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Growth and production of indigenous Katokkon chilies of Toraja (*Capsicum chinense* jacq) in various organic *Tithonia* compost compositions

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Abstract. This study aimed to investigate the effect of *Tithonia* compost application on the growth and production of several indigenous Katokkon chili (*Capsicum chinense* Jacq) of Toraja regency, South Sulawesi, which is based on the morphological appearance, that were assumed to be differently. The field experiment was conducted in the Village of Tallangura, Buntao District, North Toraja Regency. The site is located at the altitude of 800 meters above sea level with a minimum temperature of 18.7°C - 20.1°C and a maximum temperature of 20.1°C - 29.4°C. The experiment was conducted as Split Plot Design consisting of 2 factors. The whole-plot factor consisted of three Katokkon chili landraces, i.e. Limbong Sampolo, Leatung #1 and Leatung #2. The split-plot factor was compost at 3 levels of *Tithonia* levels: 12.5%, 25.0%, and 37.5% of *Tithonia*, respectively. Each treatment was repeated 3 times and consisted of 15 plants in each plot. The results showed that the Leatung #2 Katokkon chili and 37.5% of *Tithonia* compost had the highest yield at 46 days after planting (DAP), and the best plant height of 38.78 cm. The Leatung #1 Katokkon chili and 25.0% of *Tithonia* compost produced the most productive branches at 60 DAP with 44.33 branches. With 7.62% the Limbong Sampolo Katokkon chili had the lowest percentage of fallen fruits, while the Leatung#2 Katokkon chili accession showed the highest fruit diameter with 3.35 cm.

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1. Introduction

Katokkon is one of the indigenous chili varieties originating from Toraja district, South Sulawesi, Indonesia. It has been registered in the Center for Plant Variety and Agricultural Licensing Protection. Katokkon chili is a unique pepper-like shape of a smaller size compared to bell pepper. This chili has been officially registered at the Center for Plant Variety and Agricultural Licensing Protection with publication number 055 / BR / PVL / 02/2014 [1]. Its distinctive taste and aroma (strong spicy scent) distinguishes it from other varieties, hence it is a specialty variety. This chili also famous for its high spiciness which ranges from 30,000 to 50,000 SHU (Scoville Heat Unit) [2] However, there is not much evidence about the Toraja Katokkon chili growth and production performances, which is unfortunate considering its relevance and popularity as local indigenous chili. The group of large sized chili in Toraja is dominated by the Katokkon chili variety (80%), because farmers believe that local

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varieties are resistant to pests and diseases [3]. Morphologically, Katokkon chili consists of several types, however, there are no specific sub varieties known that have been officially introduced. Therefore, apart from the attempts to increase the yield, the investigation on the actual variations and types of Katokkon becomes an area of interest for further research. One of the first steps to identify genetic diversity is to understand the diversity of appearance and morphology of the chili, which is possible by assessing the qualitative and quantitative traits of the plant and its parts [4]. This study aims to investigate the morphological traits of three Katokkon landraces to fill this knowledge gap of the specific character of the three Katokkon types. Moreover, it shows the production and growth parameters of the three landraces under three different *Tithonia*- enriched compost treatments.

2. Types of Katokkon chili used in the study based on their morphological appearances

Katokkon chili was selected based on its various fruit appearance which lead to the assumption that they belong to different sub-species. The naming and labelling of Limbong Sampolo, Leatung #1 and Leatung #2 represent the name of the villages where the seeds were collected. These villages are well known as Katokkon production centres in Toraja. The names are not yet officially registered, but for this study the names are used for labelling the landraces.

The three types of Katokkon used in this study have similarities in the vegetative parts, especially in the leaves. All of the Katokkon landraces have elliptic leaf shape (Ovalis) with tapered leaf tips (Acuminatus), a rounded leaf base (Obtusus), a pinnate leaf frame (Penninervis), and an entire leaf margin (Integer), with dark green colored leaves. The differences are seen in the fruit characters and the yields potential. Information regarding the qualitative and quantitative characters of the Katokkon types planted in this study were based on farmers' experienced-based information and knowledge. The three Katokkon chili plant landraces are displayed in figure 1.

