EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON SOYBEAN (*Glycine max* L.) GRAIN YIELD IN DRY LAND OF INDONESIA

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Abstract. Increasing soybean (*Glycine max* L.) production in dry land can be done through intensification using organic and inorganic fertilizer. The aim of the study was to evaluate the optimization use of organic and inorganic NPK fertilizers on soil and soybean productivity on dry land. The experiment was arranged in a randomized complete block design with three replications on dry land in Gresik, East Java, Indonesia. The treatments evaluated were 12 dosage combinations of ZA (ammonium sulphate), SP-18 (super phosphate-18), KCl (potassium chloride), and chicken manure. The study was conducted on dry land without and with 5,000 kg cow manure/ha. The soybean seed used in this research was Argomulyo. The results showed that (1) application of 5,000 kg cow manure/ha increased the yield of Argomulyo soybean variety by 0.21 t/ha (9%), (2) application of 100 kg KCl/ha + 50 kg ZA/ha + 100 kg SP-18/ha + 5,000 kg cow manure/ha, and 50 kg ZA/ha + 2,500 kg chicken manure/ha + 5,000 kg cow manure/ha increased soybean yield by 0.95-1.38 t/ha (50-74%), (3) application of 100 kg KCl/ha increased P uptake by 68%, Ca uptake by 60%, and Mg uptake by 54% compared to without fertilizer, (4) application of 50 kg KCl/ha + 2,500 kg chicken manure/ha increased N uptake by 48%, application of 50 kg ZA/ha + 100 kg SP-18/ha increased K uptake by 117%, and application of 50 kg ZA/ha increased Ca uptake by 60% compared without fertilizer, and (5) application of 5,000 kg cow manure/ha improved the physical properties of the soil by reducing soil bulk density by 7% and soil penetration by 37% and increasing soil permeability of 2.20 cm/hour from 1.78 cm/hour to 3.98 cm/hour. Soybean cultivation of the Argomulyo variety on dry land in Gresik requires the addition of organic cow manure 5000 kg/ha plus ZA fertilizer 50 kg/ha + chicken manure 2500 kg/ha or ZA fertilizer 50 kg/ha + SP-18 100 kg/ha + KCl 100 kg/ha to increase yield 0.95–1.38 t/ha and improve soil physical fertility. This study gives the information that the use of organic and inorganic fertilizer is an alternative technology that is required to maintain and increase the productivity of soybean and soils in dry land to support sustainable soybean cultivation.
Keywords: *Argomulyo variety, application, chicken manure, optimization, productivity*

Introduction

Dry land is defined as land that has never been waterlogged most of the year. The productivity of dry land is generally low, thus limiting the productivity of cultivated plants. Physical characteristics of dry land soils in Indonesia especially in East Java and

Central Java that are planted with maize (*Zea mays* L.), soybean (*Glycine max* L.), and peanuts (*Arachis hypogea* L.) is dominated by clay and silt fractions. The soil organic-C content ranges from 0.47-3.09%, the N-total content ranges from 0.11-0.22%, with pH (H_2O) 4.65-7.60, level of P_2O_5 Bray-1 ranged from 3 to 87 ppm, and level of P_2O_5 Olsen is between 5 and 64 ppm. K content is between 0.08 and 1.20 me/100 g. Fe-P and Al-P levels > 50 ppm are more than 50% of the survey locations; the highest Ca-P levels (25 ppm) is only in one location. On average, Fe-P > Al-P >> Ca-P. The diversity of soil fertility causes diversity in soybean yields (Iletri, 1998; Harsono, 1999; Kuntyastuti and Radjit, 2000). According to Nurjaya et al. (1998) soils rich in P and K elements are found in intensification areas, while those with low P and K status are found in non-intensified or rainfed areas. Taufiq (2001) reported that Alfisol soil in East Java and Central Java is potentially deficient in P. Dry land needs improvement to increase productivity by providing ameliorant materials such as agricultural lime, dolomite, organic matter or biochar. Balanced fertilization is very effective and efficient to increase soil productivity, and is carried out based on soil nutrient status and nutrient needs by plants (Kasno, 2019).

Apart from paddy fields, soybeans are also grown on dry land with lower productivity compared to rice fields. The role of dry land soybean is in supporting efforts to increase production through intensification using organic and inorganic fertilizers. Increasing soybean yield on suboptimal land requires the addition of organic fertilizers, biological fertilizers, lime, and inorganic fertilizers. In addition, the use of varieties suitable for specific agroecology is also highly recommended (Barus, 2013).

Nutrients that limit soybean growth in dry land are elements of P and K (Kuntyastuti and Radjit, 2000) and organic matter (Kuntyastuti and Taufiq, 2008). The addition of organic fertilizers and inorganic fertilizers is reported to improve and increase growth, soybean yield, and soil fertility (Vende et al., 2013; Hanifa and Lutojo, 2014; Naini, 2015; Juarsah, 2016; Widiastuti and Latifah, 2016; Wijanarko, 2016; Sari et al., 2017; Setiawati et al., 2017; Yuniarti et al., 2019; Kristiono et al., 2020). On dry land, the use of SP36 (super phosphate-36) fertilizer and chicken manure increases soybean yield (Kuntyastuti, 2000), and the addition of 100 kg S fertilizer/ha increases the efficiency of KCl fertilizer on soybeans (Kuntyastuti and Santoso, 2001). Sulfur fertilization and Rhizobium sp inoculation can also increase soybean yields (Getachew, 2017). The use of organic fertilizers can reduce the need for NPK inorganic fertilizers (Sitawati, 2020). The yield of soybean fertilized by 50 kg Urea/ha + 75 kg SP36/ha + 100 kg KCl/ha is not different from that fertilized by 25 kg Urea/ha + 37.5 kg SP36/ha + 50 kg KCl/ha + 500 kg guano manure/ha (Wahyudin et al., 2017). Meanwhile, the addition of biological fertilizers of *Rhizobium, Azotobacter sp.*, *Azospirillum sp.*, or endomycorrhizae also improves soybean growth in dry land (Permanasari et al., 2014; Kartina et al., 2015; Kiuk et al., 2019). The addition of biofertilizer Agrimeth + NPK inorganic fertilizer 50% recommendation increases soybean yield 1.26 t/ha (100%) compared to recommended 100% NPK fertilizer (Purba, 2016). Application of 50% NPK + 50% poultry manure and 100% poultry manure improved soil chemical properties and nutrient uptake of soybean (Almaz, 2017).

