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Response of Eggplant, Yard-Long Bean, and Kangkong on Polyethylene Mulched and Drip Irrigation System

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ABSTRACT

Eggplant, yard long bean, and kangkong, were grown with polyethylene mulch with a drip irrigation system on Podzolic soil with low pH (4.5), low C-Organic (0.97%), very low total-N (0.17 %), low K content (0.15 me (100 g)$^{-1}$), but had a high soil P_2O_5 concentration (13.7 ppm) to evaluate the best crop management practices under this soil condition. Combination of polyethylene mulch treatments (with and without), fertilizer (with and without), number of irrigation lines (0, 1, and 2 lines), and methods of fertilizer applications (preplant, split, and drip) were arranged in a Randomized Completely Block Design with four replications. The results showed that the use of mulch and fertilizer significantly increased yield of all crops. One line irrigation system also resulted in the best yield. Preplanting application of 100% P, 50% N and K in addition to 50% N and K applied 10 times weekly was the best methods to produce Eggplant, Yard Long Bean, Kangkong under polyethylene mulched and drip irrigation system.

Keywords: *Solanum melongena* L, fertilization, fertigation, *Ipomoea reptans* L, micro-irrigation, polyethylene-mulched, *Vigna unguilata* L.

INTRODUCTION

Drip or trickle irrigation is a very efficient method of applying water and nutrients to crops. For many crops, the conversion from sprinkler to drip irrigation can reduce water use by 50%. Crop yields can be increased by improving water and fertility management and a better control of plant diseases and weeds. When drip irrigation is used in combination with polyethylene mulch, yields can be increased even further. These benefits are only possible when a drip irrigation system is properly designed, managed, and maintained. Producing economical yield of bell pepper (*Capsicum annuum*, L.) while conserving water and nutrient is an intregated approach to fertlization and irrigation (Simonne *et al.*, 2006).

Drip irrigation systems have the highest potential water application efficiency of the irrigation system used in commercial vegetables production. Mohammad and Zuraiqi (2002) reported that application of irrigation to replenish 80% of the Class A pan evaporation twice a week can support plant growth and yield of garlic (*Allium sativum* L.). Kaya *et al*. (2005) showed that cucumber plant (*Cucumis sativus* L.) receiving reduced water application (75% Class A pan evaporation every 3 days) showed significant reduction in all parameter when compared with well-watered plant (125% class A pan evaporation daily).

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Field studies have shown a significant decrease in irrigation requirements of tomatoes with the use of drip irrigation system and compared to sub irrigation system. Marketable yield, fruit size, and fruit quality were comparable and in some cases better with the use of drip irrigation than sub irrigation (Pitts and Clark, 1991). Locascio *et al*. (1989) showed that when fertilizer was applied through the drip system, yields were higher than with fertilizer applied only before planting. Ensico-Medina *et al*. (2008) showed that applying P in only one application or spliting the same amount of phosporus in two application resulted in no different on lint yield gross return and cotton quality.

Polyethylene (*Black-Silver*) mulched was increasingly adopted by Indonesian vegetables farmer. Some advantages of polyethylene mulched include controlling weeds, soil temperature and humidity, fertilizer and water loss. Using polyethylene mulched increased yield of Chilli pepper from 0.8 to 3.4 tons ha^{-1} in dry season, and 2.5 to 4.9 tons ha^{-1} in wet season compared with no mulched (Vos *et al*., 1991). Black polythylene mulched improved fruit yield, fruit size, plant dry matter, total leaf area, and chlorophyll and nutrient concentration in leaves of cucumber under stress condition (Kirnak and Demirtas, 2006). Mulching mitigates negative effects of water stress on plant growth and fruit yield in field grown pepper plants particularly in semi-arid condition and also increase N availability to the plants (Kirnak *et al.,* 2003)

Base on general culture, eggplant (*Solanum melongena* L.) belongs to the vegetables fruit groups, yard-long bean (*Vigna unguilata*, L.) belong to pulses groups, whereas

kangkong *(Ipomoea reptans,* L.) is leafy vegetables groups. Eggplant need transplanting while kangong and yard long bean are direct- seeded (AVRDC, 1990). Therefore, each of plant material used in this experiment can represent crop management system for other vegetables in their group.

