Optimum Fertilizer Rate for Kangkong (*Ipomoea reptans* L.) Production in *Ultisols* Nanggung

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Abstract

Nitrogen, phosphor, and potasium availability are the most limiting factors for maximum growth and yield. Kangkong (*Ipomoea reptans* L.) is an important traditional leafy vegetable crops cultivated in Indonesia. Kangkong (*Ipomoea reptans* L.) was grown to evaluate the optimum rates of N, P, and K fertilizer in Ultisols Nanggung-Bogor soil with low pH (5.5), low C-Organic (1.54%), very low N-total (0.12 %), low K content (0.29 me/100 g), but very high soil P_2O_5 concentration (19.2 ppm) to evaluate the best crop management practices with sarter solution. The experiment was conducted in Hambaro village-Nanggung, Bogor, Indonesia from January to April 2008. The treatments were: N, P, K fertilizer rate of 0%, 50%, 100%, 150% and 200% from the fertilizer recommendation rate (100 kg/ha N, 135 kg/ha P_2O_5 and 135 kg/ha K_2O). This experiment used Randomized Complete Block Design with four replications (each farmer field as one replication). Total plots were 15 x 4 = 60, with plot sizeat 1.5 x 5 m. Kangkong (local variety) was planted in four rows per plot, 25 cm between rows and 15 cm within rows, at 10 seed per planting. The application of N to 200 kg/ha, P_2O_5 to 270 kg/ha, and K_2O to 270 kg/ha quadratically increased total and relative yield of kangkong. Base on $Y = -0.0021x^2 + 0.572x + 56.857$ for N, $Y = -0.0013x^2 + 0.3673x + 72.102$ for P_2O_5, and $Y = -0.0001x^2 + 0.0959x + 84.102$ for K_2O the optimum rates for each nutrient was 136-141-674 kg N- P_2O_5- K_2O /ha. The fertilizer recommendation based on K threshold (no K) was 41-40-0 and P threshold was 24-0-0 kg N- P_2O_5- K_2O /ha. However, no fertilizer was needed on N threshold. In the recommendation based on optimum yield (136-141-674), the percentage increase in cost (134,0) was higher than the expected increase in yield (19.28). Based on the yield vs. cost rule therefore, the most economical recommendation would be 41-40-0 kg N- P_2O_5- K_2O /ha (K threshold).

Keyworda : *Kangkong, optimum fertilizer rate, ultisol*

Introduction

Kangkong (*Ipomoea reptans* L.) is an important traditional leafy vegetable crops cultivated in Indonesia. Practically all parts of the young plants are eaten. Since older stems become fibrous, young succulent tips are preferred. Kangkong belongs to the family *Convovulaceae* which can be grown in lowland and upland farms. It is preferred for cultivation because of its shorter growth cycle, and it is fast growing, widely adaptable, and better tolerant to disease. Kangkong usually grows in home gardens, but is now becoming one of the significant commercial vegetables. In Indonesia, yield potential of Kangkong has not yet been fully exploited or studied due to low use of inputs and lack of information on production technology.

In Indonesia, growing vegetable crops in Ultisol soils is not widely observed, although Ultisols occupy almost 25% of total Indonesian land surface. The major problems in Ultisols are the deficiency of plant nutrients such as phosphorous (P) and potassium (K). Ultisols have acid to very acid soil reaction, high Al and Fe saturation which are specific properties that restrict plant growth. The presence of argillic horizon in the soil influences soil physical properties such as reduction of both macro and micropores, enlargement of surface run-off and finally supporting soil erosion. Most studies indicated that liming, and fertilizing by organic and iorganic fertilizers could overcome some constraints in Ultisols (Prasetyo and Suriadikarta, 2006; Kasno, Setyorini and Tuberkih, 2006).

Fertilization is one of the management practices that can be implemented to increase vegetable yield. Nitrogen and potassium are fundamental to achieve high marketable yield while phosphorus is essential for early growth and root development. The importance of potassium in ensuring normal growth and production of quality fruits is well recognized (IPNI, 2008). Nitrogen is the nutrient needed in largest quantities by plants and the one most frequently applied as fertilizer. Application rates are critical, because too much or too little directly impacts crop growth. Correct form of nitrogen is critical where the ammonium form can restrict growth and adversely affect quality. Application of phosphorus and potassium rate depends on the potential level of nutrient availability from the soil. Excessive phosphorus fertilizer can aggravate iron and zinc deficiencies and increase soil salt content, excessive potash fertilizer can also increase soil salt content too (Whiting, O'Meara, and Wilson, 2007).

Rochayati *et al.* (1999) reported that until now, fertilization practices observed by most farmers are applied to all plants, whereas fertilization rates depend on plant species and variety, soil type, location and agricultural practices. Fertilization recommendations are crop-specific and location-specific. Proper fertilization of a crop is a requirement to obtain maximum yield. In addition to yield obtained, quality of the commodity is an important factor of profit and shelflife for high-value crops (Hochmuth *et al.*, 1993).

This research was conducted to evaluate optimum rates of N, P, and K fertilizer on Kangkong (*Ipomoea reptans* L.) grown in *Ultisols,* Nanggung-Jasinga soil with low pH (5.5), low C-Organic (1.54%), very low N-total (0.12

%), low K content (0.29 me/100 g), but very high soil P_2O_5 concentration (19.2 ppm).