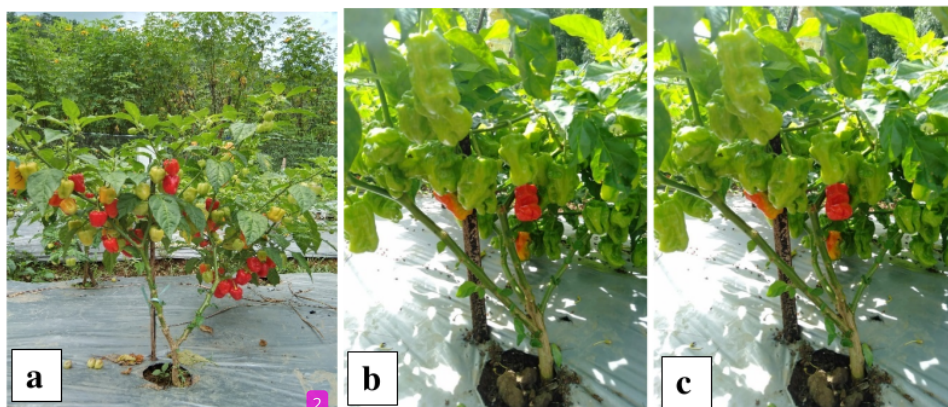


Figure 1. Appearances of the three Katokkon chili landraces in this study: a) Limbong Sampolo; b) Leatung #1; c) Leatung #2.

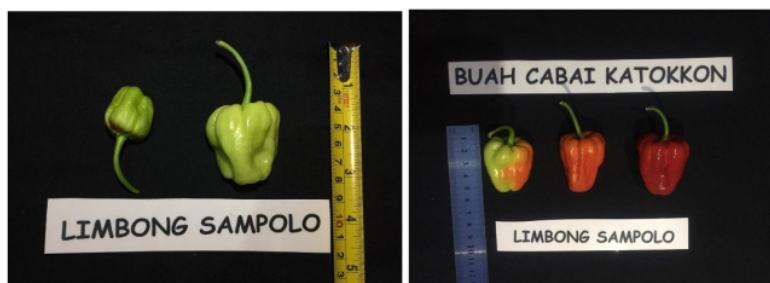
2.1. Katokkon Chili from Limbong Sampolo Village

This type of Katokkon chili has a round, short fat fruit with a flat fruit base (figure 2), with a fruit length of 2.2 - 5.8 cm and a diameter of 1.18 - 4.08 cm similar to bell peppers. The average fruit yield of the first harvest is 30.64 fruits per plant with a fruit weight of 234.36 g. It has a distinctive aroma and a specific very spicy taste. Young fruits are light green with a purple color at the base of the fruit, while ripe fruits are bright red. Table 1 describes this katokkon type with its features.

Table 1. Description of Katokkon chili derived from Limbong Sampolo village

Name of seeds origin	Limbong sampolo
Leaf shape	Elliptic (<i>Ovalis</i>)
Leaf tip (apex folii)	Tapered/Apiculate (<i>Acuminatus</i>)
Leaf base (basis folii)	Rounded (<i>Obtusus</i>)
Leaf frame (nervatio)	Pinnate (<i>Penninervis</i>)
Leaf margin (margo folii)	Entire (<i>Integer</i>)
Leaf color	Dark green
Young fruit color	light green with a purple color at the base of the fruit
Ripen fruit color	Bright red
Average fruit weight per plant of 2 nd harvest	234.36 g
Fruit shape	Round, short fat fruit with a flat fruit base
Fruit diameter	1.18 - 4.08 cm
Fruit length	2.2 - 5.8 cm
Average number of fruit per plant of first harvest	30.64
Fallen fruit incidence	Low
Main pests and diseases	Aphids, fruit flies

Source: Primary data from farmers and GT-Kondoran Motivators' experienced-based information and knowledge, 2019

**Figure 2.** Appearance of Katokkon fruit of Limbong Sampolo origin

2.2. Katokkon Chili #1 from Leatung Village

Leatung #1 Katokkon chili has an elliptical shape and the base of the fruit is rippled (undulated) (figure 3). Fruit length is 2 - 5.7 cm and fruit diameter is 1.79 - 4.68 cm. The average fruit yield of the first harvest is 29.97 fruits per plant with an average weight of 215.56 g. Leatung Katokkon has like Limbong Sampolo a distinctive aroma and a very spicy specific taste. Young fruits are dark green while ripe fruits are bright red. The traits of this Katokkon type is summarized in table 2.

