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Potential of Scallion Population (*Allium fistulosum* L.) in Intercropping Pattern with Katokkon Chili and LOF Type in Increasing Productivity

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Abstract

This study aims to determine the effect of the spring onion (*Allium fistulosum* L.) population in an intercropping pattern with Katokkon chilli (Capsicum annuum L. var. sinensis) and the type of Plant Organic Compost (LOF) on plant productivity. The research was conducted from February to September 2024 in Lilikira Village, Nanggala District, North Toraja Regency. A two-factor factorial design was arranged in a randomized block design (RBD). The first factor was the intercropping planting pattern, which consisted of three levels: TS1 (Katokkon intercropped with one row of spring onions), TS2 (Katokkon intercropped with two rows of spring onions), and TS3 (Katokkon intercropped with three rows of spring onions). The second factor was the type of LOF, which included three levels: P0 (control), P1 (banana tuber LOF), and P2 (krokot LOF). The results showed that the intercropping pattern of spring onions with a population of 20 spring onions per plot with Katokkon chili combined with the type of banana tuber LOF had a significant effect on the variables of Katokkon chili, namely flowering age, number of productive branches, number of fruits per plant, number of fruits per plot, fruit weight per plant and fruit weight per plot. The intercropping pattern of spring onions with a population of 20 spring onions per plot with Katokkon chili combined with the type of banana tuber LOF had a significant effect on the variables of spring onions, namely the number of leaves at 8 weeks after planting, the number of shoots, weight per clump and weight of clump per plot.

Keywords: Banana Tuber LOF, Intercropping, Katokkon chili, Krokot LOF, Spring onions

1. Introduction

Katokkon chilli is a local Toraja variety with a high level of spiciness, namely 30,000 to 50,000 Scoville Heat Units (SHU) and a distinctive aroma (Kasmiati, 2021). The selling value of this chili is relatively high when compared to national chili, namely an average of 40,000-60,000 per kg, and can even reach a price of 100,000 per kg in the Toraja market. Katokkon chili production at the farmer level is still relatively low compared to the potential yield due to less intensive maintenance, fertilization, and management of pests and plant diseases. Farmers' dependence on chemical fertilizers is an obstacle to cultivation that farmers in Toraja often experience. Excessive use of chemical fertilizers can cause land degradation and production stagnation. In addition, the scarcity and high price of chemical fertilizers cause farmers to generally not fertilize as they should in plant cultivation technology.

Banana pith liquid organic fertilizer (LOF) and purslane LOF can be an alternative to overcome the scarcity of chemical fertilizers because they contain macro and micronutrients and are more easily absorbed by plants because they have undergone a fermentation process. Banana LOF contains nutrients NO3 3087 ppm, NH4 1120 ppm, P2O5 439 ppm, K2O 574, and high levels of phenolic acid in banana LOF helps bind Al, Fe and Ca ions to help the availability of soil P, which useful in the process of flowering and fruit formation (Kartana et al., 2021). According to Kiral (2019), purslane can be used as a vegetable pesticide and organic fertilizer. The tannin content in purslane causes plants given purslane to be disliked by pests. Purslane is also rich in nutrients, including nitrogen, phosphorus, magnesium and potassium.

In addition, in the Katokkon cultivation system, the

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planting distance is quite wide, on average 80 cm or 100 cm, so there is still a large empty space between plants. This condition indicates that there is inefficiency in the use of growing space and the capture of sunlight by plants. Intercropping planting patterns can be an alternative to increase land use efficiency. Efficiency is an effort to use resources minimally but can provide high results for crop production. The efficiency of intercropping land use compared to monoculture can be seen from the land equivalency value (NKL); if NKL is greater than 1 (> 1), it means that it provides profitable results (Dewi et al., 2017). The intercropping system can increase land productivity if it is right to choose the type of plant so that it can form a mutually beneficial interaction.

