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Combination of bio-organo-mineral fertilizers on optimizing the growth and production of tomatoes (*Solanum lycopersicum* L.) in dryland environment

Kombinasi pupuk hayati-organik-anorganik dalam optimasi pertumbuhan dan produksi tanaman tomat (*Solanum lycopersicum* L.) di lahan kering

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ABSTRACT
Mineral or inorganic fertilizers are increasingly being used to increase tomato productivity. However, excessive use of inorganic fertilizers may negatively impact soil fertility and microbial activity. To maintain food safety and agricultural sustainability, the use of inorganic fertilizers must be balanced with organic fertilizers. Additionally, sub-optimal land such as dryland can be used to optimize tomato productivity, particularly in the North Lombok Regency, Indonesia. This study aimed to investigate the effect and interaction of a combination of liquid organic fertilizer (LOF), plant growth regulator (PGR), and NPK fertilizers as inorganic fertilizers on the growth and yield of tomatoes in dryland. The experimental design was a completely randomized block design, with two factors: the concentrations of commercial inorganic fertilizer (0, 1,300, and 2,600 ppm) and the type of commercial LOF (Bio-Extrim and Organox) + commercial PGR (Hormax). The results showed that the interaction was not significantly different between inorganic fertilizer and LOF + PGR, except for mean fruit weight in the first week of harvest. However, there were differences in responses at the level of each factor. The application of inorganic fertilizer at 2,600 ppm increased tomato productivity by 13.81%. LOF was only significantly different in fruit weight/plant in the first week of harvest and was not significant after that.

ABSTRAK
Pupuk mineral atau anorganik semakin banyak digunakan untuk meningkatkan produktivitas tomat. Namun, penggunaan pupuk anorganik yang berlebihan dapat berdampak negatif terhadap kesuburan tanah dan aktivitas mikroba. Untuk menjaga keamanan pangan dan keberlanjutan pertanian, penggunaan pupuk anorganik harus diimbangi dengan pupuk organik. Selain itu, lahan sub-optimal seperti lahan kering dapat dimanfaatkan untuk mengoptimalkan produktivitas tomat, khususnya di Kabupaten Lombok Utara, Indonesia. Penelitian ini bertujuan untuk mengetahui pengaruh dan interaksi kombinasi pupuk organik cair (POC), zat pengatur tumbuh (ZPT), dan pupuk NPK sebagai pupuk anorganik terhadap pertumbuhan dan hasil tomat di lahan kering. Rancangan percobaan yang digunakan adalah rancangan acak kelompok lengkap, dengan dua faktor yaitu konsentrasi pupuk anorganik komersial (0, 1,300, dan 2,600 ppm) dan jenis POC komersial (Bio-Extrim dan Organox) + ZPT komersial (Hormax). Hasil penelitian menunjukkan bahwa interaksi tidak berbeda nyata antara pupuk anorganik dengan POC + ZPT, kecuali rata-rata bobot buah pada minggu pertama panen. Namun, terdapat perbedaan respon pada level masing-masing faktor. Pemberian pupuk anorganik 2,600 ppm meningkatkan produktivitas tomat sebesar 13.81%. POC hanya berbeda nyata pada berat buah/tanaman pada minggu pertama panen dan setelah itu tidak berbeda nyata.

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INTRODUCTION

Tomatoes (*Solanum lycopersicum* L.) originate from the South American continent and have spread to several countries, including Chile, Ecuador, and Peru (Saavedra et al., 2017; Khairi et al., 2022). Tomato fruits are consumed fresh or used as raw materials for making tomato sauce and paste. Tomatoes are known for their high nutritional content, containing 3.84 g of carbohydrates, 17.8 mg of vitamin C, 24 g of vitamin A, 2,860 μg of lycopene, and other nutrients (USDA, 2022). The productivity of tomato cultivation in Indonesia has been increasing from 15.31 to 18.93 ton/ha from 2016 to 2020 (FAO, 2022). One way to further increase productivity is by optimizing land for plant cultivation, particularly in North Lombok Regency where many sub-optimal lands are classified as dryland. The dryland is characterized by low soil fertility, low nutrient content in the topsoil, and reduced microbial activity, which are not optimal for plant root development and growth. The dryland in North Lombok Regency has a soil texture of entisol which is dominated by sand (93%) and silt (7%) (Kreshnadhi et al., 2021). The water in dryland causes severe impacts on plants. Water deficit causes a decrease in the absorption of nutrients by plant roots; accordingly, the growth and accumulation of biomass are reduced; the following effect can lead to an excess accumulation of reactive oxygen species (ROS) caused by oxidative stress (Ahanger et al., 2021). In addition, it causes a decrease in plant productivity through physiological (stomata closure and root architecture); for this reason, it threatens food security (Ullah et al., 2021). Consequently, using dryland must also be supported by maximum inputs, such as water management, high-yield tomato seeds, and fertilizer use. In addition to land use, nutrients in the soil are also vital for plants. Organic and inorganic fertilizers suitable for plant needs are the initial stage of fertilization management and are beneficial for the environment, such as reducing excessive fertilizer residues.

