season, the citrus plant produce high production level, it could happened because there are plenty water available in the soil. Otherwise at the dry season, the citrus plant produce low production level, it could happened because there is insufficient water inside the soil. If there are insufficient water inside the soil, the quality of citrus productions will be lower than condition under the plenty of water in the soil. In the other hand, the price sale value of citrus productions at rainy season from citrus farmers tend to be lower than dry season. From this facts, it really needs some efforts to increase the citrus productions especially to face the dry season.

Generally, the most problem always faced by the citrus farmer community in

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Batu is water availability. In the dry season, the minimum water availability in soil influence on decreasing of citrus quantity and quality. Related to that, citrus production decreased ca. 40-45% (BPS Kota Batu, 2004).

Based on this facts and in order to improve quantity and quality of citrus productions, therefore needs introduction and innovation of new technology such as sprinkle irrigation system in dry season to provide and manage water efficiently and effectively. By providing of water, production of citrus can be maintained every year.

MATERIALS AND METHODS

Construction Plan of Sprinkle Irrigation System and calibration of each *nozzle* has been done in Laboratory of Natural Resources and Environmental Engineering, Agricultural Technology Faculty, Brawijaya University. Installation trial of sprinkle irrigation system has been done in citrus plantation belongs to citrus farmer in Selorejo Village, Batu Malang. In this research, *Randomized Block Design* was arranged with factorial, and consisted of two factors, such as: 1) height of riser pipe and 2) time of watering. Riser Pipe Height (R) as factor I was consisted of three level i.e.: Control (R_0), 50 cm height (R_1), 100 cm height (R_2), and 150 cm height from base field of each riser pipe. Time of watering (T) as factor II was consisted of four i.e.: Once a week (T_1), Twice a week (T_2), Three times a week (T_3) and Four times a week (T_4). Control was referred to conventional method with adopted by farmer that permitted plant appropriate under environment condition.

Combination of the treatments included as 1) Riser Pipe 100 cm height and once a week of watering (T_1R_1); 2) Riser Pipe 100 cm height and once a week of watering (T_1R_2); 3) Riser Pipe 150 cm height and once a week of watering (T_1R_3); 4) Riser Pipe 100 cm height and twice a week of watering (T_2R_1); 5) Riser Pipe 100 cm height and twice a week of watering (T_2R_2); 6) Riser Pipe 150 cm height and twice a week of watering. (T_2R_3); 7) Riser Pipe 50 cm height and three times a week of watering (T_3R_1); 8) Riser Pipe 100 cm height and to be watered three times a week (T_3R_2); 9) Riser Pipe 150 cm height and three times a week of watering (T_3R_3); 10) Riser Pipe 50 cm height and four times a week of watering (T_4R_1); 11) Riser Pipe 100 cm height and to be watered four times a week (T_4R_2) and 12) Riser Pipe 150 cm height and four times a week of watering (T_4R_3). Each combination was repeated three times, and resulted 48 combinations.

Soil characteristic, pF water degree, porosity, infiltration rate of water in the soil were observed and calculated. All of soil samples were collected from the research field. In case of pF water degree, samples of soil were taken from ca. 50 cm in depth. Total availability of soil humidity on dusty clay of soil classification taken from relevant literature based on the research on various kind of soil classification at the past.

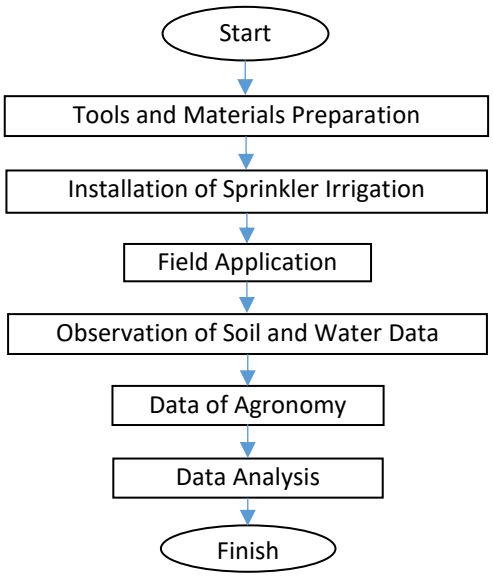

Figure 1. Flow Chart of Research.