The use of P inorganic fertilizer and manure is one of the alternatives to improve soil P fertility status, increase yields, and sustain better productivity of soy-wheat cropping patterns on dry land Vertisols (Reddy et al., 1999). Phosphorus deficiency significantly decreased nutrient uptake by all plant parts especially in drought conditions (Rotaru et al., 2014). Continuous application of P fertilizer enhanced available P (Bray-P), but

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application of lime reduced the accumulation of P in soil. Balanced fertilizer management with suitable amendment (organic manure/lime) compulsorily required for optimum nutrient supply without affecting soil health for sustainable production (Vishwanath, 2020). On dry land with a pH of 6.9, 1.21% organic C, low levels of P, K, and S elements, the use of 150 kg rock phosphate/ha increases soybean yields 35-50% and increases the efficiency of using chicken manure and cow manure by 50% (Kuntyastuti et al., 2003). According to Ghosh et al. (2003) 100% recommended dose of NP fertilization can increase the sustainable yield index. The agronomic efficiency was higher at the 50% recommended dose of NP fertilization compared to 100% recommended dose of NP fertilization. Soil organic C content decreased after four years of planting and availability of P elements increased with continuous NP fertilization for four years. In Latosol and Podsolik soils, the use of cow dung is better than that of straw compost. The addition of cow dung and straw is better given after the application of P-inorganic fertilizer (Sari et al., 2017).

The use of 4,000 kg manure + 30 kg N + 26 kg P + 25 kg K/ha in each growing season is an alternative fertilizer to improve soil physical properties and soybean productivity because it increases the efficiency of water and nutrient use (Bandyopadhyay et al., 2010). Improvement of soil fertility due to the use of manure caused by the activity of dehydrogenase enzymes; acid and alkaline phosphatase; cellulose; and protease activity, which ultimately improves nutrient transformation (Saha et al., 2008). The best soybean growth and yield was obtained in the treatment of 20 t/ha manure + Trichoderma sp. 20 g/polybag (Sarawa, 2014).

Intensive cultivation, the use of inorganic fertilizers and erosion can reduce the carbon content of microorganisms (Susilawati, 2013) and cause a decrease in yield. Ding et al. (2016) reported that inorganic fertilizer plus manure increased microbial size and diversity and changed microbial composition.

Cultivation of plants without organic fertilizers reduced soil organic C content by 39-43% compared to soil treated with organic fertilizers. The increase in soil organic C was 26, 18, and 6% of the total C-organic in added manure, rice straw, and green manure (Ghosh et al., 2012). The use of manure for 15 years increased the C-organic and N-total soil as well as the enzyme activity of invertase, b-glucosidase, urease, acid and alkaline phosphatase, and dehydrogenase in the soil. Long term use of manure is the best alternative to improve soil quality and microbial activity (Liang et al., 2014). The activity of the plasma membrane H+-ATPase enzyme can be increased by the addition of Ca, thereby increasing nutrient uptake (Liang and Zhang, 2018). Ca nutrient promotes a more positive partial N-balance in soybean, contributing N to the rotation, reducing the dependency on synthetic N fertilizers and the mining of soil N reservoir from soil organic matter, and increasing the long-term sustainability (Alves et al., 2021). In connection with the foregoing research that has been carried out, this study aimed was to evaluate the optimization use of organic and inorganic NPK fertilizers on soil and soybean productivity on dry land.

Materials and Methods

Place and time of study

The study was conducted on dry land in Bolo Village, Ujungpangkah District, Gresik Regency, East Java Province, Indonesia at the coordinates of 6.957881 and 112.531537 East Longitude.

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Research design

The experiment was arranged in a randomized complete block design with three replications. The treatments evaluated were 12 dosage combinations of ZA (ammonium sulphate), SP-18 (super phosphate-18), KCl (potassium chloride), and chicken manure (*Table 1*). The study was conducted on dry land without and with application of 5,000 kg cow manure/ha. ZA inorganic fertilizer contains 20.8% N and 23.8% S, SP-18 contains 18% P_2O_5, and KCl contains 60% K_2O. Chemical properties of cow manure and chicken manure presented in *Table 2*.

