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Inorganic Nutrient Composition and Frequency of Ratoon on Kangkong (*Ipomoea reptans* Poir) in Pot Trial Using Ultisol Media for Urban Farming

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ABSTRACT

Kangkong (Ipomoea reptans) *is a type of vegetable that is quite easy to cultivate. Cultivation of kangkong with a ratoon system is more efficient in cultivation time and input, and harvesting can be done more than once. Yield of ratoon cultivation system is influenced by ratoon frequency and nutrition. This study aims to determine the effect of inorganic nutrient composition and ratoon frequency. The research was conducted from January to March 2022 at the University of Bangka Belitung. The research method used factorial Completely Randomized Design (CRD). The first factor was the composition of inorganic nutrients, consisting of N1 (AB mix), N2 (NPK + Gandasil D), and N3 (NPK + Growmore). The second factor is the frequency of ratoon, consisting of R0 (no ratoon), R1 (ratoon frequency of 1), R2 (ratoon frequency of 2), and R3 (ratoon frequency of 3). The results revealed that treatment combinations had no significant effect on all observed variables. Composition of inorganic nutrients have a significant effect on root variables with the AB mix treatment as the best. Ratoon frequency treatment had a significant effect on almost all variables (except total number of leaves) with the best treatment being without ratoons (R0). The average total number of leaves of kangkong plants showed the highest yield in the N3R3 treatment, reaching 14.52 strands and the lowest yield in the N1R1 treatment with 12.81 strands.*

1. INTRODUCTION

Kangkong or water spinach (*Ipomoea reptans*) is a type of vegetable that is popular in Indonesia. Kangkong has a relatively short harvest time, namely 4-6 weeks. This vegetable is quite popular with the public, apart from being an easy cultivation process, it also contains nutrients that are good for body health. Kangkong contains carbohydrates, protein, fat, calcium, phosphorus, iron, vitamin A, vitamin B1 and vitamin C (Swastini, 2015). This nutritional content makes kangkong one of the plants that can meet nutritional needs. Urban farming is economically profitable and also improves the beauty of the city. Urban farming is implemented with the concept of sustainable agriculture (Fauzi *et al.*, 2016), which is carried out by optimizing yards as household-scale agricultural land (Swardana, 2020). Cultivating kangkong plants using a pot planting system can be an alternative.

Kangkong cultivation is generally carried out using a plucking or single harvest system, in contrast to the ratoon cultivation system which can be harvested several times. Ratoon is a new shoot that appears after pruning (Mareza *et al.*, 2016). Pruning is done to regenerate new shoots on the parent plant. Ratooned kangkong is more efficient in cultivation time and input compared to conventional kangkong cultivation, so it has great potential for development.

Another advantage of the ratoon cultivation system is that the harvest time of the plants is shorter (Ambarita *et al.*, 2017). However, the weakness of the ratoon system is that the crop yield after ratoon is generally less than the first crop. Nurhaliza *et al.* (2020) stated that the more often plants are ratooned, the lower the production produced. Therefore, it is necessary to know the correct ratoon frequency for kangkong plants.

Kangkong is a type of plant that is harvested in the vegetative phase. According to Sabran *et al.* (2015) the vegetative phase is greatly influenced by the levels of nutrients absorbed by the plant. The regrowth phase of plants after pruning requires meristem tissue and sufficient nutrition. Meristem tissue is young tissue that has the potential to grow again. The research results of Nuzul *et al.* (2018) revealed that ratoon rice produces fewer tillers because the nutrients in the plant are not sufficient to support the growth of the tillers. AB mix nutrition is commonly used in hydroponic cultivation and is equipped with complete nutrient content. The application of AB mix as fertilizer in non-hydroponic media has been tested on red chili plants and provided good growth results (Sianturi *et al.*, 2021). The results of research by Nugraha & Susila (2015) on hydroponic spinach plants show the ability of NPK fertilizer as an alternative nutrient to replace AB mix nutrition. The maximum growth achieved with NPK fertilization can reach 86% when compared to using AB mix nutrients where maximum growth of 100% can be achieved.