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RESULT AND DISCUSSION

Soil Characteristic.

Table 1 showed that value of pF soil porosity in location of research was 57.37%. Soil characteristic in research location showed well condition. The higher value of soil porosity can make the soil absorb water easier. The composition of soil showed 56.33% of dust, 23.67% of sand, and 20% of clay, and finally it can be categorized as dusty clay. The dusty clay of soil classification texture dominated by micro pores so it will have inter capacity of water flow that rather slow-moving so the infiltration rate also rather slow-moving (Soepardi, 1983).

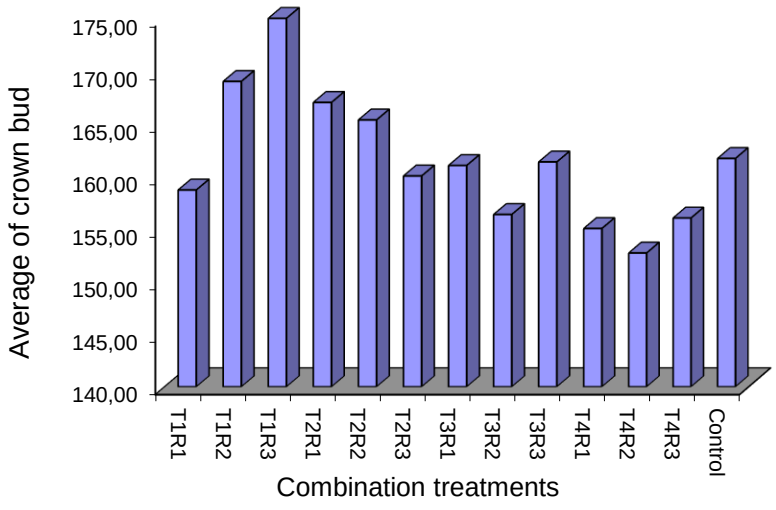
The Impact of Riser Pipe Height and Time of Watering to Flower Blooming (Bud Crown Flower).

Result showed that there are very obvious differences between treatments especially at time of watering. The impact of riser pipe height and time of watering of T1R3 treatment indicated the inclination of the highest number was 175 flowers (bud crown), and the lowest number was 152667 flowers (Figure 2). The differences amount of flowers in each treatment indicated the obvious impact caused by time of watering.

Table 1. Physics Analysis of Soil

Porosity (%)	pF Water Degree (cm^3/cm^3)		Sand	Dust	Clay	Classification
	2,50	4,20		(%)		
57,37	0,34	0,21	23,67	56,33	20	Dusty Clay

Source: Laboratorium Test Result, 2014.



T_1R_1: 50 cm pipe, 1x watering; **T_1R_2**:100 cm pipe, 1x watering; **T_1R_3**:150 cm pipe, 1x watering; **T_2R_1**: 50 cm pipe, 2x watering; **T_2R_2**: 100 cm pipe, 2x watering; **T_2R_3**:150 cm pipe, 2x watering; **T_3R_1**: 50 cm pipe, 3x watering; **T_3R_2**: 100 cm pipe, 3x watering; **T_3R_3**: 150 cm pipe, 3x watering; **T_4R_1**: 50 cm pipe, 4x watering; **T_4R_2**: 100 cm pipe, 4x watering; **T_4R_3**: 150 cm pipe, 4x watering.

Figure 2. Average of crown bud for each combination treatment.

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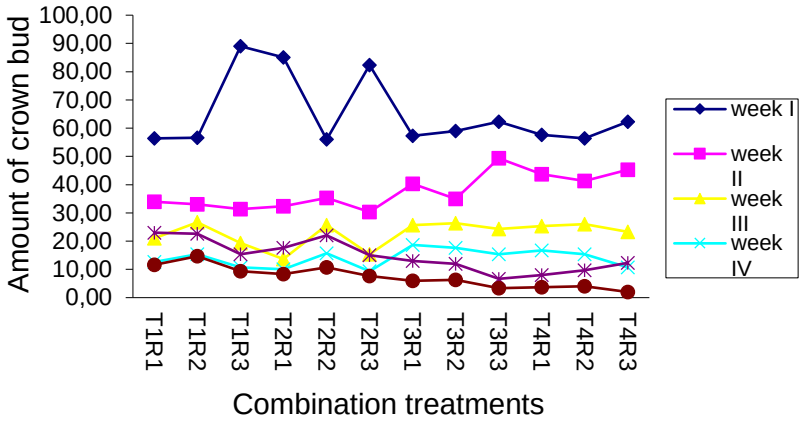