Table 2. Description of Katokkon chili #1 derived from Leatung village

Name of seeds origin	Leatung
Leaf shape	Elliptic (<i>Ovalis</i>)
Leaf tip (apex folii)	Tapered/Apiculate (<i>Acuminatus</i>)
Leaf base (basis folii)	Rounded (<i>Obtusus</i>)
Leaf frame (nervatio)	Pinnate (<i>Penninervis</i>)
Leaf margin (margo folii)	Entire (<i>Integer</i>)

Leaf color	Dark green
Young fruit color	Dark green
Ripen fruit color	Bright red
Average fruit weight per plant of first harvest	215.56 g
Fruit shape	Oval, with an undulated fruit base
Fruit diameter	1.79 - 4.68 cm
Fruit length	2.0 - 5.7 cm
Average number of fruit per plant of first harvest	29.97
Fallen fruit incidence	High
Main pests and diseases	Aphids, fruit flies, army worm

Source: Primary data from farmers and GT-Kondorran Motivators' experienced-based information and knowledge, 2019

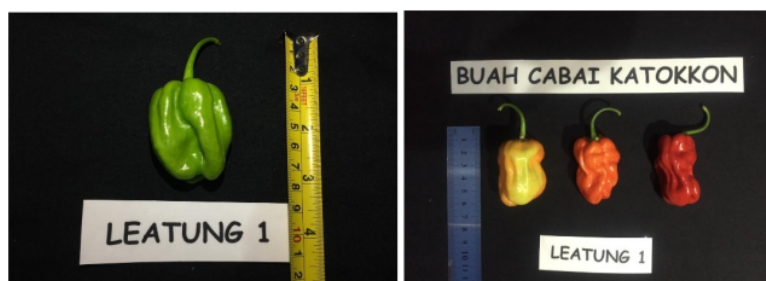


Figure 3. Appearance of Katokkon fruit #1 of Leatung origin

2.3. Katokkon Chili #2 from Leatung Village

Leatung #2 Katokkon chili has a round fruit shape at the upper part of the fruit and tapered at the base of the fruit (figure 4). The fruit length is 3 - 6.7 cm with fruit diameter of 2.45 - 4.42 cm. The average fruit yield of first harvest is 45.75 fruits per plant with a total average fruit weight of 401.11 g. The aroma and taste is also distinct and very spicy. Young fruits are light green while mature fruits are bright red. The observed traits are displayed in table 3.

Table 3. Description of Katokkon chili #2 derived from Leatung village

Name of seeds origin	Leatung
Leaf shape	Elliptic (<i>Ovalis</i>)
Leaf tip (apex folii)	Tapered/Apiculate (<i>Acuminatus</i>)
Leaf base (basis folii)	Rounded (<i>Obtusus</i>)
Leaf frame (nervatio)	Pinnate (<i>Penninervis</i>)
Leaf margin (margo folii)	Entire (<i>Integer</i>)
Leaf color	Dark green
Young fruit color	Light green
Ripen fruit color	Bright red
Average fruit weight per plant of first harvest	234.36 g
Fruit shape	Round at the upper part and tapered at the base
Fruit diameter	2.45 - 4.42 cm
Fruit length	3.0 - 6.7 cm

Average number of fruit per plant of first harvest	45.75
Fallen fruit incidence	Medium
Main pests and diseases	Aphids, fruit flies, army worm

Source: Primary data from farmers and GT-Kondoran Motivators' experienced-based information and knowledge, 2019

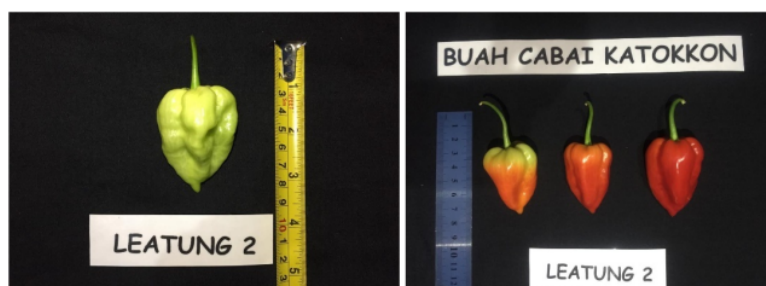


Figure 4. Appearance of Katokkon fruit #2 of Leatung origin

3. *Tithonia* plant and compost

Tithonia (*Tithonia diversifolia* L.) which is known locally as 'Ki Pahit' or 'Paitan' is a flowering plant of the family Asteraceae, and as a native of Central America called Mexican sunflower. It has many branches, and soft and rather small trunks, that are able to rapidly forming a very dense bush [5].

