Syntax Literate: Jurnal Ilmiah Indonesia p–ISSN: 2541-0849
e-ISSN: 2548-1398
Vol. 7, No. 10, Oktober 2022

APPLICATION OF SPECIAL FORMULA NPK FERTILIZER AND COMPOST TO INCREASING COCOA (Theobroma cacao L.) PRODUCTION AND PRODUCTIVITY

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Abstract

This research is aimed to analyze effect of special formula NPK fertilizer and compost doses to increasing cocoa production and productivity. This research was conducted in Cendana Hijau, Wotu, East Luwu, South Sulawesi on February until August 2021. This research was conducted by experiment using Split Plot Design with 3 replications. Main plots are compost doses consist of 3 levels, namely without compost (k0), 2,5 kg/tree dose (k1), and 5 kg/tree dose (k2). And sub plots are special formula NPK fertilizer consist of 5 levels, namely without NPK fertilizer (p0), 200 kg/ha special formula NPK fertilizer (p1), 400 kg/ha special formula NPK fertilizer (p2), 600 kg/ha special formula NPK fertilizer (p3), and 400 kg/ha NPK Phonska (p4). The result of this research showed that 5 kg/tree compost contributed highest avarage, especially number of pod harvested (29.13 pods) and beans per pod (36.52 beans). Special formula NPK fertilizer 600 kg/ha contributed the highest number of pod harvested (30.26 pods) and beans per pod (33.53 beans). Compost at dose 5 kg/tree and special formula NPK 600 kg/ha contributed highest average of dry weight beans per pods (70.77 g), dry weight of 100 beans (190.5 g), pod index (12.6), dry bean production per tree (2.33 g), and dry bean production per hectare (1.94 ton/ha).

Keywords: Cacao, Compost, Production, Special Formula NPK Fertilizer

Introduction

Cocoa (*Theobroma cacao* L.) is one of the plantation crops that plays an important role in the Indonesian economu because it is one of the foreign exchange earners in Indonesia. This is in accordance with the Directorate General of Plantation of the Agriculture Ministry Republic of Indonesia (2019) program that cocoa (*T. cacao* L.) is one of the leading commodities in Indonesia, after oil palm and rubber plants which have contributed foreign exchange for the country of US$ 1.13 billion in 2018. Indonesia's existence as a cocoa producer in the world shows that Indonesian cocoa is quite calculated and has the opportunity to dominate the global market, especially cocoa

How to cite: Muhtar, Nasaruddin, B Rasyid, Kurniawan (2022) Application Of Special Formula Npk Fertilizer And Compost To Increasing Cocoa (Theobroma cacao L.) Production And Productivity, Syntax Literate: Jurnal Ilmiah Indonesia, *(7)* 10,

E-ISSN: 2548-1398
Published by: Ridwan Institute

bean producers and exports and also this is the reasons makes Indonesia leading cocoa exporting country in the world.

However, cocoa production in Indonesia has continued to decline since 2011. Cocoa bean production in Indonesia in 2010 reached 559,000 tons, but in 2011 it decreased to 459,000 tons and cocoa production continues to decline until now, in 2019 cocoa production in Indonesia decreased to 217,090 tons (Department of Horticultural Food Crops and Plantations of South Sulawesi Province 2020). Meanwhile, cocoa production in the international market also experienced a decline. According to the International Cacao Organization (2012), in 2011 Indonesia was the third cocoa producer in the world besides Ivory Coast and Ghana, producing around 15% of the world's cocoa after Ivory Coast which was the largest contributor to cocoa production at 34%, followed by Ghana at 18%. However, Indonesian cocoa production in 2018-2019 fell to become the sixth producer in the world after Ivory Coast, Ghana, Ecuador, Cameroon and Nigeria (International Cacao Organization 2019).