Ultisol soil is a type of soil that is widespread in Indonesia. The distribution area of ultisol soil is around 45.79 million ha or 25% of Indonesia's land area (Alibasyah, 2016). The physical, chemical and biological properties of ultisol soil are less favorable for plant growth. Rauf *et al.* (2020) added that ultisol soil has thin natural soil fertility in the A horizon with low organic matter content. The use of ultisol soil as a planting medium has potential with the right processing and fertilization system. The research results of Irawan *et al.* (2017) by adding NPK fertilizer to ultisol soil is able to provide the nutrients needed by plants. NPK fertilizer contains the main macro nutrients, namely nitrogen, phosphorus and potassium. In this research, the NPK application was further complemented by the addition of micro elements originating from liquid complementary fertilizer (LCF). The effectiveness of LCF-enriched NPK which is used as an alternative nutrient in pot system kangkong cultivation as a liquid fertilizer which is poured onto the soil has not yet been studied and compared with AB mix. The research results of Anam & Amiroh (2017) showed that the addition of Gandasil D fertilizer (3 g/L of water) gave the best results for the growth and production of kangkong plants. Based on the explanation above, this research was conducted to determine the composition of inorganic nutrients and the appropriate ratoon frequency to obtain optimal kangkong crop yields.

2. MATERIALS AND METHODS

The materials used in this research were kangkong seeds, ultisol soil, water, AB mix nutrients, NPK fertilizer, Gandasil D, and Growmore 20-20-20. The tools used in the research were digital scale, pH meter, and Munsell Color chart for plant tissues.

The research was carried out using the factorial Completely Randomized Design (CRD) experimental method. The first factor is the treatment of the composition of the inorganic nutrient mixture with 3 levels of treatment, namely: N1 = AB mix 5 mL/L of water; N2 = NPK + Gandasil D = 1 g NPK + 0.5 g Gandasil D per liter of water; and N3 = NPK + Growmore = 1 g NPK + 0.5 g Growmore per 1 liter of water.

The second factor was ratoon frequency treatment with 4 levels. The schedule of pruning or harvesting for different ratoon frequency was summarized in Table 1. There were 12 treatment combinations that was replicated 3 times. Each treatment combination consisted of 5 pots so that 180 experimental unit pots were provided.

Table 1. Treatment of ratoon frequency on kangkong

Code	Time for 1st ratoon (DAP)	Time for 2nd ratoon (DAP)	Time for 3rd ratoon (DAP)	Final harvest (DAP)
R_0	-	-	-	32
R_1	16	-	-	32
R_2	16	24	-	32
R_3	14	20	26	32

Note: Code for R_0 (no ratoon), R_1 (ratoon frequency 1X), R_2 (ratoon frequency 2X), and R_3 (ratoon frequency 3X).

2.1. Experimental Procedure

The research was carried out in January-March 2022. Research activities were carried out at the Research and Experimental Field of University of Bangka Belitung. The research was carried out in a steel-framed grow house with a UV plastic roof, with dimensions of 15 m long, 3 m wide and 3 m high. The planting medium used was a layer of ultisol soil with a depth of 15 cm. The planting medium was air-dried and then sieved. Each polybag was filled with 3 kg soil. Seedling of kangkong seeds were performed using tissue media and transferred to polybags at the age of 2 DAS (days after seedling), with each polybag containing 5 kangkong plants. Inorganic nutrients were applied when the plants are 5 DAT (days after transplanting). Fertilization was carried out again every 5 days until the plants were 25 HST. The volume of fertilizer watering was based on field capacity of the soil, namely 480 mL/polybag. Ratoon treatment was carried out according to ratooning schedule (Table 1) with a pruning height of 4 cm above ground level. Harvesting before 32 DAT was done by cutting the shoots and leaving the stem so that the shoots regrow. Final harvesting at 32 DAT for all treatments was carried out by removing all plant parts (roots, stems, and leaves). The roots of the kangkong plants were washed until clean for further post-harvest observations.

The variables observed were total plant height, total number of leaves, leaf color, total leaf area, total stem diameter, total wet shoot weight, total shoot dry weight, root wet weight at 32 DAT, root dry weight at 32 DAT, root volume at 32 DAT, and the root-shoot ratio. The root volume was measured by placing the roots in a measuring cup containing water of known initial volume, then placing the roots completely in the water (calculated as the final volume). The root volume was the difference between the final volume and the initial volume. Quantitative data from observations was processed using the analysis of variance (ANOVA) method at a confidence level of 95%. Analysis results that have a significant effect will be carried out with further tests using the Duncan Multiple Range Test (DMRT) at a confidence level of 95%. Qualitative data from observations was presented in the form of images and descriptions.

