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Fertilizer Efficiency for Improvement of Chili Productivity through Starter Solution Technology

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Abstract. This paper is to provide a lesson learnt related to application of starter solution technology –an efficient method to apply fertilizers - for chilli production in Indonesia. Indonesian agriculture is facing a threat from soil and water contamination from agro-chemicals. As the use of inorganic fertilizers is inefficient, a large extent of fertilizers is not captivated by the production system, and these spills will contaminate soil and water resources. However, it is not too late to conserve our earth from being contaminated by agro-chemicals using starter solution technology. We studied starter solution technology, based on the two field trials with farmers in one of the vegetable producing regions. Using this technology was able to reduce the use of inorganic fertilizers by 50% of current level without significant reduction in yield. This means that application of the technology increased efficiency of fertilizer use. This leads to increase in net income gained by farmers. Broader economic benefit exists if farmers apply SST. Further challenge is to improve and disseminate such technology to intensive farming of other crops.

Keywords: Starter solution technology, vegetable farming, agro-chemical waste, soil and water conservation.

1. Introduction

Agricultural sector is very important in developing countries, including Indonesia. The sector provides jobs in both rural and sub-urban areas through value chain of the produces. In some developing countries, the sector provides significant contribution to national income. In, Indonesia the sector provides about 50% of employment and 15% of national income. However, the Indonesian agriculture is facing a threat from soil and water contamination from agro-chemicals.

Since ancient times until today, organic fertilizers have been used as fertilizers in farming systems. Organic fertilizers can improve the physical properties of the soil through the formation of soil aggregate structure and steady and is closely related to water binding ability of soil, water infiltration, reducing the risk to the threat of erosion, increasing the ion exchange capacity and as the soil temperature control everything good effect on plant growth [1].

Yield of chili in East Java during 2010-2013 was still lower than that in other provinces in Indonesia [2]. Therefore, it needs a technology that can be applied to overcome low fertility and inefficient use of fertilizers in the soil. A study reports that to address these problems need to be prefixed with N P K fertilization experiment in the locations of the planting, and then analyze the correlation between fertilization and harvest, recommended fertilizer for the plants, determine the level of soil fertility and implement fertilization based fertility ground [3].

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Starter Solution Technology (SST) is a technology developed by AVRDC - the World Vegetable Center and has been disseminated to Thailand, Indonesia, China, India and Taiwan. SST is an innovative technology to reduce fertilizer and simultaneously increase productivity fertilization. The objective is to provide for the application of nutrients to the young plants before an established root system. SST is certainly very influential to increase plant growth at a young age [4]. Application SST also minimizes transplant shock. When the plants were transferred from a protected environment to the open fields, an interruption in the normal growth has affect absorption of nutrient in the soil. Such as the disruption of the root system, rapid nutrient intake helps the plant in the quick recovery in the formation of new roots and growth of the top.

The use of SST has many advantages: very short chili plant growth between 3-4 months, due to the short period of growth often results in the provision of fertilizer for plant growth becomes inefficient, increasing the growth of young plants, reducing the need for fertilizers, increasing the amount of interest, increase nutrients available to plants than organic fertilizers, and reducing pollution or pollution of the plant [3].

Besides, fertilizers applied in the soil solution is more readily available than the application of fertilizer in solid form., The release of protoplasts from cell walls caused by shrinkage or reduction in volume, because the fluid in protoplasts has become more concentrated and therefore more negative osmotic potential [5]. With so diffusion through the pores of the membrane must plasma membrane, a process known as osmosis [6]. This paper is to provide a lesson learnt related to application of starter solution technology –an efficient method to apply fertilizers— for vegetable production in Indonesia. Particular purpose is to assess further the use of SST combined with balanced fertilizer management.

2. Literature Review

Since the publication of *Silent Spring* by Rachel Carson in 1963, issues of environmental problems related to intensive agriculture have been raised. A number of publications raising concerns over the sustainability of intensive agriculture have continued to increase since the late 1970s [7], [8]. Demand for a clean and healthy environment is greater today than it has ever been because of growing property rights of people to a better environment. The expression of greater demand for a better environment is seen in several ways. The existence of organisations that lobby for environmental regulations and policies is one of the expressions.

The demand for a better environment has grown because of two main elucidations. First, as people have increasing income, the demand for a wider range of goods and services is increasing as well. One of these goods and services is a high quality environment. Second, as knowledge of the effect of human actions on the environment grows, people show they are capable of taking measures that improve the environment. For instance, it is well known that agrochemicals poison wildlife through a food chain process, and kill beneficial organisms. In principle, people are able to design measures that limit such problems.

In Indonesia, environmental degradation related to intensive agricultural practices had been recognised well during the Green Revolution [7], [8]. Land degradation is associated with agrochemical use which has damaging effects on the environment [9]. The high use of agrochemicals was triggered by agrochemical-augmenting technological change during the Green Revolution [10].