Tithonia is regarded as annual weed that grows in many lowlands and highlands like in Toraja, and is commonly used as green manure or compost. However, farmers in Toraja do not widely utilize *Tithonia* as an organic material. This plant is particularly suitable for steeply sloping land which is regularly found in Toraja since it can be used as erosion control. The canopy is easy to prune and it will lush again. The leaves and stems are used for feeding animals or are returned to the land by mixing it into organic fertilizers [5].

Compost which are enriched with *Tithonia* could help to improve the quality of compost made by farmers in terms of the nutrient content. Up to recently, farmers in Toraja produced compost with local materials whose nutrient contents they did not know. *Tithonia's* nutrient content ranges from 3.1-5.5% of nitrogen (N), 0.2-0.55% of phosphate (P), and 2.5-5.5% of potassium (K) [6]. In comparison to other compost materials commonly used by farmers, *Tithonia* contains higher nutrients. Therefore, *Tithonia*-enriched compost can reduce the application of inorganic fertilizers. Moreover, it has the potential to improve soil structure, to increase soil permeability, and can restore conditions of land dependence on inorganic (chemical) fertilizers [7][6].

A study in upland rice [8] revealed that 70% *Tithonia* + 30% Urea in Ultisol soil can produce the highest total soil N of 0.35%. C-Organic content in upland rice increased by 39.47% in the media fertilized with *Tithonia* compost and urea (90%: 10%) compared to those only fertilized with inorganic fertilizer (100% Urea). Another research in lowland paddy fields [9] similarly showed that the use of rice straw compost mixed with *Tithonia* in intensified rice fields could reduce the use of chemical fertilizers by 50 kg ha⁻¹ (equivalent to saving of 25% of the recommended dose), and 75 kg ha⁻¹ KCl (saved 100% of the recommended dose). In addition, the use of P fertilizer was temporarily not required.

The advantage of the green manure *Tithonia* as organic fertilizer is that it quickly decomposes and releases the available N, P, and K elements. Other studies reveal, that organic *Tithonia* fertilizers increase the productivity of soybean, rice, tomato, and okra, and it is reported as a major nutrient source in maize in Kenya, Malawi, and Zimbabwe [7].

4. Methodology

4.1. Study site

An on-farm experiment was established in Tallang Sura' village, Buntao District, North Toraja Regency (3°03'01.5"S 119°56'43.6"E, altitude: 800 m) on a site that is typical for rural vegetable gardens. The site has been planted with vegetables for the several years. The village receives an annual rainfall of 2,088 mm in 2019 according to the village weather station managed by the farmers. During the production period, the minimum average monthly temperature ranged between 18.7°C - 20.1°C minimum and 20.1°C - 29.4°C as maximum. The soil at the research site in Tallang Sura Village tends to be clay even though the composition of sand and silt are balanced. The percentage of each texture is 40% clay, 32% sand, and 28% silt .

4.2. Experimental design and treatment

The experiment took place in the growing season in 2019 (January to June). It was a two factorial split plot design with three replicates and nine treatments. The whole-plot factor consisted of three landraces of Katokkon: v1 = Katokkon from Limbong Sampolo, v2 = Katokkon #1 from Leatung and v3 = Katokkon #2 from Leatung. The split-plot factor consisted of the rate of *Tithonia* of the compost (p). Three levels of compost were prepared, namely: p1 = 12.5% *Tithonia* compost, p2 = 25.0% *Tithonia* compost, p3 = 37.5% *Tithonia* compost. The rest materials were combined other green wastes and buffalo manure with consistent proportion. With nine treatment combinations which were repeated 3 times, the experiment contained 27 units. Each experimental unit consisted of planting beds of 5 m x 1 m with 60 x 60 cm plant spacing, and there were 15 plants for each bed, making a total of 405 plants. The compost treatments were applied once at the beginning, two weeks before planting. The plot management was in line with local practice and included. Table 4 presents the stages from land preparation to harvesting of the Katokkon chili.