3. RESULTS AND DISCUSSION

3.1. Leaf Color

Figure 1 and 2 show kangkong plants cultivated under different treatments. The figure was grouped according to inorganic nutrient composition treatment factor (Figure 1) and ratoon frequency factor (Figure 2). The results of observations of leaf color changes showed that treatment without ratoon (R0) and ratoon frequency 1X (R1) combined

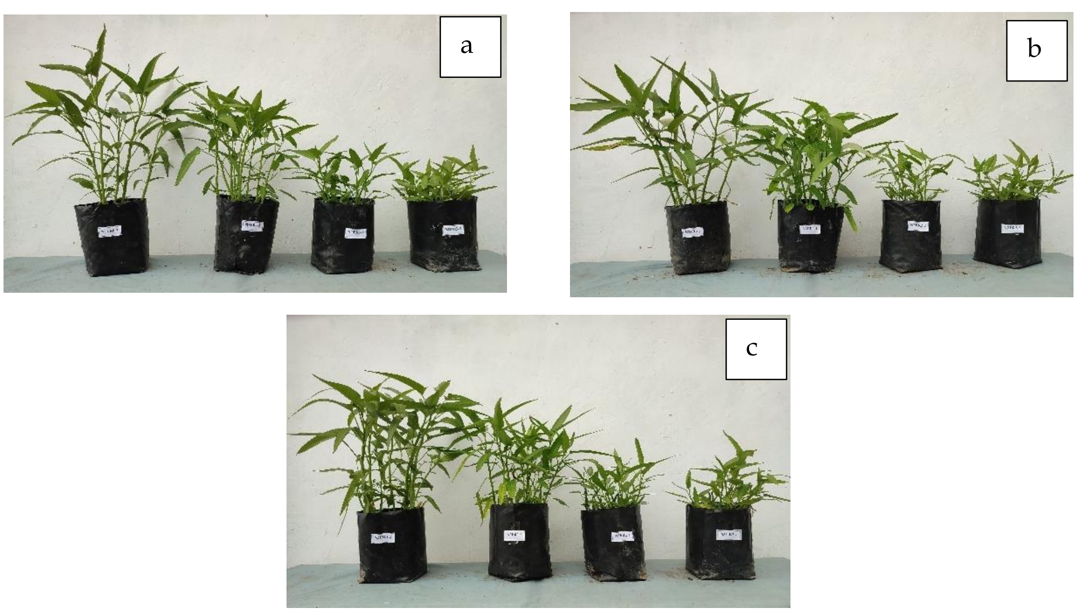

Figure 3. Kangkong plants 32 HST treated with inorganic nutrient composition a. N1 (AB Mix), b. N2 (NPK + Gandasil D), and c. N3 (NPK + Growmore)

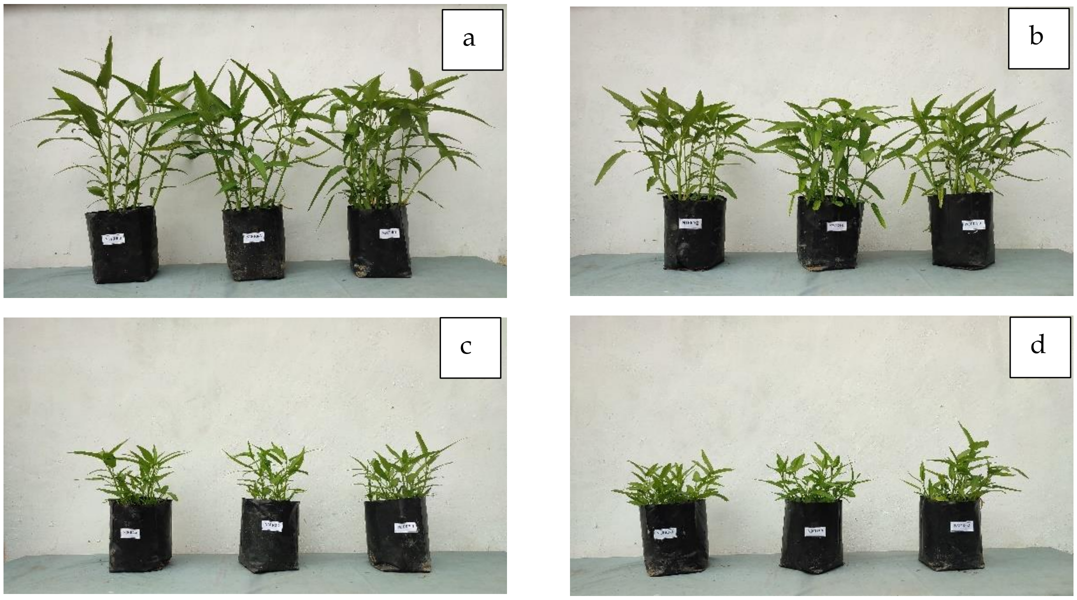

Figure 4. Kangkong plants at 32 DAT with ratoon frequency treatment: (a) R0 (no ratoon), (b) R1 (1X ratoon), (c) R2 (2X ratoon), and (d) R3 (3X ratoon)