In recent years, the application of organic fertilizer and plant growth regulator (PGR) as a bio-fertilizer have received more attention because it can produce healthier and safer products and can improve soil quality (Zheng et al., 2020). Organic fertilizer is used because they are environmentally friendly, and their application is an excellent step in reducing excessive inorganic fertilizer. Organic fertilizer helps provide the nutritional needs of plants, which can be seen from the increase in yield and quality of plants whose performance is the same as inorganic fertilizer. Islam et al. (2017) reported that liquid organic fertilizer (LOF) contains complete macro-micronutrients and PGR, such as gibberellic acid (GA) and indole acetic acid (IAA). Accordingly, fertilization management is adjusted to the needs of plants because it can cause a high risk of nutrient loss (Mpanga et al., 2018). LOF is an alternative fertilizer application from foliar spray or near-root irrigation. LOF is a fertilizer that is more easily absorbed by roots and efficient in the application. The results study reported by Murtic et al. (2018) showed that LOF could increase total soluble solids, total phenolics, total flavonoids, and total antioxidants in tomatoes. The combination of LOF and PGR can provide benefits for the growth and production of tomato. LOF can provide the necessary nutrients for tomato, increase microbial activity, and increase nitrogen fixing bacteria, phosphate and potassium solubilization bacteria in the soil (Nhu et al., 2018; Handayani et al., 2021; Pu et al., 2022). PGR can improve the process of photosynthesis, root growth, and fruit production in tomato. Research has shown that the use of a combination of LOF and PGR in plant cultivation can improve the quality and quantity of soluble sugars, vegetative and generative growth (Suherman et al., 2017; Gao et al., 2020; Kasim et al., 2020). The PGR is directly involved in regulating senescence, flowering, seed germination, regulating physiological processes, and increasing fruit formation (Zahid et al., 2023). PGR increase tolerance to environmental stresses such as drought, cold, and heat, which is due to the production and transcription of anti-stress genes such as heat shock proteins (Noein and Soleymani, 2022). The study result that have been reported by Tahaei et al. (2022) tested the PGR which significantly increased the physiology of maize (*Zea mays* L.) and gene expression (rab17), consequently that plant tolerance to drought stress increased.

The study of the combination of organic and inorganic fertilizers on tomato is still limited and requires in-depth investigation. Several studies have reported the benefits of applying LOF and PGR compared to inorganic fertilizers on tomato. For instance, Coppens et al. (2016) found that the dry weight of plants, sugars (glucose and fructose), and carotenoids of tomatoes were better with LOF and PGR than inorganic fertilizers. Furthermore, organically cultivated tomatoes have been found to have lower nitrate residues compared to conventionally cultivated tomatoes (Watanabe et al., 2015). Therefore, the combination of inorganic and bio-organic fertilizers is expected to be sustainable in agriculture, especially in tomato cultivation. This study was undertaken to determine bio-organic and inorganic fertilizer, sole, or interaction, affect growth and yield of tomato in dryland.

MATERIALS & METHODS

Materials and location

The materials used were commercial LOF (Bio-Extrim and Organox, Bangkit Jaya Abadi, Indonesia), commercial PGR (Hormax, Bangkit Jaya Abadi, Indonesia), and commercial NPK 15-15-15 (Phonska, Pupuk Indonesia Group, Indonesia); these combinations it was called bio-organo-mineral fertilizers in this study. The growing media was soil, cow manure compost, and rice husk ash with a composition ratio of 3:1:1. The pesticide used with active ingredient was 200 g/L azoxystrobin + 125 g/L difenoconazole (AmistarTop, Syngenta, Indonesia) as a fungicide, the insecticide used with active ingredient 45 g/L chlorantraniliprole + 18 g/L abamectin (Voliam Targo, Syngenta, Indonesia), and seeds of tomato var. Servo F1 (East-West Seed, Indonesia). The research was carried out in Gumantar village, Kayangan district, North Lombok regency, West Nusa Tenggara Province, Indonesia, with an altitude of 60 m asl (Figure 1). The location had a temperature of 31.54 ± 0.14°C, RH of 64.71 ± 0.11%, sunlight intensity of 68,464.67 ± 26.25 lx, and wind speed of 4.20 ± 0.03 m/s.