Scallion plants exhibit compatibility for intercropping with Katokkon chili plants due to their distinct growth requirements. Scallions thrive in low light conditions and possess shallow root systems, whereas Katokkon chili plants necessitate full sunlight and develop deeper roots. The interspersion of scallions among chili plants may also mitigate pest infestations, as the presence of scallions can interfere with pests' ability to identify their preferred hosts. This observation aligns with the findings of Pasorong (2022), who noted that scallions serve as effective intercropping or intermediate plants due to their preference for low light and relatively high soil moisture, given that scallions are composed of over 70% water. In the Toraja region, scallions are predominantly cultivated on a small scale as garden plants despite their significant economic potential. However, there is a lack of specific information regarding the role of banana tuber LOF and Krokot LOF within the intercropping framework of Katokkon chili and scallions in enhancing overall plant productivity.

This research seeks to evaluate the efficacy of banana stem LOF and Krokot LOF within the intercropping framework of Katokkon Chili and Scallions to enhance agricultural productivity. The findings of this study are anticipated to contribute valuable insights for advancing Katokkon and scallion farming practices in the Toraja region.

2. Material and Methods

This research was conducted in Lilikira Village, Nanggala Subdistrict, North Toraja Regency 2°55'24.55 “S, 120°0'41.78 ”E. Located at an altitude of 885 m above sea level from February to September 2024.