This is thought to be due to the loss of nutrients in the root area through harvesting, washing and denetrification which contributes to soil degradation in cocoa plantations. Asrul (2013) stated that the nutrients N, P and K will be transported in 1 ton of cocoa beans, equivalent to 42-50 kg of urea, 43-48 kg of TSP, 34-43 kg of KCl, and 20 kg of kieserite, while those transported in pods peel equivalent to 32-37 kg urea, 20-25 TSP, 249-310 kg KCl and 22 kg kieserite.

To overcome this problem is to use a special formula NPK fertilizer on cocoa plants produced by PT. Pupuk Kaltim because this research is a collaboration between researchers and PT. Pupuk Kaltim fertilizer. This special formula NPK fertilizer has the advantage that it contains more nutrients, namely the macronutrient N; 14%, P_2O_5; 12 % K_2O; 16%, MgO; 4 %, CaO, 4 %, S; 3% and the micro elements are ZnO; 0.3 % and B2O3; 0.4%, which is compared to other NPK fertilizers that only contain NPK macro nutrients (Pupuk Kaltim 2020).

The results showed that the use of a special formula NPK fertilizer (14-12-16) on cocoa plants in nurseries up to 6 months after treatment was more efficient or agronomically more effective and better than a single NPK fertilizer on the growth of cocoa seedlings (Pupuk Kaltim and Balitan 2020). This is the basis for conducting further testing on cocoa plantations that have been producing. Another problem is not making efforts to improve soil fertility due to excessive and continuous use of inorganic fertilizers and not combining it with the use of organic fertilizers such as compost which results in decreased crop fertility. This happens because farmers are reluctant to use compost and prefer to use chemical fertilizers because of the higher nutrient content so that the effect on plants is seen more quickly, while the effect of compost is not visible quickly. As a result, soil organic matter content decreases, soil fertility decreases, yields continue to decline. The use of high concentrations of chemical fertilizers with high doses and in combination with organic fertilizers for a long period of time causes degradation of soil fertility due to nutrient imbalances or other nutrient deficiencies, and the decreasing organic matter content of the soil. To overcome the problem of

decreasing soil fertility is to maximize the use of limited resources at the farmer level. It is hoped that it will have an impact on improving the welfare of cocoa farmers today, namely by providing organic materials, one example is the provision of compost from cocoa husk waste combined with other materials such as banana stems. and gamal leaves. The addition of organic matter can increase the C-organic content of the soil and also with the increase in C-organic soil can affect the soil properties for the better physically, chemically and biologically. Carbon is a food source for soil microorganisms, so the presence of C-organic in the soil will stimulate the activities of microorganisms thereby increasing the process of soil decomposition and also reactions that require the assistance of microorganisms, such as P dissolution and N fixation (Afandi et al 2015).

The mineral nutrient content of cocoa pods is quite high, especially potassium and nitrogen nutrients. It was reported that 61% of the total nutrients of the cocoa pods are stored in the pods themselves. The nutrient content of compost made from cocoa pods is 1.81% N, 26.61% C-organic, 0.31% P_2O_5, 6.08% K_2O, 1.22% CaO, 1.37% MgO, and 44,85 cmol kg-1 KTK. Utilization of cocoa pod compost can increase cocoa production until 19.48% (Saragih and Ardian 2017).

Based on the results of Kurniawan's research (2019), it was shown that a dose of 2.5 kg to 10 kg cocoa pod compost on 2.5 year old cocoa plants as an effort to increase soil fertility in plantation areas, that resulted in a fairly average research result. both on the soil pH value, KTK value, soil C-organic content, soil phosphorus content and soil K content, which when compared with the control treatment an increase in soil fertility

Methods

Place and time

This research was conducted in Cendana Hijau, Wotu, East Luwu, South Sulawesi on February to August 2021. Soil sample analysis was conducted in Physics, Chemistry, and Soil Fertility, Soil Science Department, Faculty of Agriculture, Hasanuddin University.

Tools and materials

The tools used in this research were a hoe, bucket, analytical scale, soil drill, knife, machete, scissors, laptop, and stationery. The materials used in this research were phonska NPK fertilizer, special formula Pelangi NPK Fertilizer, compost, cocoa plants from the shoot graft of 45 clones aged 3 years, label, tape, bag, and sack.