Combination between drip irrigation and polyethylene mulched have recently used as an advanced technology to produce high quality vegetable. This technology may become one of the best management practices to solve water shortage for vegetable production. Until recently, this technology has not been being introduced by Indonesian vegetable's farmer. Therefore, the best management practices of this technology need to be verified and established before adopted by vegetable farmers in Indonesia. The objective of this experiment is to determine the best methods to grow eggplants, kangkong, and yard-long bean using polyethylene mulched and drip irrigation system.

MATERIAL AND METHODS

Research was carried out at the Tenjo Demo Farm, Tenjo area, Bogor Regency from April to November 2004. Prior to fertilizer application, soil samples were taken with a soil probe from the top 15 cm of an *Ultisol*. Fertilizer was applied at 117-41-131 kg N-P_2O_5-K_2O·ha^{-1} from Urea, SP36, and potassium sulphate. All the P and 50% of N and K applied preplant, and 50% of N and K were fertigated.

Treatments were Mulch + No Line + 100% Preplant (P1), Mulch + No line + No Fertilizer (P2), Mulch + 1 line+ 100% Preplant (P3), Mulch + 1 line + Split (P4), Mulch + 1 line + Drip (P5), Mulch + 2 lines 100% Preplant, (P6), Mulch + 2 lines + Split (P7), Mulch + 2 lines + Drip (P8), No mulch + no lines + 100% preplant. Treatments were arranged in Randomized Completely Block design with four replications

For preplant application, fertilizers were applied by broadcasted and rototilling into raised beds of approximately 90 cm wide and 20 cm high. Drip applications were applied 10 times weekly, and split applications were 50% preplant and 50% drip.

Dripper line, an irrigation tubing (orifice diameter, 0.025 cm; emitter spacing, 20 cm; rate of 1.7 liter hours) was placed on the soil surface at 10 cm from the bed center and covered with black polyethylene mulch (Sonoco with 0.0038 cm thickness). Vegetables crop used in this experiment were eggplant (*Solanum melongena*) var. Ungu, kangkong (*Ipomoea reptans)* var. Sutera, and yard-long bean (*Vigna unguilata*) var. Putih panjang. Eggplants were spaced 0.6 m within row and 0.6 m between rows (double rows). Yard long bean were spaced 0.25 m within row and 0.6 m between rows (double rows). Kangkong were spaced 0.1 m within row and 0.25 m between rows (four rows). The irrigation was applied 2 times per day (9 a.m. and 2 p.m.) each of 30 minutes running or about 21.25 l L pot^{-1} (5 m^2). Irrigation was applied if there was no rain.

Scoring were conducted on fresh weight of marketable eggplants (fruit diameter 2-3.5 cm), non marketable eggplant (fruit diameter < 2 cm and culls), marketable yard-long bean (fruit length>30 cm), non-marketable yard-long bean (fruit length<30 cm and culls,), marketable kangkong (plant height 20-30 cm), non-marketable kangkong (plant height <20 cm and culls), and total yield (marketable yield + non-markertable yield). Analysis of variance of data was calculated using SAS 6.12 (SAS Institute, N.C). Orthogonal contrast were used to compare mulch (no mulch *vs* with mulch), number of line (no line *vs* 1 line, no line *vs* 2 lines, 1 line *vs* 2 lines), and fertilizer application (no fertilizer *vs* with fertilizer).

RESULT AND DISCUSSION

Soil Analysis

Soil analysis showed that soil pH (water) at the experimental area was acidic (4.5). Therefore, Dolomitic lime was applied to increase soil pH to 6-6.5 unit. C-Organic content was low (0.97%), N total content was very low (0.17%), and C/N ratio was considered very low (6). To improved soil fertility especially for organic content, manure was applied at 20 tons ha^{-1}. Soil P_2O_5 concentration (Bray 1) was high (13.7 ppm) and K (NH_4 Acetate 1N, pH 7) was low (0.15 me (100 g)$^{-1}$).