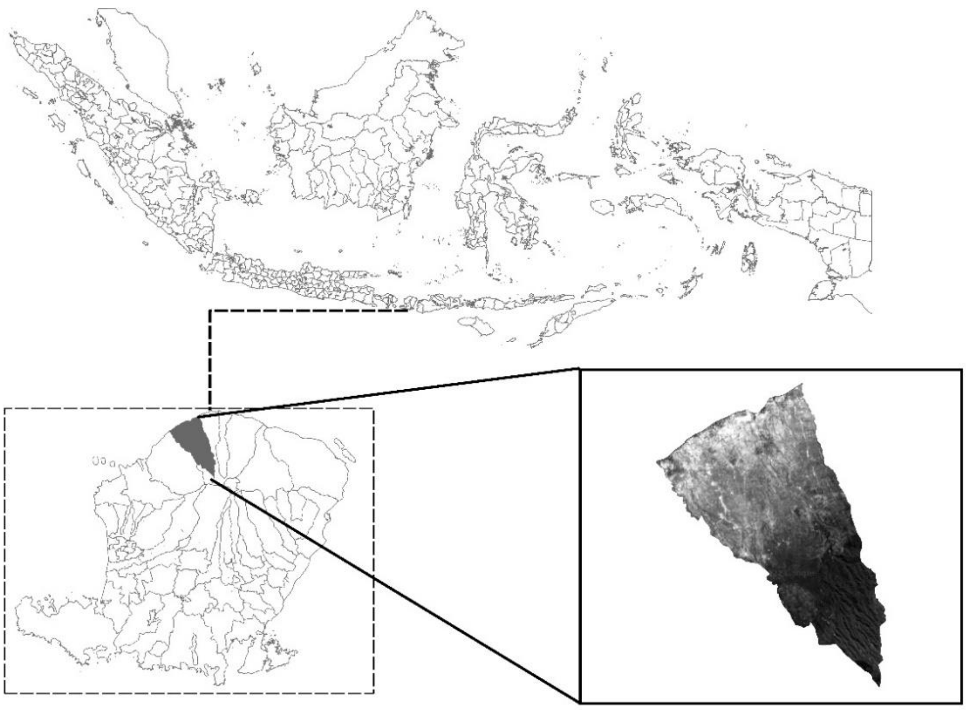

Figure 1. Geographical location of the experimental site (latitude 8°14'59"S and longitude 116°17'30"E)

Experimental design

The research design was performed with a completely randomized block design (CRBD) with two factors. This study was conducted with three replications. The first factor was inorganic fertilizer concentrations, which consisted of levels 0, 1,300, and 2,600 ppm. The second factor was combining commercial LOF (Bio-Extrim and Organox) + commercial PGR (Hormax), which consisted of two levels: Bio-Extrim + Hormax and Organox + Hormax. The inorganic fertilizer given was 5 g/plant for all plants before planting (one time) by given in topsoil as basic fertilizer. For the treatment, the inorganic fertilizer was given based on the concentration of treatment three times at 14, 28, and 42 days after planting (DAP) (Nurahmi et al., 2010). The notation for this study was N0.O1 = 0 ppm inorganic fertilizer & Bio-Extrim + Hormax; N0.O2 = 0 ppm inorganic fertilizer & Organox + Hormax; N1.O1= 1,300 ppm inorganic fertilizer & Bio-Extrim + Hormax; N1.O2= 1,300 ppm inorganic fertilizer & Organox + Hormax; N2.O1= 2,600 ppm inorganic fertilizer & Bio-Extrim + Hormax; N2.O2= 2,600 ppm inorganic fertilizer & Organox + Hormax.

The application of inorganic fertilizer treatment involved dissolving 220 mL of inorganic fertilizer in water per plant. This method is based on a previous study conducted by Al-Taee and Al-Shammari (2022) with certain modifications made to enhance its effectiveness. Meanwhile, LOF was given 6,700 ppm and LOF was combined with PGR at concentration of 3,300 ppm with LOF spray volume of 250 mL/plant (Gullap et al., 2014). Application of LOF and PGR by combining, then carried out in foliar spraying three times at 14, 30, and 45 DAP. Moekasan et al. (2015) which has been modified for tomato cultivation process. The water was given once a week by irrigation and depending on rain. Planting distance was 50 × 50 cm. Planting in the experimental field was carried out when plants were 21 days after seedling. Control of pests and plant diseases with chemicals with a concentration of 1,000 ppm (according to recommendation use). Harvesting was performed in the 1st week of harvest (50–56 DAP) to the 5th week (78–84 DAP), with fruits having been deeper red at harvest time.