Table 4. Stages in Katokkon chili planting

Stages	Time of practice
<u>Land preparation</u> Consisted of land clearance of weeds and other green wastes, minimum soil tillaging and planting beds formation for trial plots of 5 m x1 m, with a 30 cm distance between beds. The bed height was 30 cm	Week 1
<u>Seeds sowing and transplanting</u> The seeds were soaked in warm water (around 50°C) mixed with shallot extract for 12 hours. Growing media was made of a mixture of soil, buffalo manure and ashes with a ratio of 1: 1: 1. Seeding was positioned in a shady area and always kept in humid conditions. After 5 weeks or when the seedlings have 7-8 leaves, they were selected to determine healthy and strong seedlings. Selected ones were those that grow uniformly and healthy.	Week 1 – 6
<u>Compost application</u> The application of <i>Tithonia</i> compost to plant beds was performed 2 weeks before transplanting, it is expected that the compost and soil can mix and decompose properly. The compost was applied in each planting line of beds as much as 20 kg / bed	Week 4
<u>Mulching</u> Mulching was performed after compost application. Installation of silver black plastic mulch was done in a sunny day, thus the plastic mulch can be stretched and attached perfectly. After installation the mulch were punctured for planting holes with a spacing of 60 x 60 cm.	Week 4
<u>Planting</u> Katokkon chilli seedlings that are 5 weeks old or having 7-8 leaves were ready for planting in the field. Planting was carried out in the morning, and water sufficiency is essential for plants during their growth.	Week 6
<u>Plant maintenance</u>	Week 6 –

- Intensive watering was performed every day after planting in the morning or afternoon. After flowering the watering was done every two days and adjusted to environmental conditions. Week 20
- Two types of pruning: shoot and bud pruning. Shoot topping was conducted 28 days after planting, aiming to get a lot of branches by trimming the shoots off the plants. When a branch was formed, buds pruning was done twice, during the period between 15 and 30 days after planting. Without buds pruning chili plant will grow slowly.
- Pest and disease control was carried out using plant-based (bio) pesticides that did not leave harmful residues and are environmentally friendly. Application by spraying in the morning or evening 2 times a week or as necessary. Apart from that there was also installation of insect traps (yellow traps) as a control for fruit fly pests. Every 1 month there was administration of petrogenol
- Supplementary nutrition through liquid organic fertilizer was applied 2 times a week by watering into the root zone near the plant so that it did not directly hit the plant stems. Application was given every 3 days in the morning or evening with 1 liter of organic liquid fertilizer was mixed with 5 liters of water.

Harvesting

Week 20-22

Physiological characteristics which indicate the ripeness were solid fruit and red color. Harvesting was done by picking fruit along with the stems that aim to keep the katokkon chili fresh longer. The harvesting was done in the morning because the fruit's weight is in an optimal condition due to accumulation of substances at night and less evaporation. Harvesting was done 4 times.

4.3. Data collection

The on-farm experiment follows the notion of farmer-led research. The research farmer club of Tallang Sura' was trained in data collection and maintenance of the experiment. The farmers took part in the experiment. They recorded data and regularly discussed with the university researchers challenges and observations during recording. Recording was done according to a standard research protocols. Major observations were conducted in the generative growth phase until harvest. The observed characters were the plant height, productive branches, time of flowering, number of fruit per plant, weight of fruits per plant, fruit drops rate, fruit diameter.

4.4. Data analysis

Recorded data of each trait was collected by the research farmer club representative for further analysis. The differences between the treatments were tested by an ANOVA using LSD as the further test. Data transformation was used for rectifying the data distribution prior for the further data test. The data was computed using the SPSS software.

5. Results

5.1. Vegetative parameters

The analysis of the vegetative parameters included plant height and number of productive branches. The results are presented in the following tables 5 and 6.

Table 5. The average plant height (cm) at 46 days after planting (DAP) by the interaction of the Katokkon chili type and *Tithonia* compost

Katokkon Type	Compost			LSD α 0.05 (V)
	<i>Tithonia</i> 12.5%	<i>Tithonia</i> 25.0%	<i>Tithonia</i> 37.5%	
Limbong Sampolo	30.33 ^a _x	28.46 ^a _x	16.73 ^b _y	1.08
Leatung 1	29.06 ^a _x	27.92 ^a _x	29.07 ^a _x	
Leatung 2	25.84 ^b _x	35.80 ^{ab} _x	38.78 ^a _x	

LSD $\alpha 0.05$ 1.13

Note: Numbers followed by the same letters in rows (a, b, c) and columns (x, y, z) indicate that they are not significantly different in LSD $\alpha 0.05$.