with the application of inorganic fertilizer in various compositions resulted in darker leaf color compared to ratoon frequency 2X (R2) and ratoon frequency 3X (R3). The leaf color of kangkong plants with the inorganic nutrient composition treatment combined with ratoon frequency 2X (R2) was relatively the same as the inorganic nutrient composition treatment combined with ratoon frequency 3X (R3).

The leaf color variable of kangkong plants in the ratoon frequency treatment resulted in the leaf color tending to be the same, namely Green Yellow (5GY) in all treatments, but there were differences in the Value and Chroma values. The Value indicates the darkness of the color of the leaf, where the smaller the Value, the darker the color of a leaf. Chroma value shows the gradation of purity of the color spectrum of the leaf. The results of research on ratoon frequency treatments R0 (without ratoon) and R1 (ratoon frequency 1X) gave darker leaf color results. This is because the time interval for ratting plants is too short, causing the harvested plants to be still quite young and the chlorophyll content of the leaves is still low. This can be seen from the treatment of R2 and R3 with a shorter rattan interval compared to R0 and R1, producing lighter leaf colors. According to Santoso & Widyawati (2020), the chlorophyll content in leaves will increase as the age of the leaves increases, which is influenced by the nutrient content of nitrogen (N), magnesium (Mg), and the availability of sunlight.

Leaf color changes in the inorganic nutrient composition treatment did not show color differences based on visual observation using Munsell Color Charts for Plant Tissues, but using AB mix resulted in darker leaf colors compared to other nutrients. This is because the AB mix used contains the nutrient Mg higher than the other two nutritional sources. Based on the nutrient composition, AB mix contains 6.6% Mg, higher than Gandasil D (1%) and Growmore (0.01%).

Table 2. Color of kangkong leaves at the age of 32 DAT using the Munsell Color Charts for Plant Tissues book

Frekuensi Ratun	Inorganic nutrient composition		
	N1	N2	N3
R0	5 GY 4/6	5 GY 4/4	5 GY 4/6
R1	5 GY 4/6	5 GY 4/6	5 GY 5/6
R2	5 GY 5/6	5 GY 5/8	5 GY 5/8
R3	5 GY 5/6	5 GY 5/8	5 GY 5/8

Note: N1 (AB mix), N2 (NPK + Gandasil D), N3 (NPK + Growmore), R0 (no ratoon), R1 (ratoon 1X), R2 (ratoon 2X), R3 (ratoon 3X)