Research methods

This research was conducted by experiment using Split Plot Design with 3 replications. Main plots are compost doses consist of 3 levels, namely without compost (k0), 2,5 kg/tree dose (k1), and 5 kg/tree dose (k2). And sub plots are special formula NPK fertilizer consist of 5 levels, namely without NPK fertilizer (p0), 200 kg ha^{-1} special formula NPK fertilizer (p1), 400 kg ha^{-1} special formula NPK fertilizer (p2), 600 kg ha^{-1} special formula NPK fertilizer (p3), and 400 kg ha^{-1} NPK Phonska (p4). Each

treatment was repeated 3 times with four sample plants for each experimental unit so that there were 180 experimental units.

Observation

Harvested pods were carried out at the end of the research by counting all the ripe pods that can be harvested from the ground to the secondary branches. Harvesting of ripe pods is carried out in stages, the maturity of cocoa pods does not occur at the same time, so harvesting is carried out at any time when the pods is ripe. Number of beans per pod, weight of beans per pod, weight of 100 dry beans, were observed at the end of the research. Pod index was calculated by: (Number of beans per pod)/(weight of dry beans) (Nasaruddin 2010). Production per tree and per hectare was observed at the end of the research.

Data analysis

Observational data will be analyzed by ANOVA at the 95% confidence level. If the treatment has a significant effect, further test will be carried out with BNT test 0.05.

Results And Discussion

Results

Harvested pods

Table 1
Effect of Compost Doses and NPK Fertilizer on Harvested Pods

Compost doses (k)	NPK Fertilizers (p)					Average	NP. BNT 0.05
	0.kg ha^{-1} (p0)	Special formula 200 kg ha^{-1} (p1)	Special formula 400 kg ha^{-1} (p2)	Special formula 600 kg ha^{-1} (p3)	Phonska NPK 400 kg ha^{-1} (p4)		
0 kg per tree (k0)	23.78	17.00	20.56	24.78	24.89	22.20c	
2.5 kg per tree (k1)	20.56	23.67	23.56	33.00	30.33	26.22b	1.67
5,0 kg per tree (k2)	28.44	27.33	28.89	33.00	28.00	29.13a	
Average	24.26qr	22.67r	24.33qr	30.26 p	27.74 pq		
NP. BNT 0.05			4.93				

Note: Mean values with different letters in columns (a,b,c) and rows (p,q,r) are significantly different at 0.05 level by BNT.

Beans per pod

Table 2
Effect of Compost Doses and NPK Fertilizer on Beans per Pod

Compost doses (k)	NPK Fertilizers (p)					Average	NP. BNT 0.05
	0.kg ha^{-1} (p0)	Special formula 200 kg ha^{-1} (p1)	Special formula 400 kg ha^{-1} (p2)	Special formula 600 kg ha^{-1} (p3)	Phonska NPK 400 kg ha^{-1} (p4)		
0 kg per tree	23.19	28.42	23.19	28.22	29.92	26.59b	3.49

(k0)						
2.5 kg per tree (k1)	21.53	26.74	25.94	35.11	34.15	28.69b
5,0 kg per tree (k2)	31.38	41.37	38.66	37.27	33.90	36.52a
Average	25.36q	32.18p	29.27pq	33.53p	32.65p	
NP. BNT 0.05			5.78			

Note: Mean values with different letters in columns (a,b) and rows (p,q) are significantly different at 0.05 level by BNT.