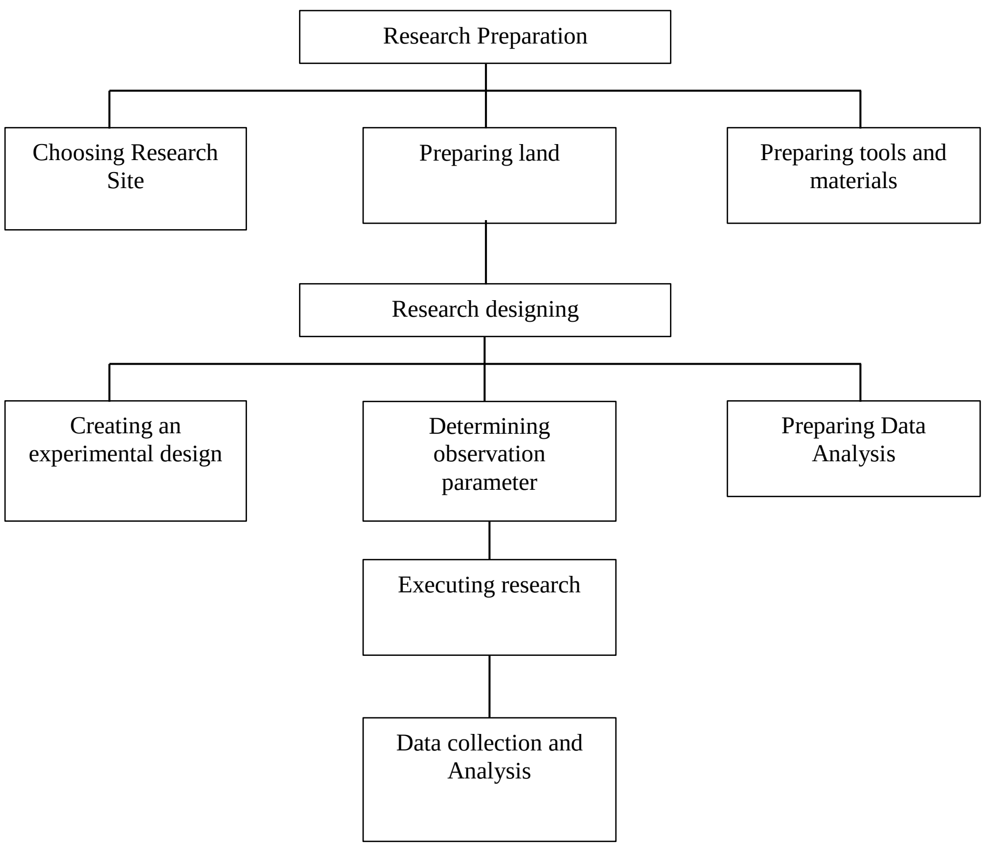

Figure 1. Research flow diagram

The 2-factor factorial study was arranged in a Randomized Group Design (RAK). The first factor was Intercropping Cropping Pattern consisting of 3 levels: TS1 (Catokkon intercropping and 1 row of leek), TS2 (Catokkon intercropping and 2 rows of leek) and TS3 (Catokkon intercropping and 3 rows of leek). The second factor is the type of LOF, which consists of 3 levels: P0 (control), P1 (banana stalk LOF), P2 (purslane LOF) and 9 treatment combinations were repeated three times so that there were 27 experimental units. Each experimental unit was applied to a plot measuring 2.4 m x 3 m. The number of plants in intercropping for Katokkon chili with a distance of 80 x 60 cm is 12 plants, while leeks with a spacing of 20 x 20 cm in TS1, namely 1 row of leeks there are 20 plants, in TS2 2 rows of leeks there are 40 plants, and in TS3, namely 3 rows of leeks there are 60 plants. Variables for the growth and yield of Katokkon Chili plants include (1) Plant height, (2) Number of productive branches, (3) 75% flowering age, (4) Number of fruits per plant, (5) Fruit diameter, (6) Fruit weight. Variables for growth and yield of leaf onion plants include (1) plant height, (2) number of leaves, (3) number of tillers, (4) suing diameter and (5) plant weight.

3. Results and Discussion

3.1. Katokkon Chili

a. Plant Height

The analysis of variance conducted on the height measurements of Katokkon chili plants at 4, 6, and 8 weeks post-planting revealed that the intercropping of spring onions with Katokkon chili, in conjunction with various types of LOF, did not yield statistically significant effects. This finding suggests that even at the highest densities of spring onions, there was no notable impact on the vegetative growth phase of the Katokkon chili plants. It is hypothesized that the availability of water and nutrients remains adequate for the growth of the chili plants, as their root systems extend deeper than those of the spring onions.

Table 1. Average Plant Height 4, 6 and 8 weeks after planting

Treatment	Plant Height (cm)		
	4 mst	6 mst	8 mst
TS1P0	18.82 ± 1.00	24.13 ± 1.00	57.90 ± 1.20
TS1P1	19.64 ± 0.70	25.33 ± 0.80	60.51 ± 1.10
TS1P2	18.66 ± 1.20	24,72 ± 1.40	59,30 ± 1.20
TS2P0	16.07 ± 1.00	21.07 ± 1.60	46.35 ± 1.30
TS2P1	16.48 ± 1.60	21.48 ± 1.80	47.25 ± 1.40
TS2P2	16.13 ± 1.30	23.13 ± 1.80	51.56 ± 1.30
TS3P0	16.05 ± 1.10	21.13 ± 1.80	44.48 ± 1.40
TS3P1	15.71 ± 1.40	20.85 ± 1.40	45.87 ± 1.20
TS3P2	15.52 ± 1.30	22.38 ± 1.50	50.16 ± 1.10

Description: TS = Intercropping Pattern, P = Liquid Organic Fertilizer, WAP = (Week After Planting)

Consequently, it is likely that significant competition for these resources has not occurred, even at elevated spring onion populations. Furthermore, the data illustrated in Table 1 indicates a trend where higher populations of spring onions correspond to relatively reduced heights of Katokkon chili plants by the 8-week mark. This observation implies that as the plants mature, the density of spring onion populations begins to influence the utilization of environmental resources by the Katokkon chili.