T_1R_1: 50 cm pipe, 1x watering; **T_1R_2**:100 cm pipe, 1x watering; **T_1R_3**:150 cm pipe, 1x watering; **T_2R_1**: 50 cm pipe, 2x watering; **T_2R_2**: 100 cm pipe, 2x watering; **T_2R_3**:150 cm pipe, 2x watering; **T_3R_1**: 50 cm pipe, 3x watering; **T_3R_2**: 100 cm pipe, 3x watering; **T_3R_3**: 150 cm pipe, 3x watering; **T_4R_1**: 50 cm pipe, 4x watering; **T_4R_2**: 100 cm pipe, 4x watering; **T_4R_3**: 150 cm pipe, 4x watering.

Figure 3. Amount of crown bud for each combination treatment every week.

The differences amount of flowers (bud crown) at Figure 3, caused by the formation and blooming of flowers (bud crown) determined by amount of branch which experience *roozet* process (compressed). The formation of *roozet* happened when the plant damaged on the edge. *Roozet* formed from storage of photosyntesis result's residue after it is distributed to entire part of plant then saved by the plant to the tip of branches. Soelarso (1996), explained that carbohydrate residue from catabolism process will be saved as food storage. The food storage saved on each tip of branches and later will form the flowers.

For the flowers without *roozet*, when the flower has damaged, the edge of branch will take a short cut, because the branches will only produce lateral leaves and bud. The edge of branches are damaged to reduce the evaporation process. Therefore the food material supply is still going, so as the consequence there are surplus of food substance availability in plant. At this condition, the lateral buds at the branches which are not *roozed*, will appeare faster than the buds which are *roozed* in blooming flowers process.

The differences amount of flowers (bud crown) for period factor of irrigation water shower could be happened because when the plant will *roozed* it needs water so with plenty available water will make *roozet* process faster to become a flower. Treatment of T1R3 give the biggest number of flowers (bud crown) than other because beside the water energy needed to complete the formation of flower it also has very well condition than other plant. So when *roozet* flower produced a lot of number then the flower without *roozet* will produced a lot of number too.

Flowers Blooming (Blossom Crown).

Based on LSD (α=0.05), at flowers (blossom flower) indicated that there was significant differences between the combination treatments and interaction between it.

Table 2. The Impact of *Riser* Pipe Height and Time of Watering to Amount of Blossom Flower.

Treatment	Average of Flowers *)
150 cm pipe, 4x watering/week (T4R3)	222.66 *a*
Control	223.00 *a*

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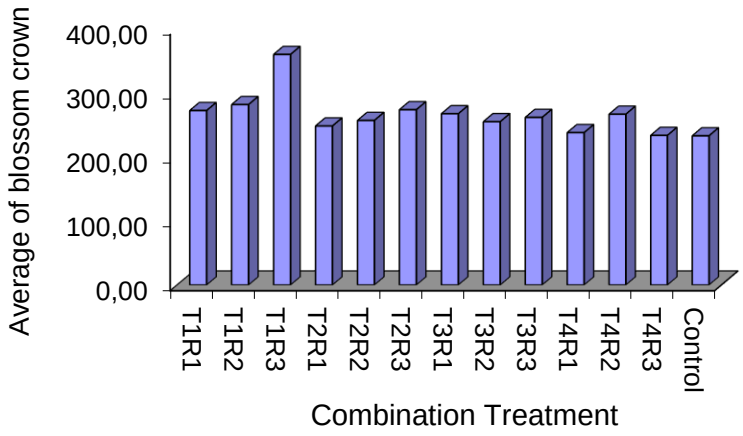
Treatment	Average of Flowers *)
50 cm pipe, 4x watering/week (T4R1)	229.00 *a*
50 cm pipe, 2x watering/week (T2R1)	238.33 *a*
100 cm pipe, 3x watering/week (T3R2)	247.00 *b*
100 cm pipe, 2x watering/week (T2R2)	249.00 *a*
150 cm pipe, 3x watering/week (T3R3)	253.66 *a*
100 cm pipe, 4x watering/week (T4R2)	255.66 *a*
50 cm pipe, 3x watering/week (T3R1)	257.33 *a*
50 cm pipe, 1x watering/ week (T1R1)	261.33 *a*
150 cm pipe, 2x watering/week (T2R3)	263.66 *bc*
100 cm pipe, 1x watering/week (T1R2)	271.66 *a*
150 cm pipe, 1x watering/week (T1R3)	349.66 *cd*