Table 1. *Combination treatments of organic and NPK inorganic fertilizer*

No.	ENVIRONMENT A (without cow manure)				ENVIRONMENT B (5,000 kg cow manure/ha)			
	ZA	**SP-18**	**KCl**	**Chicken manure**	**ZA**	**SP-18**	**KCl**	**Chicken manure**
	(kg/ha)				(kg/ha)			
1	0	0	0	0	0	0	0	0
2	50	0	0	0	50	0	0	0
3	0	100	0	0	0	100	0	0
4	0	0	100	0	0	0	100	0
5	50	100	0	0	50	100	0	0
6	50	0	100	0	50	0	100	0
7	0	100	100	0	0	100	100	0
8	50	100	100	0	50	100	100	0
9	50	0	0	2,500	50	0	0	2,500
10	0	50	0	2,500	0	50	0	2,500
11	0	0	50	2,500	0	0	50	2,500
12	0	0	0	2,500	0	0	0	2,500

Table 2. *Chemical properties of cow manure and chicken manure*

Chemical properties	Cow manure	Chicken manure	Methods
Organic-C (%)	3.86	26.9	Curmic
P_2O_5 (%)	0.13	4.21	Wet destruction HNO_3 + $HClO_4$
SO_4 (%)	3.07	7.45	Wet destruction HNO_3 + $HClO_4$
K (%)	0.44	2.62	Wet destruction HNO_3 + $HClO_4$
Ca (%)	5.35	2.67	Wet destruction HNO_3 + $HClO_4$
Mg (%)	0.28	0.34	Wet destruction HNO_3 + $HClO_4$
CEC (%)	25.1	32.0	NH_4 OAc pH 7
Fe (%)	0.39	0.18	Wet destruction HNO_3 + $HClO_4$
Mn (%)	0.170	0.08	Wet destruction HNO_3 + $HClO_4$
Cu (%)	0.011	0.08	Wet destruction HNO_3 + $HClO_4$

Remarks: Analysis were carried out in Soil and Plant Chemical Laboratory, Iletri

Seeds of Argomulyo variety (mixed with carbosulfan insecticide) were planted at a 3.2 m x 3.2 m plot with a planting space of 40 cm x 10 cm, without basic fertilizer. Between plots were made a drainage channel of 30 cm wide with a depth of 25 cm. Cultivated land, the fertilizers were supplied at planting time by making a hole in the soil of 10 cm apart next to the seedling hole. Weeding was carried out at the age of 21 and 35 days after planting (DAP). Thinning and replanting were carried out at the age of 10 DAP and leaving two plants/clumps. Pests and disease controls were carried out

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intensively according to the field conditions using deltametrin 25 g/l, fipronil 50 g/l, diafentiuron, mankozeb, and propinep 70%. At the research locations, water pump facility is available, so that soybean plants can be irrigated once every 20 days using underground water.

Observation

Soil samples were taken at a depth of 0-20 cm and 20-40 cm. Nutrient uptake analysis was carried out at the pod formation phase at 51 DAP. Parameters observed were (1) leaves chlorophyll indexes using chlorofilmeter digital SPAD brand Minolta (*Figure 1*); nutrient uptake of N, P, K, Ca, and Mg in the pod formation phase at 51 DAP, (2) plant height, number of filled pods, and weight of 100 seeds from 10 sample plants at harvest time, and (3) soybean yields in the 3.2 m x 2.5 m plots. Data obtained were subjected to analysis of variance followed by LSD test at a significant level of 5%. The condition of soybean crop in the study site is shown *in Figures 2* and *3*.

Figure 1. *Measurement of leaf chlorophyll index using a SPAD digital chlorophyllmeter*

Figure 2. *Leaf growth of Argomulyo variety during pod filling phase, Alfisol Gresik.*

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Figure 3. *Crop of Argomulyo variety during pod harvesting phase, Alfisol Gresik.*

Data analysis

Analysis of the physical and chemical properties of the soil was carried out before planting and after harvesting. Soil texture of dry land in the research location at Gresik is clay loam with a soil water holding capacity in the top soil of a depth of 0-20 cm by 16%. Soil is dominated by the silt fraction so that is loose and has the potential to support the achievement of high productivity. Farmers rarely cultivate the soil to a depth of more than 20 cm. This can be seen from the saturated hydraulic conductivity of the soil with a depth of 0-20 cm of 2.01 cm/hour, which is 65% higher than the soil depth of 20-40 cm, which is 1.22 cm/hour (*Table 3*). Saturated hydraulic conductivity (soil permeability) is the velocity of movement of water in the saturated soil (vertical flow). Water can flow easily in soil which has large pores and has good inter-pore relationships. Small pores with uniform inter-pore relationships have lower permeability because the movement of water in the soil is slower. Low soil permeability can also be caused by the soil that has never been cultivated, so that the soil pores are very small and the soil becomes compact.

Table 3. *Physical properties of Gresik dry land*

Physical properties	Depth of 0-20 cm	Depth of 20-40 cm	Methods
Saturated hydraulic conductivity (cm/hour)	2.01	1.22	Constan heat
Bulk density (g/cm^3)	1.28	1.30	Cylinder
Particle density (g/cm^3)	2.51	2.48	Picnometer
Porosity (%)	49	47	Equation BI, BJ
Penetration (N/cm^2)	259	271	Penetrometer
COLE	0.027	0.074	
Water content pF 2,5 (%)	35	38	Gravimetry
Water content pF 4,2 (%)	19	19	Gravimetry
Water holding capacity (%)	16	19	
Sand fraction (%)	22	23	Pipette
Silt fraction (%)	43	39	Pipette
Clay fraction (%)	35	38	Pipette
Texture class	Clay loam	Clay loam	Triangle texture

Remarks: Analysis was carried out in Physical Soil Laboratory, Brawijaya University

Soil compaction with a depth of 20-40 cm was also observed based on the soil penetration value, namely 271 N/cm^2 in soil depth of 20-40 cm, higher than the soil depth of 0-20 cm, namely 259 N/cm^2. Soil penetration is the power needed for an object to enter the ground. The high value of soil penetration can inhibit plant root development.

Gresik dry land soil has a neutral pH, poor in organic matter, nutrients N, S, Na, Ca, and Mg, but rich in P and K nutrients (*Table 4*). If water needs are fulfilled and fertilized, the physical and chemical fertility of the Gresik dry land soil can support the achievement of high productivity. In soil with a neutral pH, the level of macro nutrient availability is at its maximum, so that it can meet the needs of soybean plants. Chicken manure as research material is richer in organic-C, P, S, K, and Mg elements compared to cow manure, and vice versa for elements of Ca (*Table 2*).