b. Flowering Age

The findings presented in Table 2 indicate that the intercropping treatment of spring onions with Katokkon chili, supplemented by banana stem LOF (TS1P1), led to an accelerated flowering age for Katokkon chili, recorded at 37.00 days after planting (hst). This result was not significantly different from the treatment involving a population of 40 spring onion plants intercropped with Katokkon chili and purslane LOF (TS1P2), yet it was significantly distinct from other treatments. The reduced population of spring onions creates additional space for Katokkon chili, enabling it to utilize available resources more effectively, a benefit further enhanced by the nutrient contributions from both purslane and banana stem LOF applications. This dynamic facilitates adequate energy availability for the plants to transition from the vegetative to the generative phase, as evidenced by the emergence of flowers. Supporting this observation, Li et al. (2020) noted that diminished competition within intercropping systems can alleviate plant stress and expedite the shift from vegetative to reproductive stages. Conversely, an increased population of spring onions correlates with a prolonged flowering age, as demonstrated by the treatments involving 40 spring onions with banana tuber LOF (TS3P1) and 60 spring onions with purslane tuber LOF (TS3P2). A higher population intensifies competition for resources, adversely affecting photosynthesis and consequently delaying Katokkon chilli plants' reproductive phase. Furthermore, Elfarisna and Pratiwi (2022) highlighted those specific environmental factors, including temperature, variations in day length, and altitude, can influence flowering and fruiting in plants. Additionally, adequate soil nutrients are crucial for optimal plant growth and effective photosynthesis. In line with that, Barus et al. (2018) state that the amount of photosynthate produced from the photosynthesis process will be used to form flowers and fruits to maximize the resulting production.

c. Number of Productive Branches and number of fruits

The findings from the investigation into cultivating spring onions within an intercropping system alongside

Katokkon chili, utilizing various types of LOF, demonstrated a significant impact on several variables. These include the number of productive branches, the quantity of fruits per plant, and the total number per plot, as illustrated in Table 3.

Table 2. Phosphate Solubility Index (PSI) Measurement

Treatment	Flowering Age (hst)
TS1P0	43.33 ± 1.00 b
TS1P1	37.00 ± 2.00 a
TS1P2	37,33 ± 1.30 ab
TS2P0	41.00 ± 2.10 bc
TS2P1	44.67 ± 1.00 bc
TS2P2	41.00 ± 1.80 ab
TS3P0	44.33 ± 2.20 bc
TS3P1	48.00 ± 0.80 c
TS3P2	47.00 ± 0.90 C

Notes: The average values followed by the same letter in columns (a,b,c) are not significantly different at the BNJ test level of 0.05.

Table 3. Number of productive branches, number of fruits per plant and number of fruits per plot

Treatment	Number of Productive Branches	Number of Fruits per Plant	Number of Fruits per plot
TS1P0	4,34 ± 0.10 ab	46,23 ± 2.00 abc	485.00 ± 10.00 a
TS1P1	6,75 ± 0.20 d	61.58 ± 3.00 e	731.00 ± 15.00 e
TS1P2	5.67 ± 0.30 dc	52.00 ± 4.00 d	616.00 ± 20.00 d
TS2P0	3.67 ± 0.20 ab	45.17 ± 1.00 ab	533.00 ± 35.00 abc
TS2P1	4.50 ± 0.40 abc	49.00 ± 2.00 bcd	579.00 ± 33.00 bcd
TS2P2	5.08 ± 0.03 bc	50.17 ± 1.00 cd	593.00 ± 35.00 a
TS3P0	3.00 ± 0.05 a	41.83 ± 2.00 a	491.00 ± 38.00 a
TS3P1	3.25 ± 0.05 ab	44.67 ± 1.00 ab	518.33 ± 50.00 ab
TS3P2	3.75 ± 0.06 ab	46.00 ± 1.00 abc	521.00 ± 38.00 ab

Notes: The average values followed by the same letter in columns (a,b,c) are not significantly different at the BNJ test level of 0.05.

The findings indicated that the treatment involving a population of 20 leek plants cultivated in an intercropping arrangement with Katokkon chili, supplemented by banana stem LOF (TS1P1), yielded the most favorable outcomes regarding the number of productive branches. This enhancement can be attributed to reduced competition for vital resources during the primary growth phase, which facilitates an increase in photosynthate production, thereby enabling the plants to devote more energy to developing productive branches. Supporting this observation, Galuh (2022) noted that optimal vegetative growth and favorable environmental conditions correlate with improved generative growth.