Eggplant (Solanum melongena L.*)*

The effect of mulch on eggplant was significant for all measured variable except on non-marketable yield. Polyethlene mulch application increased the marketable yield from 6,654 g to 15,461 g $plot^{-1}$ (Table 1), and increased the total yield by almost two and half times. In contrast, non-marketable yield increased without mulch application. These results demonstrated that under polyethylene mulch

Table 1. The effect of mulch on marketable and non marketable yield of eggplant

Treatments	Marketable yield (g $plot^{-1}$)	Unmarketable yield (g $plot^{-1}$)	Total yield (g $plot^{-1}$)	Percent marketable yield	Percent non marketable yield
No Mulch	6,654.0	801.3	7,455.3	90.1	9.9
Mulch	15,461.4	901.5	16,362.9	94.6	5.4
Contrast	**	NS	**	**	**

** = Significant at P<0.01; NS = Not Significant at P>0.05

soil environment condition became more appropriate to support eggplant growth than without mulch on the upland area. Polyethylene mulch can reduce water loss from soil through evaporation.

Number of irrigation lines significantly influenced marketable yield and total yield per plot. However, number of line did not influenced non-marketable yield, percentage of marketable yield, and percentage of non-marketable yield (Table 2). The highest total yield and marketable yield were obtained with one irrigation line, these were 18,746.6 g plot^{-1} and 17,620.1 g plot^{-1}, respectively. With one irrigation line, marketable yield and total yield significantly higher than with no irrigation. However, the marketable yield was not significantly different between one irrigation line and two irrigation lines. The data showed that with drip irrigation line percentage of marketable yield was increased.

The effect of fertilizer significantly increased total marketable yield, but did not influence marketable yield of eggplant. An increase in total yield from 12,076.5 g plot^{-1} to 15,85.2 g plot^{-1} by fertilizer application indicates that the soil fertility in this area relatively low (Table 3). Therefore, optimizing fertilization program through drip irrigation and polyethylene mulched system for this experimental area need to be conducted to produce a better yield of eggplant.

Preplant application of 100% N and K significantly reduced marketable- and total-yield per plot (Table 4). Fertilizer application of N and K 100% through drip system resulted in a higher marketable yield and total yield than 100% preplant application. However, this result was not significant with split application where N and K were applied 50% preplant and the other 50% were applied 10 times weekly.

Table 2. The effect of number of irrigation line on marketable and non-marketable yield of eggplant

Treatments	Marketable yield (g plot^{-1})	Non-marketable yield (g plot^{-1})	Total yield (g plot^{-1})	Percent marketable yield	Percent non marketable yield
No Line (Check)	9,422.0	683.5	10,105.5	93.8	6.2
One Line	17,620.1	1,126.5	18,746.6	94.2	5.8
Two Line	16,679.1	814.7	17,493.8	95.4	4.6
Contrast					
No Line vs 1 Line	**	NS	*	NS	NS
No Line vs 2 Line	*	NS	*	NS	NS
1 Line vs 2 Line	NS	NS	*	NS	NS

*,** = Significant at P<0.05 and P<0.01, respectively; NS = Not Significant at P>0.05

Table 3. The effect of fertilizer on marketable and non-marketable yield of eggplant

Treatments	Marketable yield (g plot^{-1})	Non-marketable yield (g plot^{-1})	Total yield (g plot^{-1})	Percent marketable yield	Percent non marketable yield
No Fertilizer	11,371.8	704.8	12,076.5	94.0	6.0
Fertilizer	14,871.7	913.5	15,785.2	94.1	5.9
Contrast	NS	*	*	NS	NS

*= Significant at P<0.05; NS = Not Significant at P>0.05

Table 4. The effect of fertilizer application methods on marketable and non-marketable yield of eggplant