In rice agriculture, studies on external costs associated with agrochemical use have been done in The Philippines [11], Vietnam [12] and China [13]. The external costs analysed in the studies are based on health costs associated with pesticide uses. But, the studies do not internalise the external costs, such that the socially efficient level of pesticides has not been determined. Internalisation of external costs associated with pesticide use in Indonesian rice production has been conducted and the socially efficient level of pesticide use has been determined [14]-[16].

3. Methodology

We conducted two field trials in Kediri East Java. We selected this region because of major constraint as follow: soils have very sandy texture (sand>70%) and low in organic matter content but high in available K; overuse of fertilizers; imbalanced fertilizer application and inappropriate timing of fertilization. The first was in June 2012 and the second was in 2014.

We use chili variety of Bhaskara, a hybrid variety that is commonly grown by local farmers in the area. There were three treatments and one control (see appendix for detail treatment).

1. T1 = Control (local farmers' practices)
2. T2 = SST and balanced fertilization (farmer rate)
3. T3 = SST and balanced fertilization (medium rate)
4. T4 = SST and balanced fertilization (low rate)

The study used RCBD with five replications. Each treatment consisting of 5 plots the size of each treatment was 6.5 x 5 m containing 100 plants, so in total 2000 crop. Agronomic analysis use growth and yield indicators.

Economic analysis was used to see the advantage of using SST. Since all aspects were the same in all treatments, except the dose of fertilizers and yield, we use partial budgeting. We formulate partial budgeting as:

$$\pi_T - \pi_C = (R_T - R_C) - (C_T - C_C)$$
$$\Delta\pi = \Delta R - \Delta C$$

where R is revenue, C is total cost related to fertilizer application, subscript T and C indicate treatment and control respectively. The higher $\Delta\pi$ (additional net income) represents the better treatment.

4. Result and Discussion

Let us first to show the agronomic aspects resulting from different treatments, which is provided in Table 1 and Table 2.

Table 1: Plant Height 21-63 Dat, Trial # 1

Treatment	Plant height, (cm)			
	21 DAT (cm)	35 DAT (cm)	49 DAT (cm)	63 DAT (cm)
T1	19.4	33.7	47.4	57.1 a
T2	20.5	33.1	42.9	51.2 ab
T3	20.0	33.5	44.4	53.7 ab
T4	21.1	34.1	41.5	45.4 b
Tukey's test at p<0.05	ns**	ns	ns	

Table 2: Plant Height 14-64 Dat (cm), Trial # 2

Treatment	Plant Height (cm)							
	14 DAT		28 DAT		42 DAT		64 DAT	
T1	8.475	a	18.136	a	23.522	a	25.767	a
T2	9.860	a	16.912	a	24.336	a	23.987	a
T3	10.420	a	17.550	a	21.616	a	22.821	a
T4	9.524	a	17.959	a	23.055	a	24.231	a

For the second trial, plant height after 14 day after transplanting (DAT) is not significant differences among T1 to T4. Similarly, for the growth in the next age up at 64 DAT, still, showed growth were not significant different. For the first trial, the different plant height appeared at 63 DAT, with slight difference. The hybrid variety of Bhaskara has relatively shorter growth compared of the other varieties and relatively easy to maintain. This variety has a short lifespan, fast harvest, disease and pest resistant and has a high yield. Chili treated with SST did not show significant different to farmers' practices. This is due to SST solution plants transferred from a protected environment to open land, usually will experience a disruption in the normal growth process, so that the intake of nutrients derived from SST quickly assist in the recovery plant rooting and growth is the top of the plant, thus stimulating to improve better growth in subsequent phases [3].

Thus, despite the reduced fertilizer application to balanced fertilization average results are low (T4), a high growth performance of plants from 14 up to 64 DAT showed no significant. This proves that the fertilizer dose reduction does not reduce the growth of plant height. The second trial showed that plant height was just a half of firs trial. The second trial was attacked by the virus, this led to the growth of plant height was not optimal. As a result, that fertilizer application and SST might not show significant differences. Foliar fertilizers and organic fertilizers by farmers in the yellow virus endemic areas cannot prevent the plants from infection with the virus [17]. Plants that are already infected cannot be recovered into healthy plants although application of fertilizers exceeds the recommended dose.

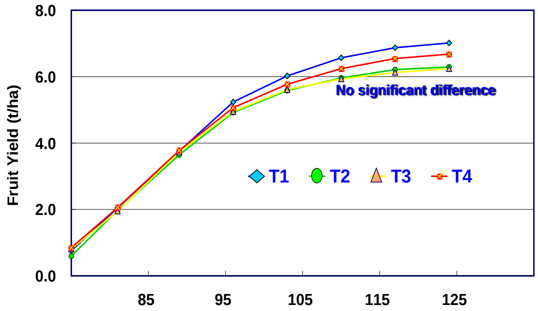

Fig. 1. Cumulative Production of Chili for Diferent Treatments.