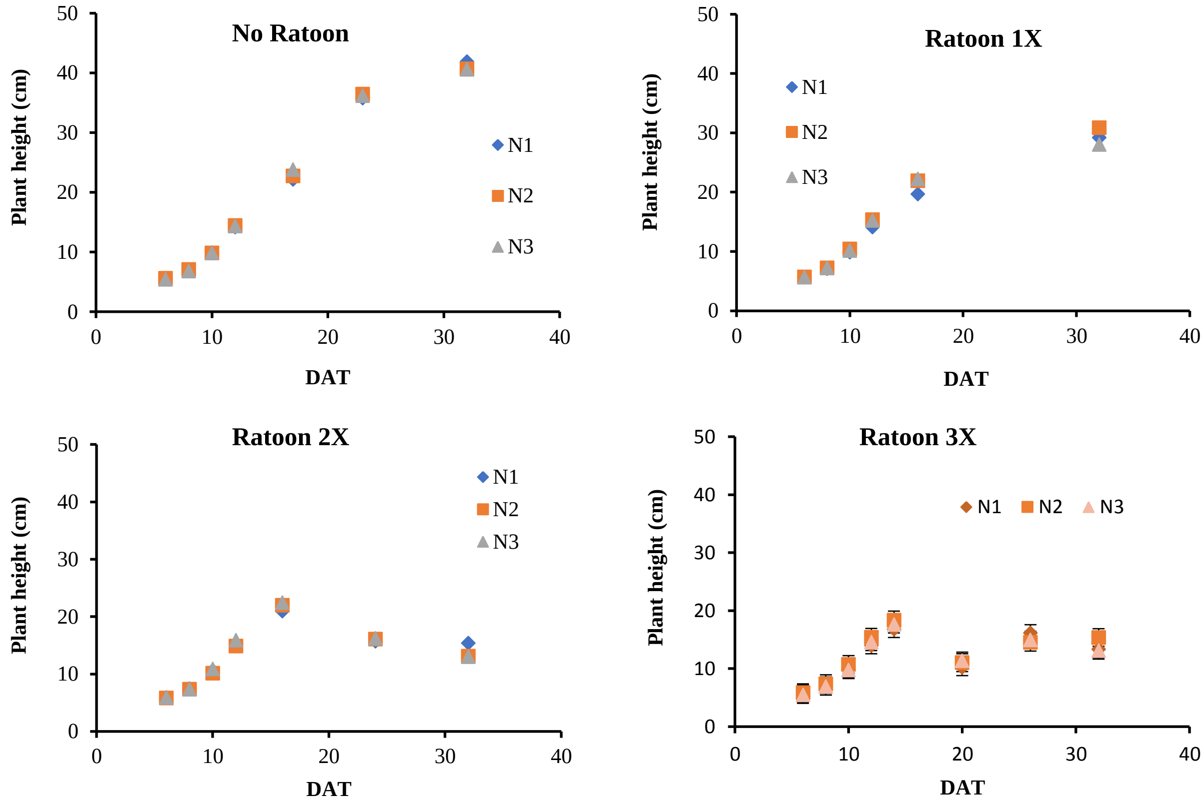

Figure 3. Plant height of kangkong due to different ratoons and inorganic fertilizer compositions observed from 6 to 32 DAT

3.2. Plant Height

Figure 3 shows plant height of kangkong for different treatment combinations. Kangkong plant height without ratoon grows linearly to around 40 cm for the three types of inorganic fertilizer composition. Kangkong plants under ratoon treatments, the remaining pruning as high as 4 cm were regrown and observed again just before the next ratoon. The height growth rate of kangkong plants was relatively the same when using different inorganic nutrient compositions for each ratoon frequency. The height of kangkong plants without ratoons (R0) increased from 6 DAP to 32 DAT with the highest average yield in the N1 treatment, namely 41.86 cm and the lowest in the N3 treatment, namely 40.6 cm. Ratoon frequency treatments R2 and R3 experienced a decrease in plant height after the first ratoon (16 DAT and 14 DAT) and experienced an increase in plant height again after the 2nd ratoon (24 DAT and 20 DAT). The N1 treatment gave the highest plant height results at ratoon frequencies R0 and R2, while the N2 treatment gave the highest plant height results at R1 and R3. The pruning height is not zero because there are remaining stems that still have leaves (pruning height 4 cm as seen in Figure 1).

3.3. Number of Leaves

Figure 4 shows the development of the number of leaves of kangkong plants in various treatment combinations. Without ratooning, the number of leaves increased to around 15 at 23 DAT. With ratoon treatment, the number of leaves decreases due to subsequent pruning (2nd ratoon) such that the number of leaves decreases again. The data was obtained before pruning, after pruning no further measurements were taken, so that data from day 16 and pruning day (ratoon) were continued from the last data, not starting from the initial data.

The growth rate of the number of leaves of kangkong plants is relatively the same when using different inorganic nutritional compositions for each ratoon frequency. The number of leaves of kangkong plants without ratoon (R0) increased until the age of 23 DAT and decreased after that in the N2 and N3 treatments. The highest peak number of