Table 4. *Chemical properties of Gresik dry land*

Chemical properties	Depth of 0-20 cm	Depth of 20-40 cm	Methods
pH H_2O	6.75	7.45	pH meter
Organic-C (%)	1.77	1.34	Curmic
Total-N (%)	0.11	0.11	Kjeldhal
P_2O_5 Bray I (ppm)	55.0	40.5	Bray-1
SO_4 (ppm)	19.8	15.9	NH_4 OAc pH 4,8
K (cmol(+) kg^{-1})	0.65	0.23	NH_4 OAc pH 7
Na (cmol(+) kg^{-1})	0.05	0.03	NH_4 OAc pH 7
Ca (cmol(+) kg^{-1})	0.82	1.55	NH_4 OAc pH 7
Mg (cmol(+) kg^{-1})	0.10	0.52	NH_4 OAc pH 7
Al (cmol(+) kg^{-1})	0.0	0.0	KCl 1 N
H (cmol(+) kg^{-1})	0.0	0.0	KCl 1 N
CEC (cmol(+) kg^{-1})	25.1	32.0	NH_4 OAc pH 7
Fe (ppm)	20.2	16.0	DTPA extract
Mn (ppm)	44.1	45.0	DTPA extract
Cu (ppm)	8.25	7.59	DTPA extract
Zn (ppm)	4.06	3.46	DTPA extract

Remarks: Analysis were carried out in Soil and Plant Chemical Laboratory, Iletri

Results and Discussion

On dry land in Gresik, optimal growth of Argomulyo soybean varieties can be obtained with good management. The application of organic fertilizer in the form of cow and chicken manure, NPK inorganic fertilizer in the form of ZA, SP-18, and KCl did not affect the chlorophyll index of soybean leaves at the age of 51 DAP on pod development stage, plant height at harvest, weight of 100 seeds, and number of filled pods/plants (*Table 5*). The chlorophyll index of soybean leaves averaged 42.3. At harvest time, the soybean plant reaches a height of 59 cm with 26 filled pods/plant and a weight of 100 seeds 19.6 g. Argomulyo weight of 100 seeds based on the description of superior varieties is 16 g, including the large seed soybean category (Iletri, 2018).

Application of 5,000 kg cow manure/ha increase Anjasmoro soybean leaves chlorophyll index at 60 DAP from 39.7 to 46.6. The soybean plant grows on dry land with pH 6.74, 1.35% organic-C, 9.5 ppm P_2O_5, 0.29 me/100 g K, 52.5 me/100 g Ca, and 7.22 me/100 g Mg. Soil is poor in P and K nutrient, but rich in Ca and Mg nutrient (Muzaiyanah et al., 2015). The availability and P nutrient uptake can be inhibited by

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high levels of Ca and Mg nutrient. In this study, soybean was grown on dry land with a pH of 6.75, 1.77% organic-C, 55 ppm P_2O_5, 0.65 me/100 g K, 0.82 me/100 g Ca, and 0.10 me/100 g Mg (*Table 4*). Soil rich in P and K nutrients, but poor in Ca and Mg nutrient.

Table 5. *Effect of organic and inorganic fertilizer on growth and yield component Argomulyo soybean varieties in Gresik dry land*

Treatment	Leaf chlorophyll index at 51 DAP	Plant height at harvest (cm)	Number of filled pods/plant	Weight of 100 seeds (g)
Environment				
Without cow manure	41.8	59.9	24.3	19.15
5,000 kg cow manure/ha	42.7	57.9	27.1	20.03
Organic and NPK inorganic fertilizer				
1. Control (without fertilizer)	40.6	56.1	23.9	18.86
2. ZA 50 ZA kg/ha	42.9	58.5	26.4	18.85
3. SP-18 100 kg/ha	43.1	56.0	24.5	19.85
4. KCl 100 kg/ha	41.8	59.4	29.6	20.10
5. ZA 50 kg + SP-18 100 kg/ha	41.6	60.1	25.0	19.03
6. ZA 50 kg + KCl 100 kg/ha	41.7	62.9	25.2	19.63
7. SP-18 100 kg + KCl 100 kg/ha	42.5	57.4	26.7	20.14
8. ZA 50 kg+ SP-18 100 kg + KCl 100 kg/ha	43.5	59.7	25.9	19.10
9. ZA 50 kg + chicken manure 2500 kg/ha	41.7	58.5	26.9	19.77
10. SP-18 50 kg + chicken manure 2500 kg/ha	42.6	59.6	26.3	19.82
11. KCl 50 kg + chicken manure 2500 kg/ha	41.9	59.6	25.5	19.94
12. Chicken manure 2500 kg/ha	43.2	59.5	22.8	20.00
Average	42.3	58.9	25.7	19.59
LSD 5%	ns	ns	ns	ns

Remarks: ns = not significant, DAP = days after planting

Application of cow manure and interaction with chicken manure and inorganic fertilizer (ZA, SP-18, and KCl) not affected growth and yield component, but affected the seeds yield of Argomulyo varieties in Gresik dry land. Application 5,000 kg cow manure/ha as an environmental differentiator can increase soybean yield by 0.27 t/ha (15%) from 1.76 t/ha to 2.03 t/ha.