Soil analysis

Soil analysis was carried out before planting on experimental land, and there were three samples for each soil observation variable. The soil texture in the experimental site was entisol (sandy loam). The soil contained nitrogen (N) total of 0.16 ± 0.02%, phosphate (P) total of 0.079 ± 0.001%, potassium (K) total of 0.224 ± 0.003%, soil organic carbon (SOC) of 0.66 ± 0.02%, and pH of 6.24 ± 0.01. N total was analyzed by following the Kjeldahl method. P total and K total were analyzed by following the Morgan-Wolf method. SOC was analyzed by following the Walkley-Black procedure. The last test was the pH of the soil using a pH Meter (Digital Soil Analyzer Tester Meter, China). The analytical method used on soil observation according to guidelines from Indonesian Soil Research Institute (Balittanah, 2009).

Fruit yield

Fruit yield was calculated using the formula as follows (Ilupeju et al., 2015):

$$FY = \frac{FP}{LA} \qquad (1)$$

where FY was fruit yield (ton/ha), FP was fruit production (ton), and LA was a land area (ha).

Observation variables and data analysis

Observation variables were vegetative growth (plant height, stem diameter, and number of branches/plants) and reproductive growth (number of fruit/plants, mean of fruit weight, fruit weight/plants, and fruit yield). Data obtained from observations were carried out with the assumption of normal distribution and homogeneity. ANOVA analyzed the data. If there was a significant difference, then a further test of Tukey's HSD was carried out with α 0.05, 0.01, and 0.001. Software used for Principal Component Analysis (PCA) biplot and data analysis were JMP v.16 and SAS® OnDemand for Academics via a web browser (https://welcome.oda.sas.com/login).

RESULTS & DISCUSSIONS

Physiology of tomato growth

The analysis results showed that there was no significant treatment combination on all observed variables. Figure 2 contains the effect of treatment on the height plant observed from 14–49 DAP. No interaction occurred between inorganic fertilizer and in plant height for all DAP. At the end of observation (49 DAP), plant height for the mean treatment combination was 110 cm. The research conducted by Hasnain et al. (2020) reported that combined application (50% inorganic fertilizer + 50% compost) was significantly higher than the control on plant height of tomato. Furthermore, the results of research by Molla et al. (2012) on plant height of 95.06 cm with N 120 kg/ha, P 108 kg/ha, K 10 kg/ha, their research results were lower than this study. The organic fertilizer could provide complete nutrition; in order to that, plant growth increases, soil quality improves (pH, soil texture, and electrical conductivity), and soil microbial activity also increases and benefits plants (Kang et al., 2022). On the other hand, excessive application of inorganic fertilizer causes an increase in soil

EC and lowers soil pH (Kang et al., 2022). As a consequence, its application causes a decrease in soil fertility, accelerates soil acidification (soil quality), and degenerate plant growth (Wu et al., 2020; Wang et al., 2020).

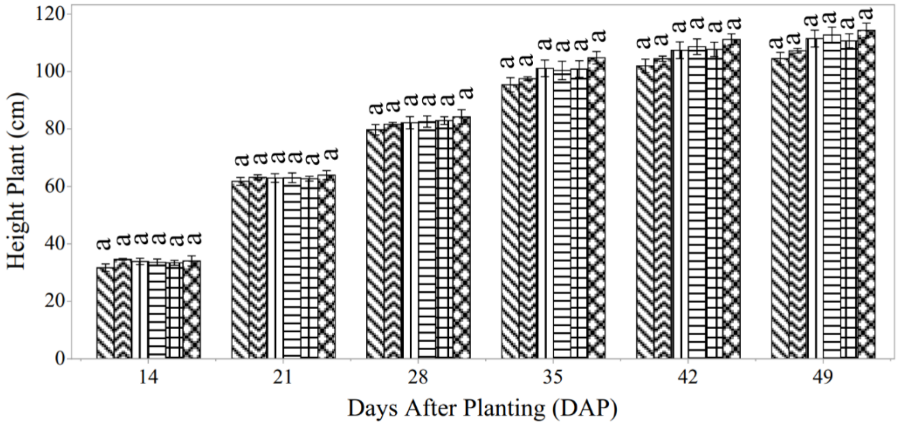

Figure 2. Treatment effect on height plant with for N0.O1, for N0.O2, for N1.O1, for N1.O2, for N2.O1, and for N2.O2; the number followed by the same letter on the same days after planting (DAP) has no significant difference based on Tukey's HSD test (* = significant with α 0.05; ** = significant with α 0.01; *** = significant with α 0.001); mean ± standard error (n = 3)