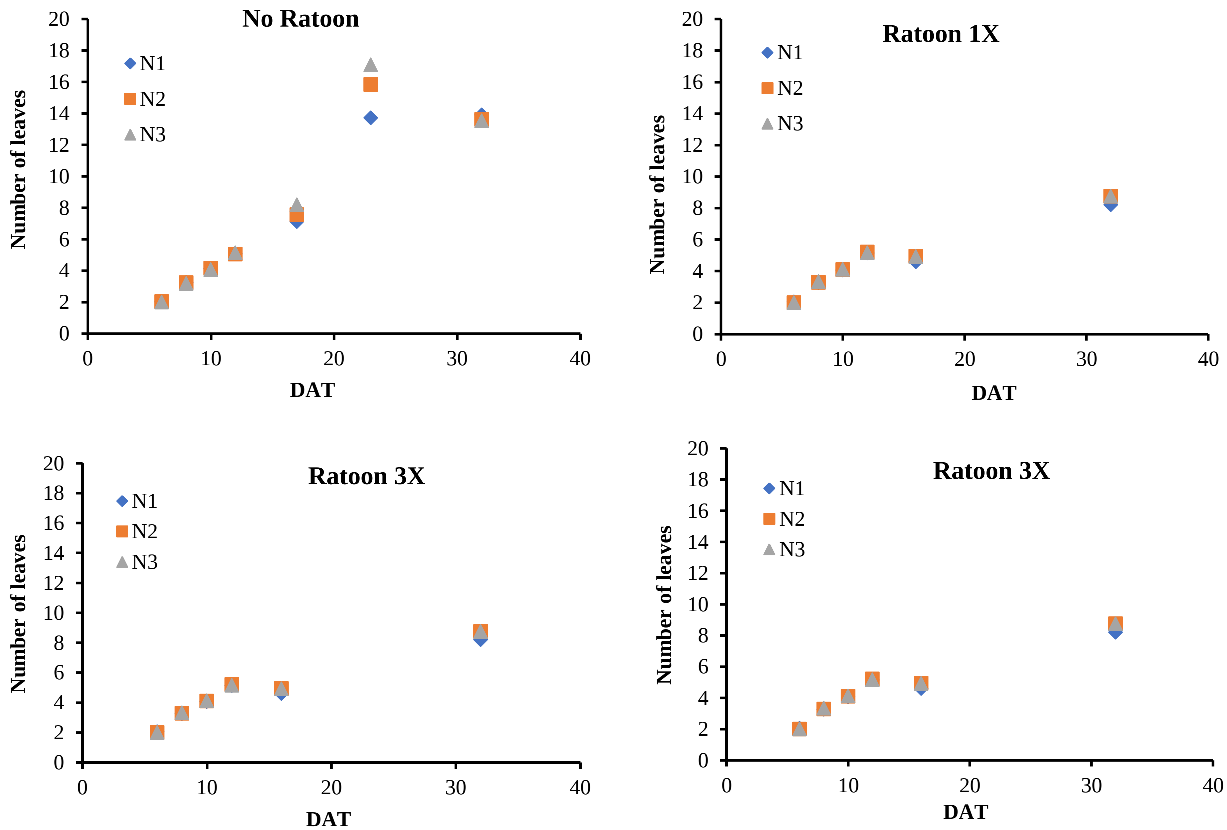

Figure 2. Number of leaves of kangkong due to different treatment combinations observed from 6 to 32 DAT (N1 = (AB mix), N2 = (NPK + Gandasil D), N3 = (NPK + Growmore), R0 = (no ratoon), R1 (ratoon 1X), R2 (ratoon 2X), R3 (ratoon 3X).

leaves for plants without ratoons (R0) at 23 DAT was in the N3 treatment, namely 17.09 and the lowest was in the N1 treatment, namely 13.27. The ratoon frequency treatments R1 and R2 experienced an increase in the number of leaves at the age of 32 DAT after the ratoon treatment, while the ratoon frequency 3X (R3) give an increase in the number of leaves at the age of 26 DAT and 32 DAT after the ratoon treatment.

3.4. Other Parameters

The results showed that the inorganic nutrient composition treatment had no significant effect on the growth of the kangkong plant canopy. This can be seen in the variables total plant height, total number of leaves, total leaf area, total stem diameter, total wet weight of the crown, and total dry weight of the crown. Table 3 shows that in total plant height the frequency of ratoons that gave the best results in treatment R1 was significantly different from treatments R0, R2 and R3. The variables total leaf area, total wet weight of the shoot, and total dry weight of the shoot were ratoon frequency which gave the best results in treatment R0 which was significantly different from treatments R1, R2, and R3. The ratoon frequency stem diameter variable gave the best results in treatment R3 which was significantly different from treatments R0, R1, and R2. The variable for total bag diameter of the treatments that was not significantly different was nutritional composition, while ratoon frequency was significantly different.

The average data in Table 4 shows that for the root variables (root wet weight, root dry weight, and root volume), the ratoon frequency treatment that gave the best results was the R0 treatment which was significantly different from the R1, R2, and R3 treatments. The inorganic nutrient composition treatment gave the best results for the wet root weight variable, namely the N1 treatment, which was significantly different from the N2 and N3 treatments. The same trend also applies to dry weight and root volume variables.