*)*The average number which followed by difference alphabet indicates the significant differences between treatments by LSD (α=0.05).*

The treatment of pipe height (R) gives the obvious differences between the treatments. *Riser* Pipe 150 cm (R3) height point out as the highest result. It happened at the treatment because the water outflow will similar with unnatural rain, then the condition of environment will similar as rainy season, where it has the highest humidity level that surely will help the process of plant blooming. The high humidity condition will reduce the evaporation rate, because it will decrease the environment temperature. At various treatments also point out the same notation, because the flower blooming condition is almost same, so it gives same response.

Time of watering (T) factor also give obvious impact to blossom flower blooming process. Plenty available water needed by the citrus plant to grow up, especially at generative period process. The treatment that the plant to be watered once a week (T1) gives the highest amount of blossom flowers than another treatment. It makes hypothesis statement stronger that with routine and appropriate of *time of watering* (T) it will produced a lot of flower number.

The impact of *riser* pipe height and water shower period indicated that the treatment of T1R3 give the highest result 349.66 flowers (blossom flowers) and the lowest result 223.66 flowers at the treatment of T4R3. While the change of blossom flowers every week in each treatment combination can be seen at **Figure 4** and **5**.



T_1R_1: 50 cm pipe, 1x watering; **T_1R_2**:100 cm pipe, 1x watering; **T_1R_3**:150 cm pipe, 1x watering; **T_2R_1**: 50 cm pipe, 2x watering; **T_2R_2**: 100 cm pipe, 2x watering; **T_2R_3**:150 cm pipe, 2x watering; **T_3R_1**: 50 cm pipe, 3x watering; **T_3R_2**: 100 cm pipe, 3x watering; **T_3R_3**: 150 cm pipe, 3x watering; **T_4R_1**: 50 cm pipe, 4x watering; **T_4R_2**: 100 cm pipe, 4x watering; **T_4R_3**: 150 cm pipe, 4x watering.

Figure 4. Average of blossom crown for each combination treatment.

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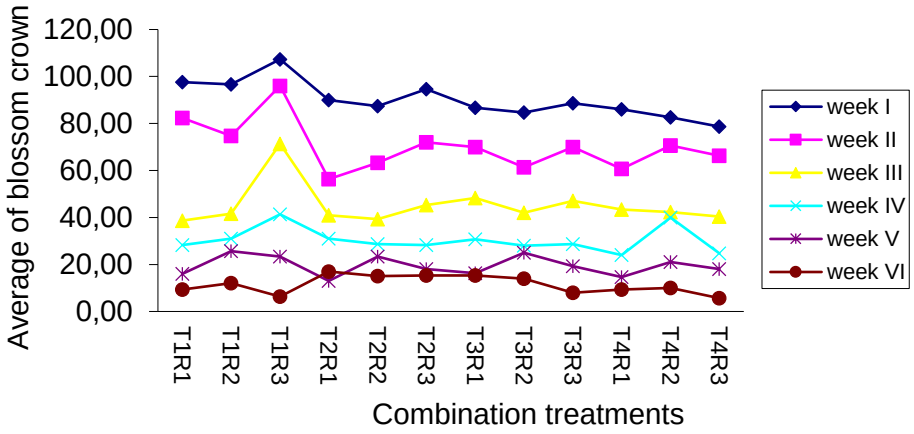

Figure 5. Average of blossom crown for each combination treatment every week.

Differences amount of flowers (blossom crown) in each treatment caused by the impact of riser pipe height and water shower period. It happened because when bud flowers were blooming become blossom only need a week of period, so at the research data found that the highest amount of flowers (blossom flower) at early weeks. That's why by given irrigation water will supported the blooming process of flowers. The treatment of T1R3 produce the highest result, it happened because of routine and appropriate irrigation and with precise of treatment will produce the maximum result.

Impact of Riser Pipe Height and Time of Watering to Ovary on Citrus Plant.