Dry weight beans per pod

Table 3
Effect of Compost Doses and NPK Fertilizer on Dry Weight Beans per Pod

Compost doses (k)	NPK Fertilizers (p)					NP. BNT 0.05
	0.kg ha^{-1} (p0)	Special formula 200 kg ha^{-1} (p1)	Special formula 400 kg ha^{-1} (p2)	Special formula 600 kg ha^{-1} (p3)	Phonska NPK 400 kg ha^{-1} (p4)	
0 kg per tree (k0)	$27.86_b{}^{r}$	$53.38_a{}^{p}$	$45.86_a{}^{pq}$	$36.59_b{}^{qr}$	$39.51_b{}^{qr}$	14.57
2.5 kg per tree (k1)	$43.59_a{}^{q}$	$59.55_a{}^{p}$	$36.45_a{}^{q}$	$61.39_a{}^{p}$	$37.10_b{}^{q}$	
5,0 kg per tree (k2)	$54.45_a{}^{qr}$	$59.98_a{}^{q}$	$42.81_a{}^{r}$	$\mathbf{70.77}_a{}^{p}$	$56.30_a{}^{q}$	
NP. BNT 0.05			12.72			

Note: Mean values with different letters in columns (a,b) and rows (p,q,r) are significantly different at 0.05 level by BNT.

Weight 100 dry beans

Table 4
Effect of Compost Doses and NPK Fertilizer on Weight 100 Dry Beans

Compost doses (k)	NPK Fertilizers (p)					NP. BNT 0.05
	0.kg ha^{-1} (p0)	Special formula 200 kg ha^{-1} (p1)	Special formula 400 kg ha^{-1} (p2)	Special formula 600 kg ha^{-1} (p3)	Phonska NPK 400 kg ha^{-1} (p4)	
0 kg per tree (k0)	$110.7_a{}^{q}$	$189.7_a{}^{p}$	$197.8_a{}^{p}$	$130.3_b{}^{q}$	$131.2_a{}^{q}$	48.8
2.5 kg per tree (k1)	$143.0_a{}^{p}$	$165.5_a{}^{p}$	$189.7_a{}^{p}$	$181.5_a{}^{p}$	$178.5_a{}^{p}$	
5,0 kg per tree (k2)	$118.6_a{}^{q}$	$144.9_a{}^{pq}$	$157.5_a{}^{pq}$	$\mathbf{190.5}_a{}^{p}$	$171.4_a{}^{p}$	
NP. BNT 0.05			41.1			

Note: Mean values with different letters in columns (a,b) and rows (p,q) are significantly different at 0.05 level by BNT.

Pod index

Table 5
Effect of Compost Doses and NPK Fertilizer on Pod Index

Compost doses (k)	NPK Fertilizers (p)					NP. BNT 0.05
	0.kg ha^{-1} (p0)	Special formula 200 kg ha^{-1} (p1)	Special formula 400 kg ha^{-1} (p2)	Special formula 600 kg ha^{-1} (p3)	Phonska NPK 400 kg ha^{-1} (p4)	
0 kg per tree (k0)	15.94_{a}^{pq}	14.67_{a}^{p}	16.89_{a}^{pq}	19.00_{b}^{q}	15.00_{a}^{p}	
2.5 kg per tree (k1)	16.72_{a}^{q}	14.50_{a}^{pq}	14.44_{a}^{pq}	12.67_{a}^{p}	13.11_{a}^{pq}	3.59
5,0 kg per tree (k2)	19.06_{a}^{q}	14.67_{a}^{p}	13.56_{a}^{p}	**12.06_{a}^{p}**	12.83_{a}^{p}	
NP. BNT 0.05			3.66			

Note: Mean values with different letters in columns (a,b) and rows (p,q) are significantly different at 0.05 level by BNT.

Dry Bean Production per Tree

Table 6
Effect of Compost Doses and NPK Fertilizer on Dry Bean Production per Tree

Compost doses (k)	NPK Fertilizers (p)					NP. BNT 0.05
	0.kg ha^{-1} (p0)	Special formula 200 kg ha^{-1} (p1)	Special formula 400 kg ha^{-1} (p2)	Special formula 600 kg ha^{-1} (p3)	Phonska NPK 400 kg ha^{-1} (p4)	
0 kg per tree (k0)	0.67_{b}^{p}	0.90_{b}^{p}	0.95_{a}^{p}	0.91_{b}^{p}	0.98_{b}^{p}	
2.5 kg per tree (k1)	0.91_{b}^{r}	1.44_{ab}^{q}	0.85_{a}^{r}	2.01_{a}^{p}	1.15_{ab}^{qr}	0.54
5,0 kg per tree (k2)	1.51_{a}^{q}	1.63_{a}^{q}	1.28_{a}^{q}	2.33_{a}^{p}	1.56_{a}^{q}	
NP. BNT 0.05			0.49			

Note: Mean values with different letters in columns (a,b) and rows (p,q,r) are significantly different at 0.05 level by BNT.