Table 3. Total plant height, total number of leaves, leaf area, stem diameter, total shoot wet weight, and total shoot dry weight in the treatment of inorganic nutritional composition and ratoon frequency.

Treatment	Total plant height (cm)	Number of leaves	Total leaf area (cm^2)	Total stem diameter (cm)	Total shoot wet weight (g)	Total shoot dry weight (g)
Inorganic nutrient composition						
N1	43,83a	13,21a	22,41a	1,05a	48,15a	2,39a
N2	44,99a	13,60a	22,20a	0,92a	48,68a	2,25a
N3	43,89a	13,75a	22,25a	0,92a	48,36a	2,28a
Ratoon frequency						
R0	41,04c	13,68a	25,41a	0,81b	68,23a	4,44a
R1	46,66a	13,39a	23b	0,91b	55,56b	2,30b
R2	43,68b	13,08a	19,27c	0,99ab	35,20c	1,27c
R3	45,59ab	13,93a	21,46bc	1,14a	34,59c	1,21c
CV (%)	5,44	5,95	9,96	21,97	11,98	20,16

Note: Numbers followed by the same letter in the same column indicate that there is no significant difference in DMRT at the 95% confidence level. CV = Coefficient of variance.

Table 4. Root wet weight, root dry weight, root volume, root-shoot ratio at 32 DAT due to different combination treatments of inorganic nutritional composition and ratoon frequency

Perlakuan	Wet root weight (g)	Dry root weight (g)	Root volume (mL)	Root-shoot ratio
Inorganic nutrient composition				
N1	24.80a	2.17a	28.13a	1.70b
N2	18.39b	1.34b	19.75b	2.81a
N3	20.16b	1.51b	22.06b	2.64a
Ratoon frequency				
R0	46.29a	4.69a	50.48a	1.01c
R1	20.13b	1.12b	22.53b	2.25b
R2	8.61c	0.40b	9.62c	3.43a
R3	9.43c	0.48b	10.26c	2.86ab
CV (%)	22.53	42.66	20.44	34.85

Note: Numbers followed by the same letter in the same column indicate that there is no significant difference in DMRT at the 95% confidence level. CV = Coefficient of variance.

The treatment of inorganic nutrient composition based on the results of analysis of variance gave a real influence on the variables of root wet weight, root dry weight, root volume and root crown ratio of kangkong plants. This shows that the type of inorganic nutritional composition used generally provides the same canopy growth response or is not significantly different. The inorganic nutrients given to kangkong plants are able to meet the nutritional needs needed during the growth period of kangkong plants until harvest. The levels of N, P and K nutrients contained in NPK + Gandasil D and NPK + Growmore are higher than AB mix, however, the nutrient content in AB mix is sufficient to support the growth of kangkong plants. Macro and micro nutrients that are available in quantities appropriate to plant needs will result in optimal growth and production (Kurniawan *et al.*, 2017). According to Wulandari *et al.* (2018), plants consist of several elements such as N, P, K and several other nutrients during the plant growth process as an energy source in the process of cell synthesis and metabolism. Nitrogen and phosphorus play a role in the formation of new cells and are the main components of organic compounds in plants such as amino acids, nucleic acids, chlorophyll, ADP and ATP. Potassium plays a role in the photosynthesis process as an enzyme activator in increasing the translocation of photosynthesis results to plant growth points.

The results of further DMRT tests on the effect of inorganic nutrient composition treatment on the variables of root wet weight, root dry weight, root volume and root crown ratio showed that AB mix nutrition provided better root growth results than other treatments. AB mix nutrition contains complete essential nutrients that plants need for their growth and development. Complete macro and micro nutrients and in balanced amounts are really needed by plants.

According to Max & Liworngawan (2013), genetic factors and the availability of nutrients in sufficient and balanced quantities greatly influence the growth period of plants. The AB mix used has a higher calcium nutrient content than other nutrients, reaching 18.1%. Calcium plays an important role in supporting plant root growth. Increasing the number of roots causes root weight and root volume to increase as well as more optimal absorption of water and nutrients. This is in accordance with the opinion of Rahmadhani *et al.* (2020) the more roots there are, the root biomass and root volume will also increase.