Furthermore, the intercropping treatment of 20 leek plants with Katokkon chili and banana stem LOF (TS1P1) resulted in the highest yield of fruits per plant and per plot. The increased fruit yield is likely due to diminished competition for water, nutrients, and sunlight, which fosters more favorable growth conditions for the Katokkon chili plants. The generative phase, characterized by flower and fruit formation, necessitates optimal growth conditions, as this phase demands significant energy for the transition from vegetative growth to fruit development. In agreement with this, Khan et al. (2023) asserted that reduced competition within an intercropping system can enhance the productivity of the primary crop's fruit. Additionally, this treatment not only resulted in more productive branches but also increased the potential fruit yield.

d. Fruit Weight

The results of the study on the intercropping pattern of spring onions with Katokkon chilies combined with different types of LOF and the results of the analysis of variance in Table 4 show that the treatment had no significant effect on the weight per fruit but had a significant effect on the weight of fruit per plant and the weight of fruit per plot.

Fruit weight per plant and plot also showed a significant increase with the treatment of 20 plants of spring onion population in the intercropping pattern with Katokkon chili combined with banana stem LOF (TS1P1). This shows that Katokkon chili plants can effectively utilize additional nutrients from banana stem LOF when competition between spring onion plants is minimized. Research by Susanto et al. (2020) supports this finding, stating that combining organic fertilizers and proper plant population management can increase yields by improving the efficiency of nutrient use and overall plant health. According to a study by Amiroh et al. (2020), high nutrient absorption can support plant growth because plant nutrients are sufficient, thus increasing plant production. The combination with banana stem LOF showed the best fruit weight because banana stems contain nutrients and growth hormones, namely cytokinins and gibberellins, which play an important role in cell division and morphogenesis activities, thus affecting fruit size. Hia supports this, A.S. et al. (2023) who stated that banana stems contain plant hormones, namely gibberellins and cytokinins, and also contain microorganisms that are useful for plants, including; phosphate-solubilizing microbes, aspergillus, azopyrillium, aeromonas, bacillus, cellulolytic microbes azetobacter.

Table 4. Weight per fruit, fruit weight per plant and fruit weight per plot

Treatment	Weight per Fruit (g)	Fruit/plant weight (g)	Fruit weight/plot (kg)
TS1P0	4.13 ± 0.50	210.39 ± 21.00 ab	2.52 ± 0.10 ab
TS1P1	5,48 ± 0.60	340.85 ± 24.00 c	4.09 ± 0.20 c
TS1P2	4.94 ± 0.20	255.60 ± 22.00 b	3,07 ± 0.20 b
TS2P0	4.22 ± 0.10	164.35 ± 11.00 a	1.97 ± 0.10 a
TS2P1	4.17 ± 0.20	200.94 ± 23.00 ab	2.41± 0.02 ab
TS2P2	4.35 ± 0.30	218.35 ± 1.00 ab	2.62 ± 0.05 ab
TS3P0	3.79 ± 0.40	159.83 ± 23.00 a	1.92 ± 0.06 a
TS3P1	4.18 ± 0.50	186.72 ± 2.00 ab	2.24 ± 0.07 ab
TS3P2	4.55 ± 0.30	209.35 ± 3.00 ab	2.51 ± 0.08 ab

Notes: The average values followed by the same letter in columns (a,b,c) are not significantly different at the BNJ test level of 0.05.