At environment without cow manure, Argomulyo soybean yield reach 1.43 t/ha on without fertilizer treatment. Addition of 50 kg ZA/ha (10.4 kg N + 11.9 kg S/ha) increase soybean yield 0.61 t/ha (43%) from 1.43 t/ha to 2.04 t/ha (*Table 6*). Addition of 100 kg KCl/ha (60 kg K_2O/ha) increase soybean yield 0.71 t/ha (50%) from 1.43 t/ha to 2.14 t/ha and not different with application of 50 kg ZA/ha. Addition 100 kg SP-18/ha + 100 kg KCl/ha (18 kg P_2O_5 + 60 kg K_2O/ha) and 50 kg ZA + 100 kg SP-18 + 100 kg KCl/ha (10.4 kg N + 11.9 kg S + 18 kg P_2O_5 + 60 kg K_2O/ha) increase 0.56 t/ha (40%) the average of soybean yield. Conversely, application of 100 kg SP-18/ha; 50 kg ZA + 100 kg SP-18/ha; 50 kg ZA + 100 kg KCl/ha, 2,500 chicken manure/ha without or with 50 kg ZA/ha or 50 kg SP-18/ha or 50 kg KCl/ha did not increase soybean yield.

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Table 6. *Effects of organic and inorganic fertilizer on Argomulyo varieties soybean yield in Gresik dry land*

Treatment	Yield with moisture content 12% (t/ha)	
	Without cow manure	**5,000 kg cow manure/ha**
1. Control (without fertilizer)	1.43 ef	2.00 bcd
2. ZA 50 kg/ha	2.04 bcd	1.96 bcd
3. SP-18 100 kg/ha	1.78 bcde	1.56 def
4. KCl 100 kg/ha	2.14 b	1.79 bcde
5. ZA 50 kg + SP-18 100 kg/ha	1.18 f	2.72 a
6. ZA 50 kg + KCl 100 kg/ha	1.83 bcde	2.20 b
7. SP-18 100 kg + KCl 100 kg/ha	2.01 bcd	2.05 bcd
8. ZA 50 kg + SP-18 100 kg + KCl 100 kg/ha	1.99 bcd	2.12 bc
9. ZA 50 kg + chicken manure 2500 kg/ha	1.56 def	2.23 ab
10. SP-18 50 kg + chicken manure 2500 kg/ha	1.63 cdef	1.87 bcde
11. KCl 50 kg + chicken manure 2500 kg/ha	1.83 bcde	1.97 bcd
12. Chicken manure 2500 kg/ha	1.74 bcde	1.85 bcde
Average	1.76 P	2.03 Q
LSD 5% (interaction)	0.5048	

In the environment with 5,000 kg cow manure/ha, Argomulyo soybean yield reached 2 t/ha without application of NPK inorganic fertilizers or chicken manure. These results were not different if 5,000 kg cow manure/ha was combined with N, P, K, NK, PK, NPK inorganic fertilizer, and 2,500 kg chicken manure/ha with or without N, P, or K inorganic fertilizer. The highest yield of 2.72 t/ha was obtained when soybean plants were given 5,000 kg cow manure/ha plus 50 kg ZA + 100 kg SP-18/ha (10.4 kg N + 11.9 kg S + 18 kg P_2O_5/ha). This yield was 1.29 t/ha (90%) higher than the control treatment without cow manure, chicken manure, and inorganic fertilizer (ZA, SP-18, and KCl) or increased 0.72 t/ha (36%) compared to 5,000 kg cow manure/ha without chicken manure and NPK inorganic fertilizer (*Table 6*). The addition of 5,000 kg cow manure + 50 kg ZA + 100 kg SP-18/ha also causes different and higher soybean yields compared to soybean yields on other fertilization treatment. In contrast, giving 2,500 kg chicken manure/ha with or without NPK inorganic fertilizer did not increase soybean yields. The dosage of chicken manure given might still be insufficient, so it does not increase soybean yield. On dry land in Lamongan and Blitar, increasing soybean yield requires 10-20 t chicken manure/ha (Kuntyastuti, 2000).

Increasing Argomulyo soybean yield ≥50% (>0.7 t/ha) becomes 2.14-2.72 t/ha can reach with application of 100 kg KCl/ha; 5,000 kg cow manure + 50 kg ZA + 100 kg SP-18/ha; 5,000 kg cow manure + 50 kg ZA + 100 kg KCl/ha or 5,000 kg cow manure + 2,500 kg chicken manure + 50 kg ZA/ha. The yield of Argomulyo soybean based on the variety description is 1.5-2.0 t/ha (Iletri, 2018). In the dry land of Penukal Abab Lematang Ilir, South Sumatra, fertilizing 25 kg Urea + 150 kg SP36 + 100 kg KCl + 2.000 kg manure + 1.000 kg dolomite/ha produces seeds 2.49 t/ha on Anjasmoro soybean varieties and 1.37 t/ha Burangrang soybean varieties (Somantri et al., 2019). On the dry land of Bima, West Nusa Tenggara, giving 100 kg NPK fertilizer (15:15:15) + 1 liter of liquid fertilizer/ha can produce seeds of 2.41 t/ha in Anjasmoro variety and 2.35 t/ha in Burangrang variety (Hipi et al., 2015). Anjasmoro soybean variety can produce seeds of 1.8 t/ha in dry land Sampang, Madura (Iletri, 2021). In contrast, in drought condition, 75 kg Urea + 100 kg SP36 + 100 kg KCl + 1,000 kg organic manure

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+ 500 kg dolomite/ha can produce only 0.74 t/ha Grobogan seeds soybean variety (Mustikawati et al., 2018).

Han (2006) reported that the addition of NPK inorganic fertilizer could increase soybean yields on Lampineung, Banda Aceh dry land. The use of combination organic fertilizer and inorganic fertilizer to increase soybean yield was also obtained on dry land in Blitar and Blora (Kuntyastuti et al., 2003), in Konawe Selatan, Southeast Sulawesi (Wahab et al., 2019), in South Kalimantan (Adie et al., 2019), and in West Sumatra (Nofrianil, 2019). According to Bandyopadhyay et al. (2010), the application of manure and NPK inorganic fertilizer can improve the allocation of dry matter to pods compared to only NPK inorganic fertilizer, thus increasing soybean yields.