Kind of result analysis at α=0.05 in fruit ovary indicated that there is obvious impact for treatments, each factors, and its interaction. Obvious different of riser pipe height also give different response. It can be seen at T1R1, T1R2, and T1R3 treatment which has different notation at various analysis. The higher riser pipe could make the water outflow similar with rain shower, besides it used to irrigation, it also creates condition looked like in rainy season, so it helps blooming process.

Tabel 3. Impact of Riser Pipe Height and Time of Watering to Ovary on Citrus Plant.

Treatment	Average of Plant Ovary *)	Notation (α=0.05)
Control	394.33	a
T4R1	415.66	a
T4R2	499.33	b
T3R2	520.33	b
T3R1	537.33	b
T4R3	578.66	bc
T3R3	590	c

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Treatment	Average of Plant Ovary *)	Notation (α=0.05)
T2R3	591	c
T2R1	591.33	c
T2R2	597.66	c
T1R1	625.66	c
T1R2	802.66	cd
T1R3	1022.66	d

Notes: *- BNT (α=0.05)= 65.979*
**) The average number which followed by difference alphabet indicates the obvious difference at the result of "experiment of the smallest obvious difference".*

Impact of riser pipe height and water shower period to ovary in citrus plant indicate the highest result 1022,66 plant ovary at T1R3 treatment and the lowest result at control treatment. Differences amount of plant ovary caused by distribution of energy to the plant. Differences amount of plant ovary indicate that there are fulfilled energy and also unfulfilled energy needed. It can be seen on the treatment of T1R1 that indicate the significance increase at the beginning of flower formation process (bud crown) until become plant ovary, it caused by enough energy availability to fulfill the legume plant at ovary plant, then it increases the ovary plant production.

The water shower period (T) factor indicates difference in the highest result of ovary plant that to be watered once a week. It indicates that the right time to be watered is on the generative phase (blooming flowers) when it needs irrigation water as one of main unsure in photosynthesis process which used to energy supply. If the water availability can`t fulfill the water needed of the plant, so the plant will insufficient water (*water stress*), but it will not happen if the plant get routine to be watered.

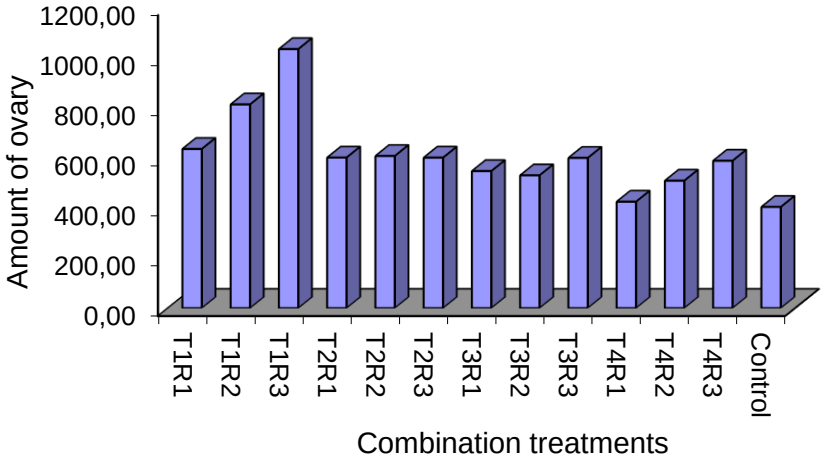

Figure 6. Amount of ovary for each combination treatment.