The tomato treated organic and inorganic fertilizer on stem diameter for all DAP (Figure 3) there was no interaction. Stem diameter from the beginning of observation (14 DAP) to the end of observation (49 DAP) with mean value 5.30 mm to 12.10 mm. The previous study from Adekiya et al. (2022) reported that inorganic fertilizer was better than organic and that stem diameter had a higher value. The availability of several elements caused N, P, K, Ca, Mg, and Fe more in inorganic fertilizer. The excess application of inorganic fertilizer also can be caused damage to the soil, such as a decrease in soil fertility (physical, chemical, and biological properties) which in turn can be caused a reduction in the nutritional value of the fruit. The negative impact of continuous inorganic fertilizer is a decrease in nutritional value and fruit quality due to the accumulation of heavy metals in plant tissues (Kochakinezhad et al., 2012).

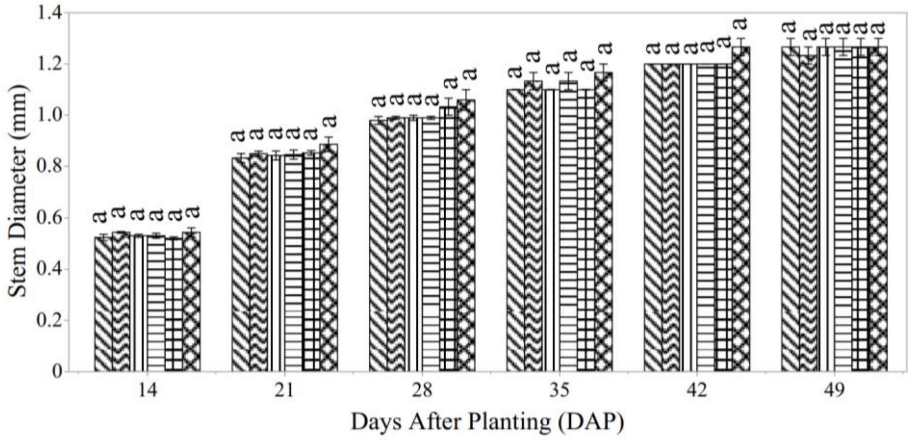

Figure 3. Treatment effect on stem diameter for N0.O1, for N0.O2, for N1.O1, for N1.O2, for N2.O1, and for N2.O2; the number followed by the same letter on the same days after planting (DAP) has no significant difference based on Tukey's HSD test (* = significant with α 0.05; ** = significant with α 0.01; *** = significant with α 0.001); mean ± standard error (n = 3)

There was no interaction observed between the variable of number of branches per plant (Figure 4) in tomatoes treated with both inorganic and organic fertilizers. The treatment combination between inorganic fertilizer (2,600 ppm) and bio-fertilizer (Organox + Hormax) resulted in the highest value of 6.67 ± 0.47. Meanwhile, the previous study by Molla et al.

(2012) reported 13.10 from inorganic N 120: P 108: K 10 kg/ha; in order to, the results were higher than in this study. High concentrations of N, P, and K can increase the number of branches. The positive benefit caused by high concentrations of P is cell division activity (Turuko and Mohammed, 2019). The molecules of P constitute the structural framework of other biomolecules such as ATP, NADPH, nucleic acids, phospholipids, and sugar-phosphates for the primary and secondary plant metabolisms (Bechtaoui et al., 2021). The bio-fertilizer given to tomato had not been able to increase the number of branches, such as Organox. According to information on the labels, Organox only contained microbes (*Azospirillum sp., Azotobacter sp., Rhizobium sp., Pseudomonas sp.*, and *Bacillus sp.*) and micronutrients (Cu, Zn, Mn, Fe, and B).