The variance analysis showed that there was an interaction between the types of Katokkon chilies and the *Tithonia* compost treatment which significantly affected the plant height observed at 46 DAP. While the Katokkon chili type and *Tithonia* compost as single factor had no significant effect. Table 5 shows that the Leatung #2 Katokkon and 37.5% of *Tithonia* (v3p3) produced the highest average plant height of 38.78 cm. The Leatung #2 Katokkon in this combination was significantly different from other Katokkon types. The 37.5% of *Tithonia* compost application (v3p3) was significantly different from 12.5% of *Tithonia* (v1p3), but not significantly different from 25.0% of *Tithonia* compost applications (v2p2). The lowest average plant height was found in the treatment of Limbong Sampolo Katokkon with *Tithonia* compost treatment 37.5% (v1p3), which was 16.73 cm. Between the three fertilizer treatments no significant difference in plant height have been observed.

Table 6. The average number of productive branches at 60 days after planting (DAP) by the interaction of the Katokkon chili type and *Tithonia* compost.

Katokkon Type	Compost			LSD $\alpha 0.05$ (V)
	<i>Tithonia</i> 12.5% (p1)	<i>Tithonia</i> 25.0% (p2)	<i>Tithonia</i> 37.5% (p3)	
v1 (Limbong Sampolo)	33.50 ^a _x	27.11 ^a _x	7.17 ^b _y	0.54
v2 (Leatung 1)	21.17 ^a _x	39.17 ^a _x	44.33 ^a _x	
v3 (Leatung 2)	18.22 ^b _x	45.28 ^a _x	36.83 ^a _x	
LSD $\alpha 0.05$	0.58			

Note: Numbers followed by the same letters in rows (a, b, c) and columns (x, y, z) indicate that they are not significantly different in LSD $\alpha 0.05$.

The variance analysis showed that there was an interaction between the types of Katokkon chili and *Tithonia* compost treatment which significantly affected the number of productive branches. While as single independent factor, the Katokkon chili type treatment and *Tithonia* compost treatment alone had no significant effect.

Table 6 shows that the Leatung #1 Katokkon and 37.5% of *Tithonia* compost (v2p3) produced the highest number of productive branches, i.e. 44.33. This treatment was significantly different from Limbong Sampolo Katokkon, which had the lowest number of productive branches. However, in the 25% *Tithonia* compost variant there were no significant differences in the number of productive branches. Here, Leatung #2 had with 45.28 branches the highest number. With the exception of Limbong Sampolo under *Tithonia* 37.5% variant, there were no differences in the number of productive branches between the three fertilizer treatments.

5.2. Generative and production parameters

Observation on generative and production variables include time of flowering, percentage of fruit drops, number of harvested fruits per plant, weight of harvested fruits per plant, fruit length and fruit diameter.

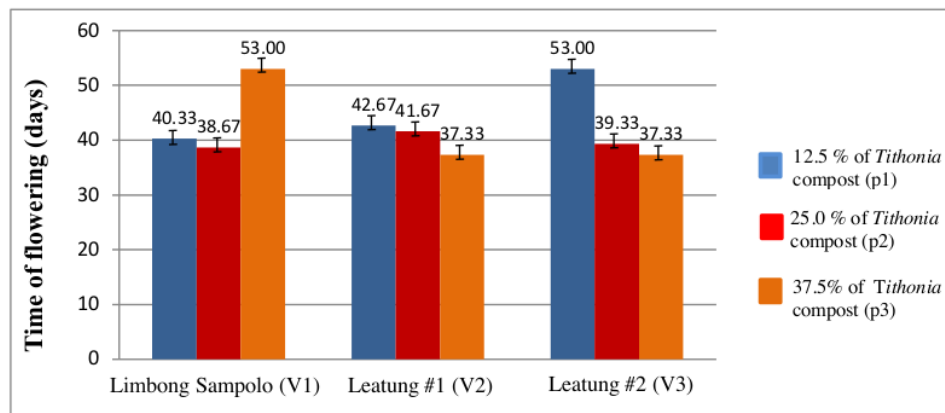


Figure 5. Average time of flowering (days) of Katokkon chili type and *Tithonia* compost treatment

The variance analysis reveals that neither the Katokkon type, nor the *Tithonia* compost variant or their interactions did significantly affect the time of flowering. Figure 5 shows that Leatung #1 and #2 under 37.5% *Tithonia* compost (v2p3) had the fastest flowering time of 37.33 days. The Limbong Sampolo Katokkon with 37.5% of *Tithonia* compost (v1p3) and the Leatung #2 Katokkon chili with 12.5% of *Tithonia* compost (v3p1) took 53 days until first flowering.

Table 7. The average percentage of fruit drops at 88 days after planting (DAP) of the Katokkon chili landraces.