Dry Bean Production per Hectare

Table 7
Effect of Compost Doses and NPK Fertilizer on Dry Bean Production per Hectare

Compost doses (k)	NPK Fertilizers (p)					NP. BNT 0.05
	0.kg ha^{-1} (p0)	Special formula 200 kg ha^{-1} (p1)	Special formula 400 kg ha^{-1} (p2)	Special formula 600 kg ha^{-1} (p3)	Phonska NPK 400 kg ha^{-1} (p4)	
0 kg per tree (k0)	0.56_{b}^{p}	0.75_{b}^{p}	0.79_{a}^{p}	0.75_{b}^{p}	0.82_{b}^{p}	
2.5 kg per tree (k1)	0.76_{b}^{r}	1.20_{a}^{q}	0.71_{a}^{r}	1.68_{a}^{p}	0.96_{ab}^{qr}	0.45
5,0 kg per tree (k2)	1.26_{a}^{q}	1.36_{a}^{q}	1.07_{a}^{q}	**1.94_{a}^{p}**	1.30_{a}^{q}	
NP. BNT 0.05			0.41			

Note: Mean values with different letters in columns (a,b) and rows (p,q,r) are significantly different at 0.05 level by BNT.

Discussion

Giving a dose of compost can improve and increase soil fertility and soil nutrient content. Increasing the amount of nutrients in the soil will have a positive impact on nutrient absorption and plant growth (Notohadiprawiro et al 2006). Nursyamsyi et al (2011) stated that nutrient uptake by plants reflects the condition of soil and plant nutrients. If the soil conditions (physical, chemical and biological properties) and plants are good, then the plant roots will absorb nutrients effectively.

The experimental results showed that the higher dose of compost given, harvested pods and beans per pod also increases. The results of research by Muthmainnah et al (2021) showed that the compost dose treatment had a significant effect on the harvested pods, beans per pod and then continued by Kurniawan (2020) who stated that the higher dose of compost given to cocoa plants, the effect on crop production will be better.

Special formula NPK fertilizer treatment had a significant effect on the harvested pods and beans per pod which dose 600 kg/ha of special formula NPK treatment gave better results. This is because the special formula NPK fertilizer does not only contain nutrients N, P, K, but also other nutrients such as Ca and Mg. In the observations, N, P, K, Ca and Mg were positively correlated with the harvested pods and beans per pod. This shows that the nutrient content of the special formula NPK fertilizer is closely related to the increase of harvested pods and beans per pod for cocoa plants.

Nitrogen content is one of the nutrients that is needed by plants, nitrogen is a nutrient that undergoes the fastest metabolic processes in plant so that it can improve the quality of photosynthesis. This is in accordance with the opinion of Saraskesta et al (2016) which states that nitrogen can increase photosynthetic capacity and can increase chlorophyll synthesis and increase antioxidant defense enzymes found in organic or inorganic compounds as nitrate (NO_3) and ammonium ($NH4^+$). Tando (2018) stated that in most agricultural soils, nitrate is the most widely absorbed form of nitrogen compounds by plants.

Nitrogen is also one of the main elements that contribute to the structure of organic molecules, including proteins, nucleic acids, cofactors and metabolites. Nasaruddin and Musa (2012) stated that plants showed a very high response to nitrogen treatment, because nitrogen is the main nutritional element that makes up amino acids and proteins.