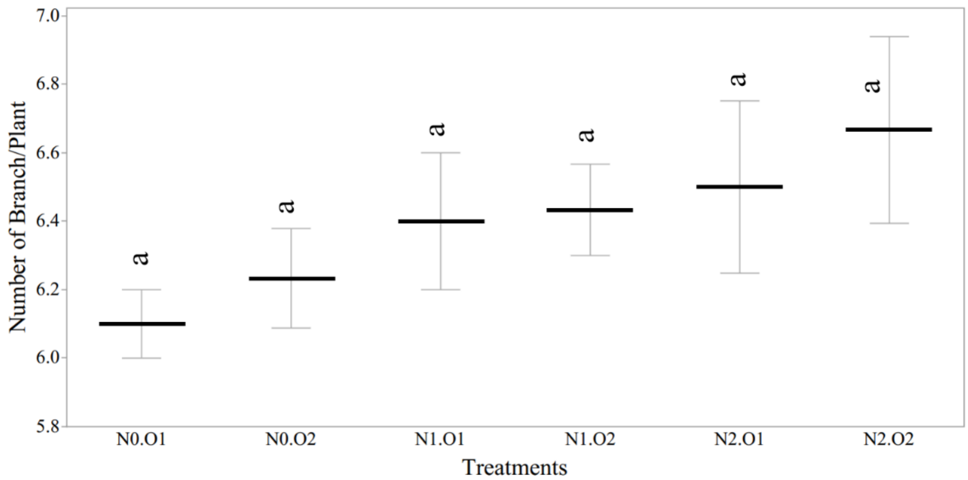

Figure 4. Treatment effect on the number of branches/plants; the number followed by the same letter has no significant difference based on Tukey's HSD test (* = significant with α 0.05; ** = significant with α 0.01; *** = significant with α 0.001); mean ± standard error (n = 3)

Table 1. Treatment effect on the number of fruit/plants from the 1st to the 5th week of harvest (n = 3)

Treatments	Number of fruit/plant					
	1st week	2nd week	3rd week	4th week	5th week	Total
	Inorganic fertilizer (N)					
0 ppm	5.22 b	7.42 b	6.62 c	5.57 b	2.53 a	27.33 c
1,300 ppm	5.60 a	7.65 b	7.05 b	5.83 ab	2.50 a	28.63 b
2,600 ppm	5.75 a	8.30 a	7.48 a	6.03 a	2.57 a	30.13 a
	Bio-organic fertilizer (O)					
Bio-Extrim	5.51 a	7.78 a	7.08 a	5.82 a	2.57 a	28.72 a
Organox	5.53 a	7.80 a	7.02 a	5.80 a	2.50 a	28.68 a
N	***	***	***	**	NS	***
O	NS	NS	NS	NS	NS	NS
Interaction N × O (+/-)	-	-	-	-	-	-

Note: NS = non-significant; (+) = interaction; (-) = not interaction; the number followed by the same letter in column and treatments factor of same has no significant difference based on Tukey's HSD test (* = α 0.05; ** = α 0.01; *** = α 0.001)

Physiology of tomato yield

The data shown in Table 1 is that the tomatoes treated with inorganic fertilizer and organic did not result interaction, meanwhile the concentration of inorganic fertilizer was significant for the number of fruit/plants from 1st week to 4th week and total. The inorganic fertilizer concentration of 2,600 ppm could increase total number of fruit/plant compared to control. The study from Laxmi et al. (2015) reported the best results of 36.72 with 50% inorganic fertilizer + 50% farm yard manure; their results were higher than this work. Meanwhile, there was no interaction between inorganic fertilizer and organic. Inorganic fertilizer was significant for fruit weight/plant at total week, then 1st and 2nd of weeks (Table 2). The treatment given organic was significantly on fruit weight/plant at 1st week of harvest. An inorganic fertilizer concentration of 2,600 ppm (1,696.38 g) could significantly increase total number of fruit/plant compared to control (1,500.30 g). The results of the study by Laxmi et al. (2015), with a value of 849 g with 50% inorganic fertilizer + 50% farm yard manure, were lower than in this study.

The fertilizers management between organic and inorganic could minimize the use of inorganic fertilizers purchased expensively and maximize the use of natural resources available to meet the essential nutrient for plants (Ilupeju et al., 2015). Organic fertilizer is safe and environmentally friendly to be applied to plants. This is why, the residue left in soil and carried to rivers or sea does not negatively impact other organisms. Organic fertilizer is a positive alternative to reduce the negative impact of inorganic fertilizer because role of plant health and soil that produces good quality fruit. N can improve the process of vegetative phase and biomass accumulation (Bilalis et al., 2018).

Table 2. Treatment effect on fruit weight/plant from the 1st to the 5th week of harvest (n = 3)

Treatments	Fruit weight/plant (g)					
	1st week	2nd week	3rd week	4th week	5th week	Total
			Inorganic fertilizer (N)			
0 ppm	259.72 b	450.57 b	405.02 a	288.88 a	96.13 a	1,500.30 b
1,300 ppm	285.00 a	483.32 ab	442.48 a	280.28 a	90.25 a	1,581.38 ab
2,600 ppm	283.33 a	542.77 a	454.45 a	310.28 a	96.38 a	1,696.38 a
			Bio-organic fertilizer (O)			
Bio-Extrim	268.13 b	489.07 a	432.97 a	292.04 a	93.32 a	1581.68 a
Organox	283.90 a	495.37 a	435.00 a	294.26 a	95.19 a	1603.70 a
N	*	**	NS	NS	NS	***
O	*	NS	NS	NS	NS	NS
Interaction N × O (+/-)	-	-	-	-	-	-