Katokkon Type	Compost			Average	LSD $\alpha 0.05$
	<i>Tithonia</i> 12.5% (p1)	<i>Tithonia</i> 25.0% (p2)	<i>Tithonia</i> 37.5% (p3)		
v1(Limbong Sampolo)	7,90	11,69	3,28	7.62 c	
v2 (Leatung 1)	19,91	14,78	22,88	19.19 a	0.73
v3 (Leatung 2)	4,35	10,29	16,70	10.44 bc	

Note: Numbers followed by the same letters in column (a, b, c) indicate that they are not significantly different in LSD $\alpha 0.05$.

The variance analysis indicates that the percentage of fallen fruits significantly differ between the Katokkon chili landraces, whereas the treatment of the *Tithonia* compost application and its interactions had no significant effect (Table 7). The highest fallen fruits were found in Leatung #1 Katokkon (v2) with an average of 19.19%, compared to Limbong Sampolo with 7.62% of fruits fallen.

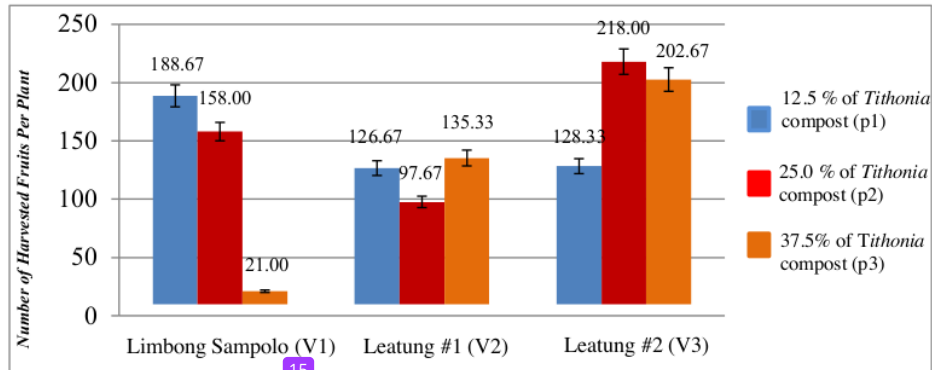


Figure 6. The average total number of harvested fruits per plant (fruit) of 4 times harvesting by the Katokkon chili type and the *Tithonia* compost treatment

Figure 6 displays the average number of harvested fruits by treatment. The ANOVA did not reveal any significant differences of the treatments and their interactions. Leatung #2 Katokkon chili had in two fertilizer variants with 203 fruits (p3) and 218 fruits (p2) the highest number of fruits. Limbong Sampolo Katokkon chili had with 21 fruits per plant the lowest number.

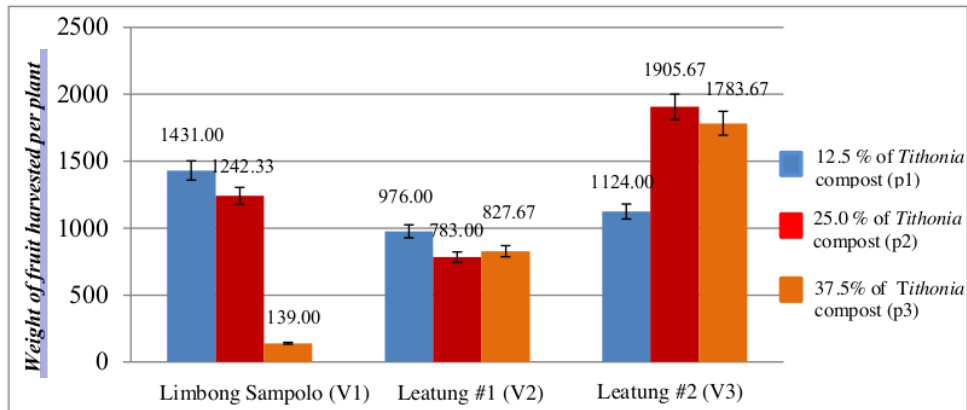


Figure 7. The average total fruit weight per plant (g) of 4 times harvesting by the Katokkon chili type and the *Tithonia* compost treatment

None of the factors or their interactions significantly affected the total fruit weight per plant which was calculated for four harvests. Figure 7 shows that Leatung #2 Katokkon chili had the highest fruit weight per plant of 1905.7 g (p2) and the second highest of 1783.7 g (p3). Limbong Sampolo Katokkon had the lowest weight of 139 g (p3).