Production level of chili in the first trial is presented in Figure 1. Up to 95 DAT, the production of chili in all treatment still was almost similar. By 105 DAT the chili production shows differences. However, the difference in such production was not statistically significant until the final harvest.

The second trial also has similar result in terms of insignificant difference in production. Presenting in Table 3, yields chili on T1 to T4 treatment carried out every 2 weeks, starting the first harvest to fifth harvest.

Table 3: Harvest of chili on T1 to T4 (g/ 20 Plant)

Treatment	Average harvest of Chili									
	I		II		III		IV		V	
T1	740	a	410	a	350	a	365	a	640	a
T2	565	a	325	a	230	a	320	a	455	a
T3	510	a	295	a	230	a	255	a	515	a
T4	905	a	435	a	325	a	305	a	620	a

Both trials show that the production of chili did not decrease when the fertilizer level was reduced. This suggests that the SST effectively and efficiently treatment work. This is due to the provision of fertilizer is useful to stimulate early growth of plants is done at the time of planting and given directly near plant roots. This affects early availability of nutrients absorbed young plants before the roots become strong and will have a direct impact to stimulate plant growth and more efficiency in the use of fertilizers. Fertilizers applied in solution to the soil more readily available than that of the solid fertilizer, because roots are growing into new areas by establishing more branches or roots search of food [18]. If the water is much available in the soil to the roots will grow far below the soil surface. In the moist state (almost field capacity) to the root of rapid diffusion, but in the dry state to approach the permanent wilting point, diffusion of water and dissolved ions can be decreased to 1000 times, so that the plant will be difficult to get water and mineral ions due to the ability of the roots to break through the soil and diffusion water and ions to the limited root.

Enough nutrients and balanced and also available to plants caused increased activity of plant physiology. This will certainly affect the plant leaf area index. If the lower leaf area index and chlorophyll content also lower, the amount of photosynthetic process for plant growth will also decrease. In this condition, the result of photosynthetic process is not only used by the plant to grow, but also most of the energy used by the virus [17]. So that the average yield is low if compared with healthy chili crop.

Since the level of production is statistically not different between farmers' practice and SST treatment, we need to analyses the economic aspect. Based on the prevailing market price of NPK Mutiara =

Rp6500/kg; compost = Rp100/kg; SP36 = Rp1000/kg; labor wage = Rp 25000/man-day; and chili (at farm-gate) = Rp5000/kg. Table 4 shows the different of additional net income resulting from application of SST.

We can see that treatment T4 showed the highest additional net income. It means that if farmers apply T4, they will get net income about IDR 2.56 million higher than if they apply usual practices. This additional net income resulted from saving of fertilizer-related costs.

Table 4: Economic aspects of SST of trial#1(Rp thousand)

	T1 (Control)	T2	T3	T4
Δ Cost	0	-260	-1,613	3,173
Δ Revenue	0	-1,500	-1,500	-500
Δ Net income	0	-1,240	113	2,673

The technology has been disseminated to and applied by more than 3000 vegetable farmers in East Java and Bali, where intensive vegetable farming exists. Direct benefit was collected by farmers as additional earning. Further positive impact of this application is a huge reduction in amount of agro-chemical waste. Soil and water are expected to be less contaminated, agricultural land becomes more productive and water resource becomes healthier. In conclusion, starter solution technology provides a hope to conserve our earth from being contaminated by unnecessary agro-chemical waste. Increasing efficiency of fertilizer use reduces the amount waste discharged into environment. Further challenge is to improve and disseminate such technology to intensive farming of other crops.

5. Conclusion

The problem of intensive farming in current practices is sustainability. The use of agrochemical is one of the culprits. In-organic fertilizers have environmental impact both on soil and water resources. Excessive use of such fertilizers has potential adverse impacts. By using SST, the potential impact can be mitigated. SST is able to reduce the need for fertilizer, more efficient and effective fertilizer use.

In particular, under the common condition in Kediri, fertilizer amounts can be reduced and application method can be improved without reducing the total fruit yields. Local yield of Bhaskara variety is about 7.5t/ha. Nutrient removals for 7.5 t/ha yield of chili fruits is estimated only around 75-80-80 of N-P_2O_5-K_2O kg/ha. The starter solution in the trial used fertilizer that farmers used to apply (NPK Mutiara fertilizer with N-P_2O_5-K_2O-CaO-MgO = 25-7-7-4-1.4 %). However, use fertilizer of higher P, K compositions may have better effects as starter solution.

In economic aspects, using SST can save the cost of fertilizers, and this is captured by farmers as additional income. Socially, the reduction of fertilizers has broader economic impact because soil and water resources can be saved from contamination. We could not count exactly the economic benefit of SST of every farmer apply SST.

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