3.2. Spring onion

a. Height of Spring Onion Plants

Based on the analysis of variance, the combination of intercropping treatments and different types of LOF had no significant effect on the height of spring onion plants at the ages of 4 weeks after planting, 6 weeks after planting, and 8 weeks after planting. This indicates that genetic factors more dominantly influence the height of spring onion plants than differences in environmental conditions due to the application of intercropping treatments and types of LOF. According to Rahayu et al. (2020), genetic factors often dominate plant height growth, although environmental conditions such as light, temperature, and humidity also play an important role. In addition, in intercropping conditions with a high population of spring onions, competition between plants is thought to be neutralized by using banana stem LOF and purslane LOF so that it does not show a significant difference in plant height. However, based on Figure 2, the graph of plant height shows a tendency for the height of spring onion plants at a lower population at 8 weeks after planting to be higher than other treatments. This shows that spring onions can respond better to LOF at a lower population level, which is thought to be due to a better plant root system.

Table 5. Height of spring onion plants

Treatment	Plant Height (cm)		
	4 mst		4 mst
TS1P0	34.69 ± 0.40	TS1P0	34.69 ± 0.40
TS1P1	37.00 ± 0.50	TS1P1	37.00 ± 0.50
TS1P2	36.67 ± 0.30	TS1P2	36.67 ± 0.30
TS2P0	28.62 ± 0.30	TS2P0	28.62 ± 0.30
TS2P1	28.43 ± 0.40	TS2P1	28.43 ± 0.40
TS2P2	30.30± 0.50	TS2P2	30.30± 0.50
TS3P0	27.20 ± 0.40	TS3P0	27.20 ± 0.40
TS3P1	27.83 ± 0.30	TS3P1	27.83 ± 0.30
TS3P2	28.70 ± 0.20	TS3P2	28.70 ± 0.20

Description: TS = Intercropping Pattern, P = Liquid Organic Fertilizer, WAP = (Week After Planting)

b. Number of leaves and number of shoots

The intercropping pattern of spring onions with Katokkon combined with LOF types showed no significant effect on the number of leaves per clump at 4 and 6 weeks after planting. In the early phase of plant growth, leaf formation is thought to be more influenced by the initial adaptation conditions of the plant to the new environment and the availability of basic nutrients that may be sufficient without additional LOF. A study by Handayani et al. (2018) showed that in the early phase, plants focus more on root adaptation and basic structure rather than increasing the number of leaves, so variations in treatment may not be significant in the number of leaves produced. At the age of 8 weeks after planting, the combination of planting pattern treatments and LOF types significantly affected the number of leaves. The combination of a population of 20 spring onion plants with banana stem LOF (TS1P1) produced the best number of spring onion leaves per clump, not significantly different from the population of 20 spring onion plants with purslane LOF (TS1P2). The higher number of leaves in lower populations indicates spring onion plants have better access to nutrients and light to support more optimal leaf formation. Sari et al. (2019) say reducing competition between plants in intercropping systems can increase leaf production by providing better-growing conditions.

The treatment of the population of spring onions in the intercropping pattern with Katokkon chili significantly affected the number of shoots of spring onions. The combination of TS1P1 treatments produced the highest number of shoots and was significant compared to other treatments. This is because, in this treatment, the plant population is lower, so there is a wider growing space available. A wider growing space supported by adding nutrients by applying banana stem LOF supports good root development, which increases water and nutrient absorption better. In line with that, Wulandari et al. (2020), optimal growth conditions in intercropping with low competition can increase the ability of plants to produce shoots. In addition, the cytokinin content in banana stems supports cell division activity in the root meristem, thereby encouraging root growth. With a better root system, plants can optimize nutrient absorption so that plant metabolism takes place more optimally and there is sufficient energy to form shoots.