Application of 5,000 kg cow manure/ha did not increase N, P, K, Ca, and Mg nutrient uptake, but application of NPK inorganic fertilizer with chicken manure giving reverse information. Application of NPK inorganic fertilizer and chicken manure can increase 10-48% N nutrient uptake; the highest was 50 kg KCl + 2,500 kg chicken manure/ha, namely 115 mg N/plant. P nutrient uptake increased 10-69%, highest on 100 kg/ha KCl treatment that was 30 mg P/plant. K nutrient uptake increased 71-130%, highest on 50 kg ZA + 100 kg SP-18/ha treatment that was 186 mg K/plant. Ca nutrient uptake increased 33-63%, highest on 50 kg ZA/ha and 100 kg KCl/ha that was 90 mg Ca/plant. Mg nutrient uptake increased 25-53%, highest on 100 kg KCl/ha that was 24 mg Mg/plant (*Table 7*). Application of 2-4 t organic manure/ha can increase NPK nutrient on soybean stem (Sabilu et al., 2015). Application of 20-40 t banana stalk bokashi/ha can increase NPK nutrient uptake on soybean plant, otherwise on application 10^3-10^5 CFU *Azotobacter* sp./mL + 23-35 g *Mycorrhizae* bio-fertilizer did not affect NPK nutrient on soybean stem (Faozi et al., 2019).

Table 7. *Effect of organic and inorganic fertilizer on Argomulyo soybean variety macro nutrient uptake at 51 DAP in Gresik dry land*

Treatment	**Macro nutrient uptake (mg/plant)**				
	N	**P**	**K**	**Ca**	**Mg**
Environment					
Without cow manure	100.3	22.6	156.0	79.4	21.0
5,000 kg cow manure/ha	101.4	21.2	157.3	81.5	20.9
Organic and NPK inorganic fertilizer					
1. Control (without fertilizer)	77.9	17.7	86.0	55.9	15.5
2. ZA 50 ZA kg/ha	112.0	28.3	175.8	89.6	22.9
3. SP-18 100 kg/ha	85.8	23.3	140.2	75.1	19.3
4. KCl 100 kg/ha	108.7	29.7	182.5	89.5	23.8
5. ZA 50 kg + SP-18 100 kg/ha	102.5	29.0	186.2	85.0	22.4
6. ZA 50 kg + KCl 100 kg/ha	101.8	23.8	150.6	74.3	20.4
7. SP-18 100 kg + KCl 100 kg/ha	107.8	21.2	157.6	85.9	21.0
8. ZA 50 kg+ SP-18 100 kg + KCl 100 kg/ha	100.7	21.2	175.6	83.0	21.6
9. ZA 50 kg + chicken manure 2500 kg/ha	96.1	19.1	151.6	78.1	20.5
10. SP-18 50 kg + chicken manure 2500 kg/ha	99.4	18.8	145.6	76.6	21.2
11. KCl 50 kg + chicken manure 2500 kg/ha	114.9	21.8	161.0	82.6	23.2
12. Chicken manure 2500 kg/ha	96.0	17.3	158.9	77.1	20.1
Average	100.3	22.6	156.0	79.4	21.0

In this study, the average soybean yield of Argomulyo varieties reached 1.90 t/ha and absorbed 100 mg N/plant, 23 mg P/plant, 156 mg K/plant, 79 mg Ca/plant, and 21 mg

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Mg/plant. In Vertisol soil Ngawi, soybean plants absorbed 430 mg N/plant, 790 mg P/plant, 450 mg K/plant, 490 mg Ca/plant, and 910 mg Mg/plant to produce 1.74 t/ha (Kuntyastuti et al., 2012). In Entisol soil Malang, soybean yield of 1.72 t/ha was obtained in soybean plant which absorbed 450 mg N/plant, 47 mg P/plant, 203 mg Ca/plant, and 55 mg Mg/plant (Kuntyastuti and Sutrisno, 2014).

Application of 5,000 kg cow manure/ha can improve physical soil fertility in Gresik dry land. Bulk density decreased from 1.25 g/cm^3 to 1.16 g/cm^3. Soil penetration measured in the field using a penetrometer at a depth of 5 cm reduced 63% and at a depth of 15 cm declined 44% (*Table 8*). Soil structure can improve with application of 5,000 kg cow manure/ha. Application cow, goat, and chicken manure can decrease bulk density or increase soil porosity, permeability rate, and soybean yield in degraded Ultisol soil Jambi. Conversely, at a depth of 25 cm, the use of cow manure does not affect soil penetration (Abdurachman et al., 2000). A soil layer of 22.5-30 cm depth, the use of 10 t manure/ha + NPK fertilizer recommended dosage (25 kg N + 25.8 kg P + 16.6 kg K/ha) does not affect saturated hydraulic conductivity and soil bulk density (Hati et al., 2006).