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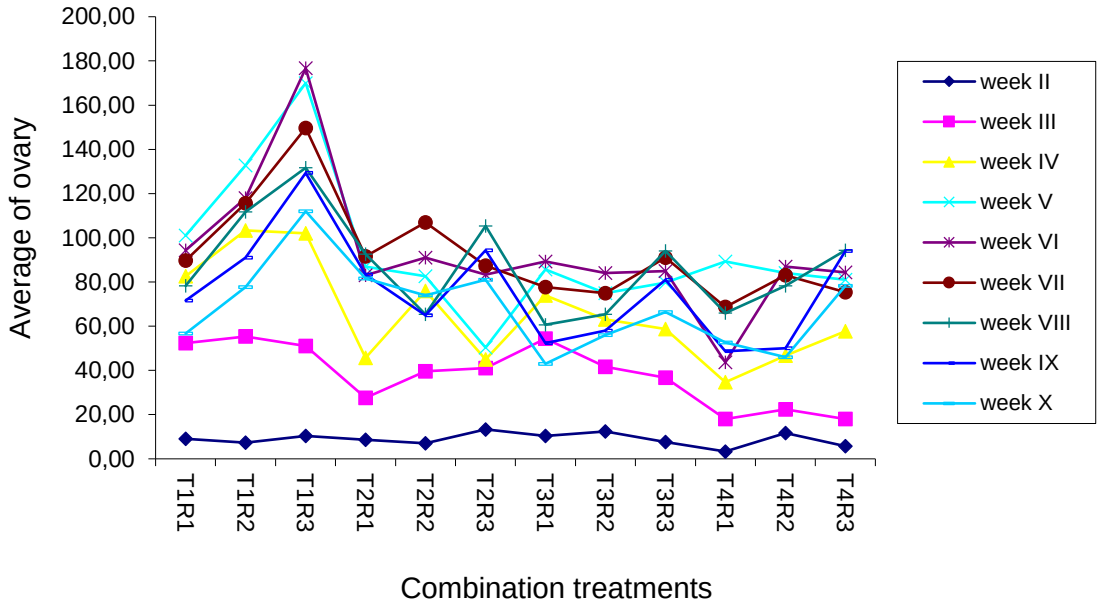

Figure 7. Average of ovary in citrus plant for each combination treatment every week.

Amount of ovary plant production indicated that the right time of plant to be watered is on plant generative phase because it may effected to the formation of ovary plant. The meaning of ovary plant is a phase after the fallen off flower beginning to be fulfilled, and at the tip of branch still founded some traces of damaged edge until the fruit has less than 4 cm diameter.

Impact of Riser Pipe Height and Water Shower Period to Amount of Fruit.

Impact of riser pipe height and time of watering indicated obvious effect whether in the treatment or each factors. Impact of riser pipe height and time of watering of fruit indicated that the treatment of T1R3 get the highest result 247.66 fruits and get the lowest result 95.66 fruit at control treatment. It was shown on **Table 4, Figure 8, and 9**.

Amount of fruits productions have significance correlation with the ovary plant production, where at the treatment of T1R3 found that the biggest value also gives biggest result. The fulfill energy also have important impact where in this treatment the energy needed by plant is plenty available to form the fruit. **Table 4** indicated that the control treatment of fruit production have similarity with the treatment of T4R1, T4R2, T3R2, T3R1 which have same notation. It is also happened to the treatment of T2R1, T2R2, T2R3 which have same notation too.

Based on result of comparison explained similarly of T4R1, T4R2, T3R2, T3R4, the plant that to be watered three times a week and four times a week can't growth maximally. It has explained, that difference amount of fruit production is caused by fulfill of energy. The plant that to be watered three times a week and four times a week were not efficient in time, because the critic point period of plant is on generative phase of the plant. If insufficient water in this phase, the citrus flower will be fallen off then the result of fruit productions could not reach maximum targets. This was happened to the similarity of amount fruit productions to the plant that to be watered three times a week and four times a week with control treatment. The plenty available water inside the soil also used for evapotranspiration by the plant, so it reduce the energy necessary to energy supply and of course it has correlation to the fruit productions.

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Table 4. Impact of Riser Pipe Height and Time of Watering to Amount of Fruit

Treatment	Average of Fruits *)
Control	95.66 *a*
T4R1	97.66 *a*
T4R2	108.00 *a*
T3R2	114.33 *a*
T3R1	124.33 *a*
T4R3	124.00 *ab*
T3R3	139.33 *b*
T2R1	156.66 *c*
T2R2	159.66 *c*
T2R3	174.00 *c*
T1R1	209.00 *c*
T1R2	222.00 *d*
T1R3	247.66 *e*

Note :
**) The average number which followed by difference alphabet indicates the obvious difference between treatments by LSD (0.05)".*