Table 6. Number of leaves and number of shoots

Treatment	Number of leaves (cm)			Number of Offspring
	4 mst	6 mst	8 mst	
TS1P0	8.42 ± 0.30	20.33 ± 0.07	21,33 ± 0.10 a	3,33 ± 0.40 bc
TS1P1	10.50 ± 0.20	22.08 ± 0.08	26.42 ± 0.30 d	5,00 ± 0.50 d
TS1P2	10.08 ± 0.10	20.42 ± 0.08	25,33 ± 0.20 cd	4.80 ± 0.30 d
TS2P0	8.83 ± 0.20	19.75 ± 0.09	22.67 ± 0.30 ab	3.75 ± 0.30 bc
TS2P1	9.83 ± 0.30	19.75 ± 0.06	22.67 ± 0.40 ab	3.92 ± 0.40 cd
TS2P2	9.37 ± 0.10	20.17 ± 0.05	24.17 ± 0.20 c	4,00 ± 0.30 cd
TS3P0	8.58 ± 0.10	19.08 ± 0.07	21.08 ± 0.30 a	2.00 ± 0.40 a
TS3P1	8.67 ± 0.20	19.75 ± 0.08	21.83 ± 0.40 ab	2.83 ± 0.50 a
TS3P2	9.83 ± 0.10	20.08 ± 0.09	23.00 ± 0.10 bc	3.08 ± 0.60 bc

Notes: The average values followed by the same letter in columns (a,b,c) are not significantly different at the BNJ test level of 0.05.

c. Clove Diameter and Plant Weight

The diameter of the spring onion cloves was not significantly affected by the combination of intercropping treatments and LOF types. This factor may be due to the ability of spring onion plants to adapt to the available nutritional conditions without significantly changing the size of the stem. According to Rahmawati et al. (2021), the diameter of the cloves is more influenced by genetic factors and overall environmental conditions and does not always show significant changes with fertilizer treatments except in conditions of severe nutrient deficiency.

Table 7. Clove Diameter and Plant Weight

Treatment	Clove Diameter (cm)	Weight per clump (g)	Clump weight per plot (kg)
TS1P0	2.,20 ± 0.07	112,07 ± 10.0 ab	4,17 ± 0.07 ab
TS1P1	3.28 ± 0.06	231,77 ± 2.00 e	6,75 ± 0.08 e
TS1P2	3.08 ± 0.08	201,66 ± 8.00 d	6,23 ± 0.008de
TS2P0	2.33 ± 0.09	124,77 ± 9.00 bc	4,87 ± 0.007bc
TS2P1	2.50 ± 0.09	135,17 ± 11.00 c	5,23 ± 0.04 c
TS2P2	2.67 ± 0.07	185,17 ± 12.00 d	5,83 ± 0.005cd
TS3P0	1.75 ± 0.06	101,78 ± 1.00 a	4,07 ± 0.03a
TS3P1	2.17 ± 0.05	105,89 ± 2.00 a	4,33 ± 0.04 ab
TS3P2	2.00 ± 0.05	107.13 ± 5.00 ab	4,55 ± 0.02 ab

Description: The average values followed by the same letter in columns (a,b,c,d,e) are not significantly different at the BNJ test level 0.05.

The treatment combinations significantly influenced the clump weight of plants and the number of clumps per plot, with the most favorable outcomes observed when utilizing 20 spring onions per plot alongside buffalo urine LOF at a concentration of 150 ml/l of water. This indicates that a reduced plant population combined with a higher concentration of LOF allows spring onions to more effectively utilize available resources. The increased growing space facilitates optimal sunlight exposure and enhances water and nutrient absorption, ultimately leading to greater biomass per individual plant. According to Susanto et al. (2020), effective management of plant population and nutrient distribution is crucial for achieving optimal results at the plot level. Furthermore, Lestari et al. (2019) demonstrated that applying liquid organic fertilizer at appropriate concentrations can enhance plant production by improving soil fertility and supplying essential nutrients for optimal growth.

4. Conclusion

The intercropping pattern of spring onion with a population of 20 plants per plot, combined with Katokkon chili, had a significant impact on the variables of Katokkon chili, including flowering age, number of productive branches, number of fruits per plant, number of fruits per plot, fruit weight per plant, and fruit weight per plot. The intercropping pattern of spring onion with a population of 20 spring onions per plot of Katokkon chili combined with a type of banana tuber LOF significantly affected the variables of spring onion, namely the number of leaves at eight weeks post-planting, the number of tillers, the weight per clump, and the weight of the clump per plot.

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