Table 8. *Effect of organic and inorganic fertilizer on bulk density and soil penetration after Argomulyo soybean varieties harvesting in Gresik dry land*

Treatment		Bulk density (g/cm^3)	Penetration 5 cm (t/feet^2)	Penetration 15 cm (t/feet^2)	Penetration 25 cm (t/feet^2)
Environment					
Without cow manure		1.25 a	3.5 a	4.5 a	4.9 a
5,000 kg cow manure/ha		1.16 b	1.3 b	2.5 b	4.8 a
Organic and NPK inorganic fertilizer					
1.	Control (without fertilizer)	1.26	2.8	3.4	5.0
2.	ZA 50 ZA kg/ha	1.22	2.7	3.7	4.8
3.	SP-18 100 kg/ha	1.19	2.5	4.0	5.0
4.	KCl 100 kg/ha	1.18	2.6	3.5	4.7
5.	ZA 50 kg + SP-18 100 kg/ha	1.21	2.3	3.3	4.8
6.	ZA 50 kg + KCl 100 kg/ha	1.23	2.2	3.1	5.0
7.	SP-18 100 kg + KCl 100 kg/ha	1.23	2.2	4.1	5.0
8.	ZA 50 kg+ SP-18 100 kg + KCl 100 kg/ha	1.22	2.5	3.6	5.0
9.	ZA 50 kg + chicken manure 2500 kg/ha	1.17	2.3	3.3	4.8
10.	SP-18 50 kg + chicken manure 2500 kg/ha	1.24	1.9	3.2	4.5
11.	KCl 50 kg + chicken manure 2500 kg/ha	1.15	2.3	3.5	4.8
12.	Chicken manure 2500 kg/ha	1.20	2.3	3.5	4.6
Average		1.21	2.4	3.5	4.8
LSD 5%		ns	ns	ns	ns

ns = not significant based on 5% probability level

The results of measurements in the laboratory showed that application of 5,000 kg cow manure/ha improves the soil physical properties. The saturated hydraulic conductivity increased from 1.78 cm/hour to 3.98 cm/hour, while particle density and soil penetration decreased by 7.8% and 36% (*Table 9*). Available water is no different. Similar results were presented by Bandyopadhyay et al. (2010), that the application of 4,000 kg manure + 30 kg N + 26 kg P + 25 kg K/ha reduced soil bulk density by 9.3% and soil penetration 42.6%, increased hydraulic conductivity 95.8%, aggregate diameter stable 13.8%, and 45.2% organic-C content compared to the treatment without fertilizer.

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Table 9. *Effect of organic and inorganic fertilizer on saturated hydraulic conductivity (SHC), particle density (PD), penetration depth of 0-10 cm and available soil water after harvesting Argomulyo soybean varieties in Gresik dry land*

Treatment	SHC (cm/ hour)	PD (g/cm^3)	Soil penetration (N/cm^2)	Available soil water (%)
Environment				
Without cow manure	1.78	2.58	360.8	12.7
5,000 kg cow manure/ha	3.98	2.38	228.7	12.3
Organic and NPK inorganic fertilizer				
1. Control (without fertilizer)	2.55	2.50	260.0	12.5
2. ZA 50 ZA kg/ha	3.45	2.50	227.0	11.5
3. SP-18 100 kg/ha	2.00	2.45	235.0	14.0
4. KCl 100 kg/ha	2.05	2.55	215.5	12.0
5. ZA 50 kg + SP-18 100 kg/ha	3.00	2.55	240.0	12.5
6. ZA 50 kg + KCl 100 kg/ha	2.60	2.55	330.0	11.0
7. SP-18 100 kg + KCl 100 kg/ha	2.75	2.40	351.0	12.5
8. ZA 50 kg+ SP-18 100 kg + KCl 100 kg/ha	2.95	2.50	340.5	14.0
9. ZA 50 kg + chicken manure 2500 kg/ha	3.55	2.45	352.0	12.5
10. SP-18 50 kg + chicken manure 2500 kg/ha	4.05	2.40	317.0	13.5
11. KCl 50 kg + chicken manure 2500 kg/ha	2.55	2.45	353.5	11.5
12. Chicken manure 2500 kg/ha	3.05	2.40	315.5	12.0
Average	2.88	2.48	294.8	12.5

The diversity of combination between NPK inorganic fertilizer and chicken manure caused variations in soil physical properties. Application of 50 kg SP-18 + 2,500 kg chicken manure/ha makes the highest saturated hydraulic conductivity (4.05 cm/hour). The lowest soil particle density (2.4 g/cm^3) was found at application 100 kg SP-18 + 100 kg KCl/ha and 2,500 kg chicken manure/ha with or without 100 kg SP-18/ha. The lowest soil penetration at the depth 0-10 cm (215.5 N/cm^2) was found at application 100 kg KCl/ha. The highest water availability (14%) was found at application 100 kg SP-18/ha or 50 kg ZA + 100 kg SP-18 + 100 kg KCl/ha.

Application of NPK inorganic fertilizers and crop residues play an important role in improving fertility and maintaining soil quality (Jiang et al., 2008). Application of 10 t manure/ha + recommended dosage of NPK fertilizer (25 kg N + 25.8 kg P + 16.6 kg K/ha) increase soybean yield from 0.90 t/ha to 1.83 t/ha (Hati et al., 2006). The increase in yield is supported by improvements in soil physical properties. The highest RLD (root length density) to a depth of 30 cm was obtained in the manure + NPK fertilizer treatment, 31.9% and 70.5% higher than NPK fertilizer and without fertilizer, and negatively correlated (r= -0,88**) with soil penetration.

Application of manure for 8 years decreases soil bulk density, increases aggregate diameter, and soil organic-C content (Bhattacharyya et al., 2007). The infiltration rate at steady state conditions in the NPK + manure treatment was 1.98 cm/hour, without fertilizer 0.72 cm/hour, and 1.20 cm/hour on NPK fertilization. Soil water sorptivity with NPK + manure was 1.06 cm/min$^{0.5}$ higher than NPK (0.61 cm/min$^{0.5}$). Application of manure and inorganic fertilizer for long term can increase organic-C and improve soil physical properties. Bhattacharyya et al. (2008) reported the results for 30 years, that NPK + manure increased soil water holding capacity, infiltration rate, organic-C, total-N, P-Olsen, K-dd, C-microbial biomass, and dehydrogenase activity compared to NPK treatment or without fertilizer. Recommendations for inorganic fertilization are

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incomplete, on the other hand, the provision of manure + NPK fertilizer every year is necessary for sustainable soil and plant productivity.