Note: NS = non-significant; (+) = interaction; (-) = not interaction; the number followed by the same letter in column and treatments factor of same has no significant difference based on Tukey's HSD test (* = α 0.05; ** = α 0.01; *** = α 0.001)

Table 3. Treatment effect on mean of fruit weight (n = 3)

Treatments	Mean of fruit weight (g/fruit)				
	1st week	2nd week	3rd week	4th week	5th week
			Inorganic fertilizer (N)		
0 ppm	49.80 a	60.80 a	61.30 a	51.87 a	37.96 a
1,300 ppm	50.94 a	63.18 a	62.76 a	48.03 a	36.14 a
2,600 ppm	49.27 a	65.47 a	60.79 a	51.50 a	41.72 a
			Bio-organic fertilizer (O)		
Bio-Extrim	48.72 b	62.80 a	61.18 a	50.18 a	39.06 a
Organox	51.29 a	63.50 a	62.05 a	50.76 a	38.15 a
N	NS	NS	NS	NS	NS
O	*	NS	NS	NS	NS
Interaction N×O (+/-)	+	-	-	-	-

Note: NS = non-significant; (+) = interaction; (-) = not interaction; the number followed by the same letter in column and treatments factor of same has no significant difference based on Tukey's HSD test (* = α 0.05; ** = α 0.01; *** = α 0.001)

The mean fruit weight of tomatoes that received inorganic fertilizer throughout all weeks did not show any significant difference, whereas the mean fruit weight of tomatoes treated with a combination of bio-organic and inorganic fertilizers, as well as those treated with only bio-organic fertilizer, showed significant differences in the first week, as shown in Table

3. After first week, there was no significant difference between the treatment combination and between treatment factors. In the study by Laxmi et al. (2015), the mean fruit weight was a value of 41.67 g with 50% inorganic fertilizer + 50% farm yard manure. Noor et al. (2019) reported a combination treatment of organic and inorganic fertilizers could increase the height plant, number of leaves, and fruit weight/plant in melon (*Cucumis melo* L.). Furthermore, Farneselli et al. (2015) reported inorganic fertilizer could be reduced by implementing environmentally friendly organic farming. Organic farming is applied by using organic fertilizer with benefits such as improving soil quality for the long term and reducing N residues in soil. Reduction of residual N in soil is very important because increased N residue in the soil will cause an imbalance between nitrate (NO_3^-) and ammonium (NH_4^+) ions, as reported by Shi et al. (2020). Based on their study, the excess NH_4^+ in *Hydrilla verticillata* (L.f.) Royle could significantly reduce chlorophyll (a and b) levels and increase the content of hydrogen peroxide (H_2O_2) in the treatment of 20 mg/L NH_4^+ compared to 2 mg/L NH_4^+ (optimum treatment). The correlation is soil and plants contained excess NH_4^+. Because the plants will bind the nutrients in the soil particles.

Table 4. Treatment effect on fruit yield (n = 3)

Treatments	Fruit yield (ton/ha)
	Inorganic Fertilizer (N)
0 ppm	60.01 b
1,300 ppm	63.26 ab
2,600 ppm	67.86 a
	Bio-organic Fertilizer (O)
Bio-Extrim	63.27 a
Organox	64.15 a
N	***
O	NS
Interaction N×O (+/-)	-

Note: NS = non-significant; (+) = interaction; (-) = not interaction; the number followed by same letter in column and treatments factor of same has not significant difference based on Tukey's HSD test (* = α 0.05; ** = α 0.01; *** = α 0.001)

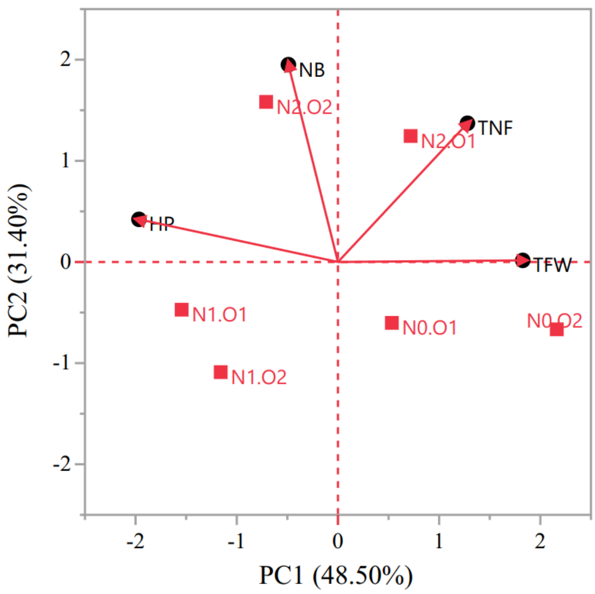

Figure 5. PCA biplot on observation variable with HP = height plant; NB = number of branch/plant, TNF = total number fruit/plant; TFW = total fruit weight/plant; PC = principal component; black dot = observation variable; red square = treatments