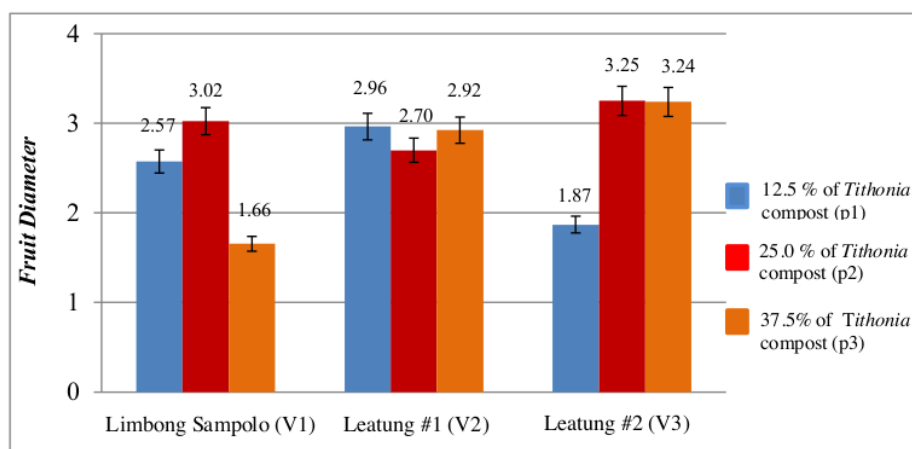


Figure 8. Average diameter of fruit (cm) of 4 times harvesting by the Katokkon chili landrace and the *Tithonia* compost treatment

Fruit diameters were also not significantly different between the treatments. Leatung #2 Katokkon chili tended to have a larger fruit diameter of 3.25 cm (p3) and 3.24 cm (p2). Limbong Sampolo Katokkon chili had the lowest fruit diameter of 1.66 cm under p3.

The three Katokkon landraces differ **5** a number of important growth and production parameters. In the vegetative phase both parameters, **plant height and number of productive branches, significantly** differ between **the** three landraces, with Leatung #2 showed the highest results related to height and number of branches. In the generative growth phase, the various productivity parameters did not significantly differ, except for fruit length and number of fallen fruits. In this generative phase, environmental parameters play a very important role for performance development. One treatment i.e. landrace of Limbong Sampolo was heavily affected by a virus, which lead to a poor result on most of the parameters. Fruit length was highest in the Leatung #2 chili with 3.93 cm, while the number of fallen fruits was lowest in Limbong Sampolo, that only had dropped 7.6% of its fruits. There was no significant effect by the three levels of *Tithonia*-enriched compost, neither in the vegetative nor in the generative phase. Participating research farmers confirm the findings and have supported the field experiment in a professional way. Moreover, they have enriched the research by providing experience-based information and knowledge.

Another important field is related to the genetic properties and traits of the Katokkon chili landraces. The visual morphological description indicates that the Katokkon landraces trialed in this research are genetically different, and thus could lead to distinct Katokkon varieties or sub-species. Variety development and seed systems should be developed to benefit all actors of the value chain, i.e. stress-tolerant and resilient seed for the producer, and in the same time nutritious, tasty and marketable fruits for the consumer. Participatory plant breeding is a feasible instrument to be conducted with the Katokkon experienced farmers in Toraja. Germplasm collection and building capacity to select for traits in breeding populations are complementing this effort. In this long-term research endeavour, Toraja Katokkon farmers should play a leading role.

6. Conclusion

The *Tithonia* compost treatment gave different responses to the vegetative parameters of the three Katokkon chilli landraces. Limbong sampolo showed a decrease in plant height with a higher concentration of *Tithonia* composting. The landrace Leatung #2 gave the opposite response. Landrace Leatung #2 showed a generative development that was more **5** prominent than the other 2 landraces. Landrace Leatung #2 produced the best total number of fruits, **weight of fruit per plant, and diameter**

of fruit for each given titonia concentration treatment. This indicates that Landrace Leatung #2 responded well to fruit formation.

Further research should go into two directions. Different compost treatments should be trialed again, but under better controlled conditions, such as in pots or planting bags, in order to analyse the nutrient uptake and the effect of compost treatment on general soil health conditions. It should still happen in farming environments, but with a focus on soil fertility parameters. In open fields, the compost effects were not significant for growth or their effect was overlaid by other environmental factors, such as pests and diseases, water or temperature stress.

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