Treatments	Marketable yield (g plot^{-1})	Unmarketable yield (g plot^{-1})	Total yield (g plot^{-1})	Percent marketable yield	Percent non marketable yield
Preplant	14,212.8	878.5	15,091.3	94.4	5.6
Drip	19,005.1	913.3	19,918.4	95.9	4.1
Split	18,230.9	1,120.0	19,350.9	94.1	5.9
Contrast					
Preplant vs Drip	NS	NS	NS	NS	NS
Preplant vs Split	**	NS	**	NS	NS
Drip vs Split	**	NS	**	NS	NS

** = Significant at P<0.01; NS = Not Significant at P>0.05

Yard Long Bean (Vigna unguilata L.*)*

The effect of mulch on yard long bean was significant for all measured variable. Polyethylene mulch application increased the marketable yield from 202 to 692 g plot^{-1} (Table 5). Total yield also increased three fold by using mulch, i.e. from 230.5 g plot^{-1} to 700.9 g plot^{-1}. Non-marketable yield decreased significantly from 28.5 g plot^{-1} to 8.1 g plot^{-1} with polyethylene mulched. Without mulch percentage of non-marketable yield increased. This result shows that under polyethylene mulch soil environment condition became more appropriate for yard long bean to grow than without mulch.

Number of irrigation lines significantly influenced marketable yield and total yield per plot. However, number of line did not influence percentage of marketable yield, and percentage of non marketable yield (Table 6). The highest total yield and marketable yield were obtained with one irrigation line; these are 906.2 g plot^{-1} and 899.4 g plot^{-1}, respectively. With no irrigation line, marketable yield and total yield significantly lower than with two irrigation line. However, there was no significant difference in marketable yield and total yield between no- and one-irrigation line treatments. Two irrigation lines showed significantly higher marketable yield and total yield than one irrigation line. Therefore, two irrigation lines under polyethylene mulched was best choice for yard long bean production.

The effect of fertilizer significantly increased marketable yield and total yield. Increasing in total yield from 228.8 g plot^{-1} to 701.1 g plot^{-1} indicated that the soil fertility was low for growing yard long bean (Table 7). Therefore, optimizing fertilization program through drip irrigation and polyethylene mulched system for yard long bean is required.

Preplant application of 100% N and K significantly reduced marketable yield and total yield per plot of yard long bean (Table 8). The lowest marketable yield and total yield per plot were obtained by preplant application. Preplant application was different with Split and Drip application for both previous variable. Fertilizer application of 50% of N and K applied preplant and 50% applied 10 times weekly (split application) showed the highest marketable yield

Table 5. The effect of mulch on marketable and non-marketable yield of yard long bean

Treatment	Marketable yield (g plot^{-1})	Non-marketable yield (g plot^{-1})	Total yield (g plot^{-1})	Percent marketable yield	Percent non marketable yield
No Mulch	202.0	28.5	230.5	88.7	13.5
Mulch	692.8	8.1	700.9	98.3	2.3
Contrast	**	*	**	**	**

*,** = Significant at P<0.05 and P<0.01, respectively

Table 6. The effect of number of irrigation lines on marketable and non-marketable yield of yard long bean

Treatments	Marketable yield (g plot^{-1})	Non-marketable yield (g plot^{-1})	Total yield (g plot^{-1})	Percent marketable yield	Percent non marketable yield
No Line (Check)	368.8	3.5	372.3	98.7	2.7
One Line	753.3	9.3	762.6	98.7	2.3
Two Line	899.4	6.8	906.2	99.3	0.7
Contrast					
No Line Vs 1 Line	NS	NS	NS	NS	NS
No Line Vs 2 Line	*	NS	*	NS	NS
1 Line Vs 2 Line	**	NS	**	NS	NS

*,** = Significant at P<0.05 and P<0.01, respectively; NS = Not Significant at P>0.05

Table 7. The effect of fertilizer on marketable and non-marketable yield of yard long bean

Treatments	Marketable yield (g plot^{-1})	Non-marketable yield (g plot^{-1})	Total yield (g plot^{-1})	Percent marketable yield	Percent non marketable yield
No Fertilizer	216.0	12.8	228.8	94.0	7.0
Fertilizer	691.1	10.0	701.1	97.7	3.2
Contrast	**	NS	**	NS	NS