Inorganic fertilizer and organic fertilizer (Table 4) did not result interaction, then only inorganic fertilizer had a significant effect on fruit yield. Inorganic fertilizer of 2,600 ppm significantly differs from the control to increase fruit yield under water deficit conditions. Salam et al. (2021) reported that combined treatment of 5 ton/ha municipal solid waste compost + 100 kg triple superphosphate (TSP)/ha + 50 kg muriate of potash/ha + 100 kg N/ha resulted in 79.0 ton/ha, accordingly results are higher than inorganic fertilizer of 2,600 ppm (67.86 ton/ha). The addition of 50 kg muriate of potash/ha carried out by Salam et al. (2021) can improve plant adaptation to stressful conditions, as reported by Johnson et al. (2022) function K is stomatal regulation and addition of K can maintain electron transport from photosynthesis, thereby reducing ROS during drought stress. Dryland is synonymous with lack of water which can cause a decrease in cell function due to ROS. Inorganic fertilizer has minimal effect on nutrients in soil, which in turn affects correlation between levels of dissolved metabolites in tomatoes and nutrients (Watanabe et al., 2015). Furthermore, addition organic fertilizer to dryland can increase plant productivity by improving physical, biological, and chemical properties of soil or by increasing function soil microbes (Zheng et al., 2020). Good fertilizer management between organic and inorganic fertilizer can increase plant productivity and food safety, as reported by Khan et al. (2017) on application (full of nitrogen, phosphate and potassium + half compost) was significant on nitrogen, phosphate and potassium uptake in plant with values of 154.97, 49.79 and 358.70 kg/ha. Furthermore, fruit yield value of 39.33 ton/ha compared to control 16.33 ton/ha. The application of organic-based agriculture is expected to improve health for human. It is also expected that there will be a symbiotic mutualism between environment-plant-microbe. Fruit quality can be assessed from food safety and also nutritional value of tomatoes.

The analysis of PCA biplot is used to reduce size of a large and mutually correlated variable to a smaller size that is not correlated with each other. Figure 5 shows biplot of results of PCA analysis on observed variables. The angle formed between two lines shows correlation between variables. Smaller angle, higher correlation between two variables. The number of branch/plant forms a small angle with treatment of 2,600 ppm for inorganic fertilizer and bio-fertilizer from Organox + Hormax and total number of fruit/plant forms a small angle with treatment of 2,600 ppm for inorganic fertilizer and bio-fertilizer from Bio-Extrim + Hormax. According Wang et al. (2019) that interaction of organic and inorganic fertilizers was able to increase seeds and straw in wheat and corn. In addition, application of a combination fertilizers was able to stabilize soil pH in range of 5.5–6.5. The results of our research can be studied more specifically about nutrients in soil and plants. The effect treatment given can be seen in growth and yield. The research report conducted by Riawan et al. (2018) showed that before and after application inorganic fertilizer combined with organic can increase N by total of 66.67%, P total of 17.39%, K total of 19.35%, and SOC by 46.67%. Meanwhile, pH decreased by 13.06%. The location for taking soil samples is on location of author's research. P deficiency are cause inhibition of plant growth and yield due to reduced input of energy metabolism (ATP) (Johri et al., 2015). The author's recommend further research on combination of organic and inorganic fertilizers that can be seen from 3-5 years to optimize growth and yield in tomato. The focus of observation variables was plant physiology and biochemistry, as well as nutrient content and microbial activity in soil.

CONCLUSION

In conclusion, the combination of bio-organic and inorganic fertilizers can be an effective strategy to increase tomato productivity in dryland environments. The results of this study showed that the application of 2,600 ppm for inorganic fertilizer and bio-fertilizer from Organox + Hormax be affected the number of branch/plant and treatment of 2,600 ppm for inorganic fertilizer and bio-fertilizer from Bio-Extrim + Hormax be affected total number of fruit/plant. Application inorganic fertilizer of 2,600 ppm can increase plant productivity by 13.81% in dryland. These findings highlight the importance of balancing the use of inorganic and bio-organic fertilizers to promote agricultural sustainability and maintain soil health. Further studies can explore the long-term effects of bio-organo-mineral fertilizers on soil fertility and microbial activity to ensure the sustainability of tomato production.

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