Phosphorus also has an important role in increasing harvested pods and beans per pod. This is because the phosphorus content plays an important role in plants as an energy-carrying compound for various metabolic processes, both as a constituent of NADP so that the phosphorus content plays a role in all metabolic processes that occur in plant so that it plays an important role in the photosynthesis process. Nasaruddin and Musa (2012) stated that phosphorus metabolism is closely related to oxidative phosphorylation in the respiration process, photosynthetic phosphorylation in photosynthesis and substrate phosphorylation. So that the phosphorus content can affect

the number of harvested pods and beans per pod. Chen (2014) stated that element P plays a role in cell division, causing accelerated maturation of beans, pod, pod's quality, grains, and increasing the final harvest weight.

Potassium content also plays an important role in plant production, because K is very influential in the photosynthesis process. Potassium can increase photosynthetic activity, thereby affecting the number of pod harvested and beans per pod. Nasaruddin (2018) states that potassium plays an important role for carbohydrate translocation. This is what causes the importance of nutrient K in plants. Fauzi and Putra (2019) explained that potassium functions is to stimulate new roots to grow, helps absorb water and soil nutrients, strengthens plant stems, improves fruit quality, and helps in the formation of carbohydrates and plant protein.

In addition to the nutrients N, P, K, there are also other nutrients that are important for plants, namely Ca and Mg. Ca and Mg are very important in plant growth and production, this is because calcium plays a role in the process of cell division and elongation and regulates the distribution of photosynthesis, while Mg plays a role in energy transportation in plants and is also a component of chlorophyll formation and enzymes in various protein synthesis processes. Nasaruddin (2018) stated that Ca is very important in the growth of cocoa plants and the element Mg can increase leaf retention and delay leaf aging because of its role as the core of chlorophyll.

Based on the results of the research conducted, it shows that there is a very significant interaction with the production parameters, especially dry weight of beans, weight of 100 dry beans, pod index, dry bean production per tree and dry bean production per hectare. This is due to the addition of a dose of compost that is able to improve the soil structure to become larger and able to increase the holding capacity of soil water and with the provision of NPK fertilizer formula and the availability of water in the soil can dissolve the nutrients available in the soil.

With the availability of water and nutrients in the soil can increase the efficiency of plants in absorbing nutrients in the soil so as to increase the production and productivity of cocoa plants. Nasarauddin and Musa (2012) stated that plant productivity is closely related to the ability of plants to efficiently absorb water and nutrients from the soil.

Dosage of compost and NPK fertilizer can increase cocoa production. This is because the dose of compost and NPK formula fertilizer can improve the physical and chemical properties of the soil, soil aggregates and soil texture and can provide macro and micro nutrients in sufficient balance so that they can affect the growth and production of cocoa plants. The application of formula NPK fertilizer can increase soil nutrient levels, especially N, P, K, Ca and Mg which greatly affect the increase in cocoa production.

The application of NPK fertilizer provides nutrients, especially N, P, K, Ca and Mg and the application of compost can increase water holding capacity, aerase pores and infiltration rate so as to facilitate the penetration of plant roots in absorbing nutrients in the soil. With the availability of nutrients in the soil, it can increase the

protein, carbohydrate and fat content in plants. Marliana (2017) stated that the adequacy of N,P,K in plant can increase photosynthetic activity.

Thus, it allows the number of pods to form more, maintains pods wilting and miscarriage and helps in the formation of protein and carbohydrates as well as accelerates the ripening of beans and pods so as to improve pods quality which can increase cocoa production. Element Ca is very important in the growth of cocoa plants and element Mg can increase leaf retention delaying leaf aging because of its role as the core of chlorophyll (Nasaruddin 2018).

Conclusions

I would like to express my special thanks of gratitude to Prof. Dr. Ir. Nasaruddin, M.P and Dr. Ir. Burhanuddin Rasyid, M.Sc, as well as our academic counselors who helped me in doing a lot of research and I come to know about to many new things. Secondly, I also would like to thank to my friends who helped me a lot in finishing this research within the limited.

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