** = Significant at P<0.05; NS = Not Significant at P>0.05

Table 8. The effect of fertilizer application methods on marketable and non-marketable yield of yard long bean

Treatments	Marketable yield (g plot^{-1})	Non-marketable yield (g plot^{-1})	Total yield (g plot^{-1})	Percent marketable yield	Percent non marketable yield
Preplant	749.3	5.1	754.4	99.3	1.0
Drip	737.4	9.4	746.8	98.6	2.5
Split	992.4	9.6	1,002.0	99.1	1.1
Contrast					
Preplant Vs Drip	NS	NS	NS	NS	NS
Preplant Vs Split	**	NS	**	NS	NS
Drip Vs Split	**	NS	**	NS	NS

** = Significant at P<0.01; NS = Not Significant at P>0.05

and total yield compared preplant application and drip application where N and K 100% applied through drip. In split application, 50% preplant is needed to support initial growth of yard long bean. It was better rather than 100 fertilizer applied preplant or 100% fertigated 10 times weekly. Similar result reported by Susila and Locascio (2001), that 40% S fertilizer applied preplant and 60% injected obtained better yield of cabbage than 100% applied preplant.

Kangkong (Ipomoea reptans L.*)*

The effect of mulch on kangkong was significant for marketable yield. By mulching, marketable yield increased from 1,151.3 g plot^{-1} to 3,059.7 g plot^{-1} (Table 9).

Number of irrigation line was significantly influenced marketable per plot of kangkong (Table 9). The highest total yield marketable yield were obtained with one irrigation line, these are 3,689.0 g plot^{-1}. With no irrigation line, marketable yield was lower than with one or two irrigation line. However, marketable yield was not significantly different between one and two lines. Therefore, one irrigation line under polyethylene mulched was enough to support kangkong growth and yield.

The effect of fertilizer significantly increased marketable yield of kangkong. An increase in total yield from 890.0 g plot^{-1} to 3,092.3 g plot^{-1} indicates that the soil fertility was too low to support Kangkong growth (Table 9). Preplant application of 100% N and K significantly reduced marketable yield of kangkong (Table 9). The lowest marketable yield per plot was obtained by preplant application, followed by drip, and split application. Fertilizer application of 50% of N and K applied preplant and 50% applied 10 times weekly (split application) showed the highest marketable yield and total yield compared preplant application and drip application where N and K 100% through drip.

Table 9. The effect of mulch, number of irrigation line, fertilizer, and fertilizer application methods on marketable yield of kangkong

Treatments	Marketable yield (g plot^{-1})
	Mulch
No mulch	1,151.3
Mulch	3,059.7
Contrast	**
	Number of irrigation line
No line (check)	1,878.8
One line	3,689.0
Two line	3,547.3
Contrast	
No line vs 1 line	*
No line vs 2 line	*
1 line vs 2 line	NS
	Fertilizer
No fertilizer	890.0
Fertilizer	3,093.3
Contrast	**
	Fertilizer application methods
Preplant	2,883.8
Drip	3,484.6
Split	4,486.0
Contrast	
Preplant vs drip	*
Preplant vs split	**
Drip vs split	**

*,** = Significant at P<0.05 and P<0.01, respectively; NS = Not significant at P>0.05

CONCLUSION

From this experiment, it can be concluded that for the soil fertility status of the experimental area that contain low pH (4.5), low C-Organic (0.97%), very low N-total (0.17%), low K content (0.15 me (100 g)$^{-1}$), but high soil P_2O_5 concentration (13.7 ppm). Fertilizer application increased yield of eggplant, yard long bean, and kangkong. Combination of polyethylene mulch and drip irigation increased yield of eggplant, yard long bean, kangkong. One line irrigation system showed the best yield for eggplant and kangkong, however for yard long bean, two lines was the best system. Split fertilizer application methods showed the best yield for eggplant, yard long bean, kangkong.

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