Cultivation of crops on dry land without P fertilizer will not be sustainable in the long term (unsustainable). Fertilization of 15-20 kg P/ha/year is needed to maintain soil fertility in order to provide available P which is sufficient for plant to produce (Ryan et al., 2008). Soybean cultivation without the addition of manure and inorganic P-fertilizer suppressed soil organic-P. The addition of manure and inorganic P-fertilizers stimulated soil organic-P. Therefore, application of manure and inorganic P-fertilizers is an effective strategy to improve soil organic-P and provide P-soil in the long term for sustainable crop production (Reddy et al., 2000).

The dry land used as the research location is intensive agricultural land and the highest Argomulyo soybean yield, 2.72 t/ha was obtained by adding 5,000 kg cow manure + 50 kg ZA + 100 kg SP-18/ha (10.4 kg N + 11.9 kg S + 18 kg P_2O_5/ha). Fan et al. (2005) recommend a balance of fertilizers to ensure continued productivity in intensive cropping patterns. The highest increase in soil organic C, namely 160 mg/ha/year was obtained by adding rice straw + N fertilizer every year + P fertilizer every two years or by adding manure + N + P fertilizer every year. The addition of organic matter to the soil in the long term can increase the soil water holding capacity, which in turn improves water availability for crops and restrains yield losses, reduces CO_2 emissions from agricultural land and sustains land productivity. Research by Manna et al. (2007) on dry land for 30 years showed that soybean yields decreased by 21 kg/ha/year in the NP fertilizer treatment and 30 kg/ha/year in the treatment without fertilizer. However, the continuous use of NPK + manure or NPK + lime can maintain soybean yields without worsening soil quality.

Soil quality index indicators are available levels of N, K, S, microbial biomass carbon and hydraulic conductivity. Conventional tillage + legume residue + 90 kg N fertilizer/ha produced the highest soil quality index (Sharma et al., 2005). Therefore, the management of yield and quality of dry land for sustainable agriculture requires soil cultivation with the addition of organic fertilizer residues and N fertilizers. The use of manure + NPK increases total biomass (Mandal et al., 2009), leaf area index, growth rate, fuel, contribution renewable energy, net energy output, non-renewable energy productivity, and higher efficiency in the use of non-renewable energy, resulting in higher yields, so that soybean yield higher than the use of NPK and control. The combination of NPK + manure can be a viable nutrient management alternative for soybean production.

According to Evanylo et al. (2008) the negative effect of use manure on the environment and ground water can be prevented by estimating the rate of N mineralization accurately. The increased risk of transporting nutrients by run off due to increased concentrations of organic-C, N, and P in the run off from compost as a soil amendment is offset by increased infiltration, porosity, and soil water holding capacity which can reduce run off volume. Jacobsen et al. (2012) explained that improving plant productivity on dry land can be done in several ways, namely initial planting with minimum soil cultivation, increasing the use of organic matter and efficient weed control, and crop rotation.

Soybean cultivation on dry land with land characteristics such as dry land in Gresik requires inorganic fertilizers to increase yield by 50% (0.7 t/ha) and a combination of inorganic fertilizers with organic fertilizers to increase yields by 90% (1.29 t/ha). According to Anshori et al. (2019) soybean productivity has a positive correlation with

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land quality. Technological improvements from farmers manual such as the use of new superior varieties, quality seed, drainage channels, regular planting, IPM principles and 2.000 kg organic fertilizer + 100 kg NPK fertilizer/ha and foliar fertilizers can increase soybean yields 0.4-0.7 t/ha (33-43%). Residues of applying organic fertilizers, P-inorganic and inoculation also have a positive impact on subsequent crop productivity (Rurangwa, 2018).

Information on increasing soybean yields and improving physical, chemical, and biological soil fertility due to intensification dry land shows that input of organic and inorganic fertilizers is still needed to increase and maintain soil and soybean productivity on dry land. However, the low soybean price factor causes farmers not to be interested in adopting the recommended technology package as a whole. Farmers are interested in applying some technology components, such as new superior varieties or regular spacing (Elizabeth and Suhartina, 2019). Input of dry land cultivation technology through amelioration measures to improve soil quality by utilizing local resources that are in-situ and prioritized diversification of superior dry land commodities must be in accorandce with the regional agro-ecosystem conditions, that is acceptable to the local community and provide added value to farm income (Matheus et al., 2017).

Conclusion

Application of 5,000 kg cow manure/ha increased 0.21 t/ha (9%) Argomulyo varieties soybean yield. Application of 100 kg KCl/ha, 50 kg ZA + 100 kg SP-18 + 5,000 kg cow manure/ha, and 50 kg ZA + 2,500 kg chicken manure + 5,000 kg cow manure/ha increase 0.95-1.38 t soybean yield/ha (50-74%). Application of 5,000 kg cow manure/ha improve soil physical properties by reducing 7% soil bulk density and 37% soil penetration, and increasing soil permeability 2.20 cm/hour from 1.78 cm/hour to 3.98 cm/hour. Soybean cultivation of the Argomulyo variety on dry land in Gresik requires the addition of organic cow manure 5000 kg/ha plus ZA fertilizer 50 kg/ha + chicken manure 2500 kg/ha or ZA fertilizer 50 kg/ha + SP-18 100 kg/ha + KCl 100 kg/ha to increase yield 0.95 – 1.38 t/ha and improve soil physical fertility. The results of this study gives the information that the use of organic and inorganic fertilizer is an alternative technology that needed to maintain and increase the productivity of soybean and soils in dry land to support sustainable soybean cultivation.

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