The ratoon frequency treatment based on the results of analysis of variance had a significant effect on almost all variables except the total number of leaves of kangkong plants. This shows that ratoon frequency influences the growth and production of kangkong plants. Pruning the apical dominant part of a plant is done with the aim of growing new tissue. According to Santoso *et al.* (2014) breaking the apical dominance of a plant has a significant impact on increasing the number of branches or shoots which influences the production of a plant. The distance between ratooning time 1 and the next in the same ratooning frequency treatment affects the production of kangkong plants, the longer the interval between ratooning, the higher the production results. This is because the plants can grow optimally before the next rattan time. According to Sibarani *et al.* (2015) long harvest intervals provide an opportunity for shoots to grow elongated, while fast harvest intervals allow for branching to form rather than shoot elongation. The results showed that the average total wet weight of the crown started from the highest in the R0 ratoon frequency treatment and the lowest in the R3 ratoon frequency treatment. This shows that the increasing number of ratoon frequencies is inversely proportional to the production results obtained.

The DMRT results regarding the effect of ratoon frequency treatment on all variables gave significantly different results, except for the total number of leaves which gave results that were not significantly different. The R0 ratoon frequency treatment (without ratoons) gave the best results for the variables total leaf area, total shoot wet weight, total shoot dry weight, root wet weight, root dry weight and root volume. The total wet weight of the canopy of ratted plants was lower than that of plants without ratoons. The high frequency of ratting means that the plants do not have enough time to grow big before the next ratting time. This also affects the growth of plant roots. Ratooned plants produce fewer roots than plants without ratoons. Ratooned plants undergo pruning so that plant growth focuses on growing new shoots rather than plant roots. Plant roots are the part of the plant that is farthest from the photosynthetic organs, so the levels of photosynthesis received by the roots are relatively less.

The leaf area variable of kangkong plants in the ratoon frequency treatment gave better results in the treatment without ratoons (R0). The average leaf area of kangkong plants without ratooning (R0) reached 25.14 cm2 and decreased with the frequency of ratooning. This is because plants that are ratted at shorter intervals do not have enough time for plant development, resulting in a narrower leaf area. Plants with a large leaf area can increase the rate of photosynthesis because the absorption of sunlight by the leaves increases. Leaves are vegetative organs that act as a site for photosynthesis, so the number and area of leaves greatly influence plant growth (Mayani *et al.*, 2015). Aryandhita & Kastono (2021) added that an optimal photosynthesis rate can produce optimal plant growth and yields.

The shoot-root ratio is the proportion of the shoot and root ratio of the plant. A high value of the shoot-root ratio indicates that the plant shoot develops better than the plant roots. This is because the proportion of the crown is greater than the plant roots. The proportion of shoots and roots is influenced by the availability of food reserves and nutrients. A low shoot-to-root ratio value results in better dry matter production (Rahmawati *et al.*, 2013). The AB mix inorganic nutrient composition treatment produced the lowest root shoot ratio value, namely 1.70. This is in line with the results of root wet weight and root volume which were higher compared to other treatments. Good root growth causes maximum nutrient absorption, resulting in good plant growth and production. Of the variables observed as a whole, the AB mix treatment provided better plant growth and yield compared to other treatments.

The R0 ratoon frequency treatment (without ratoons) produced the lowest root crown ratio value, namely 1.01, which was significantly different from the R1, R2 and R3 treatments. This shows that in the R0 treatment the plant roots were more developed than the kangkong plant crowns and vice versa in R1, R2 and R3 the plant crowns were more developed than the kangkong plant roots. The results of the ANOVA reveals that interaction of inorganic nutritional composition and ratoon frequency treatments produced insignificant effects on all observed variables.

4. CONCLUSION

The composition of inorganic nutrients has a significant effect on the root variables of kangkong plants. The N1 treatment gave the best results on the variables of root wet weight, root dry weight, and root volume of kangkong plants. Ratoon frequency had a significant effect on almost all variables of kangkong plants except the total number of leaves. The no ratoon (R0) treatment gave the best results for almost all variables except total plant height, total stem diameter, and root-shoot ratio of kangkong plants. The combination of treatments between inorganic nutrient composition and ratoon frequency had no significant effect on all kangkong plant variables.

Ratoon frequency treatment was not able to increase plant growth for all observed variables when compared to treatment without ratoon (R0). Plants that are ratooned require time to grow again after pruning, so that the frequency of ratoons is not yet comparable to those without ratoon which do not relatively experience growth disturbances.

The recommendations for this research are based on growth variables and harvest weight. Nutrient requirement for kangkong plants grown on ultisol media with or without ratoon can be fulfilled by either AB mix fertilizer, NPK+Gandasil D or NPK+Growmore. Nutrient composition did not cause significant differences for all shoot growth variables, but had a significant effect for all root variables.

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