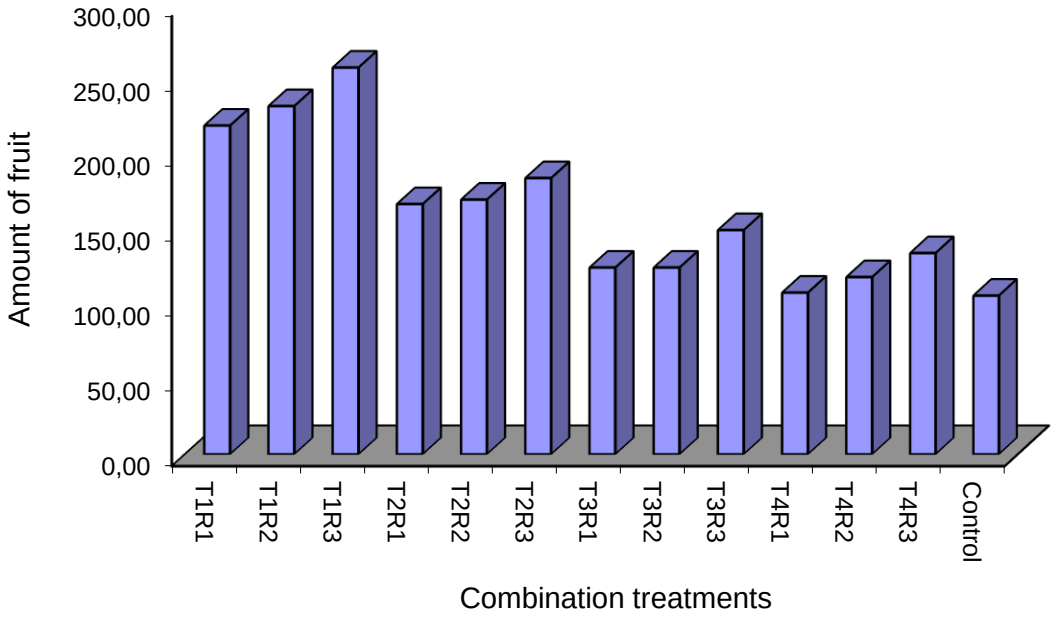

Figure 8. Amount of Fruit for each combination treatment.

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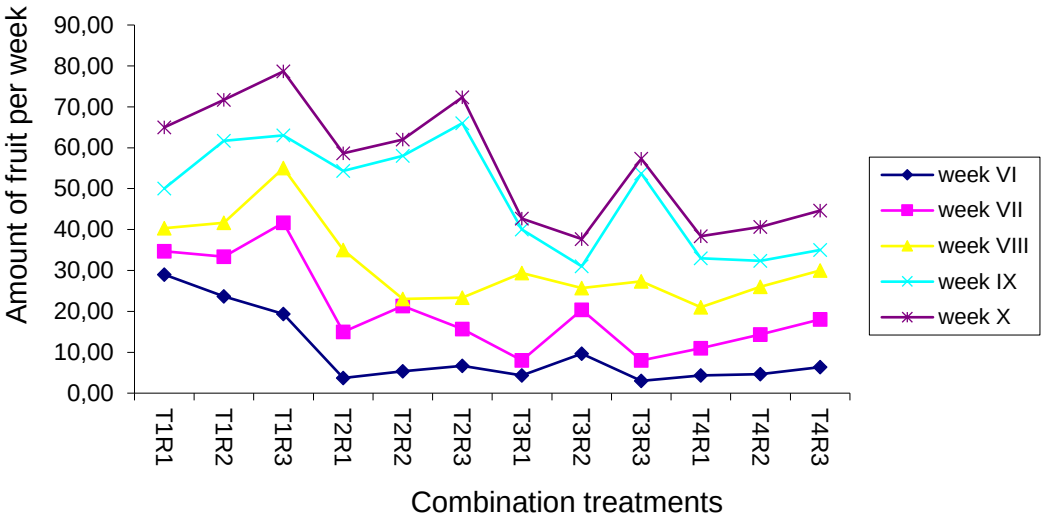

Figure 9. Amount of fruit for each combination treatment every week.

CONCLUSION

Based on the results and discussion, we concluded three points, as follow:

1. At the blooming flowers (bud crown), there were no differences between factors therefore the treatment of T1R3 have the highest inclination with 175 number of flowers.
2. Related to blossom crown, the combination treatment of T1R3 indicated 359.667 as the highest and T4R3 indicated 233.667 as the lowest.
3. In case of ovary and fruit of citrus, the combination treatment of T1R3 produced 1032.667 as the highest and the control produced 404 as the lowest.

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