Materials and Methods

The experiment was conducted at in Hambaro village-Nanggung, Bogor, Indonesia from January to April 2008. The soil type in the location is *Ultisol*, which typically have pH 5.5 and high P-fixation by Aluminium, soil P_2O_5 concentration 19.2 ppm, N-total 0.12%, K and content 0.29 me/100 g. Treatments: N, P, K fertilizer rate of 0%, 50%, 100%, 150% and 200% from fertilizer recommendation rate (100 kg/ha N, 135 kg/ha P_2O_5 and 135 kg/ha K_2O). This experiment used Completely Randomized Block Design with four replications (each farmer field as one replication). Total plots used were 15 x 4 = 60 plots, with plot size = 1.5 x 5 m. Local variety of Kangkong was planted in four rows per plot or per bed, 25 cm between rows and 15 cm within rows, 10 seeds per planting hole.

The limes ($CaCO_3$) were thoroughly incorporated (1.5 ton/ha) into the bed four weeks before planting. Furrow irrigation was carried out at one-week intervals and weeding done when necessary. Harvesting was carried out four weeks after sowing.

Fertilizer application consisted of the following:

1. N fertilizer optimization: N rate was as same as the treatments, Preplant 100% P, 50 % K, Side dress 50% K (3 weeks after planting);
2. P fertilizer optimization: P rate was as same as the treatments, Preplant 50 % N and 50% K; Side dress 50% N and 50% K(3 weeks after planting);
3. K fertilizer optimization: K rate was as same as the treatments, Preplant 100% P, 50 % N; Side dress 50% N (3 weeks after planting).

Plant height and plant diameter were measured 1,2,3 and 4 weeks after transplanting. Yield per plant and per plot were measured 5 weeks after transplanting. Analysis of variance of data was calculated using SAS 8.12 (SAS Institute, N.C). Polynomial regression was used to analyze N-P-K rate effect (linear or quadratic) and to find out the optimum rate for maximum yield. Economic evaluation was done to arrive at the recommendation choices.

Results and Discussion

Application of N, P, K fertilizer up to 200 kg $N.ha^{-1}$, 270 kg $P_2O_5.ha^{-1}$, and 200 kg $K_2O.ha^{-1}$ significantly increased vegetative growth on plant height and stem diameter of Kangkong from 1 to 5 weeks after planting. This range of fertilizer rates was appropriate to build optimum rate of each fertilizer application in the *Ultisols* with soil N-total of 0.12%, P_2O_5 concentration of 19.2 ppm, K and content of 0.29 me/100 g.

1. Plant Height

Application of N fertilizer from 0 to 200 kg $N.ha^{-1}$ increased quadratically the plant height of kangkong at 1 week to 5 weeks after planting (Table 1). A similar effect was achieved with P fertilizer application, where application of P fertilizer from 0 to 270 kg $P_2O_5.ha^{-1}$), and K fertilizer from 0 to 200 kg $K_2O.ha^{-1}$ .increased quadratically the plant height of kangkong at 1 week to 5 weeks after planting (Tables 2 and 3).

Table 1. Effect of N rate on Plant Height of Kangkong

N Rate (kg N ha^{-1})	Plant Height (cm)			
	1 WAT	2 WAT	3 WAT	4 WAT
0,00	3,38	6,30	10,16	21,84
50,00	4,29	8,01	12,95	27,78
100,00	5,41	10,13	16,40	35,15
150,00	5,42	10,12	16,34	35,06
200,00	4,98	9,30	15,02	32,22
Regression	Q**	Q**	Q**	Q**

** Significant at P = 0.01, Regression Q = Quadratic

Table 2. Effect of P rate on Plant Height of Kangkong

P Rate (kg P2O5 ha^{-1})	Plant Height (cm)			
	1 WAT	2 WAT	3 WAT	4 WAT
0,00	3,68	6,87	11,10	23,82
67,50	4,21	7,86	12,69	27,23
135,00	4,91	9,16	14,78	31,74
202,50	4,77	8,91	14,39	30,88
270,00	4,69	8,77	14,16	30,39
Regression	Q**	Q**	Q**	Q**

** Significant at P = 0.01, Regression Q = Quadratic

Table 3. Effect of K rate on Plant Height of Kangkong

K Rate (kg K_2O ha^{-1})	Plant Height (cm)			
	1 WAT	2 WAT	3 WAT	4 WAT
0,00	4,26	7,95	12,84	27,56
50,00	4,29	8,01	12,92	27,75
100,00	4,60	8,59	13,86	29,76
150,00	4,86	9,08	14,65	31,46
200,00	4,76	8,89	14,35	30,80
Regression	Q**	Q**	Q**	Q**

** Significant at P = 0.01, Regression Q = Quadratic

2. Stem Diameter

A similar pattern of fertilizer effect occurred in stem diameter, where N, K fertilizer resulted in quadratic response, and P fertilizer resulted in linear response. Application of N fertilizer from 0 to 200 kg $N.ha^{-1}$ increased quadratically the stem diameter of kangkong at 1 week to 5 weeks after planting (Table 4) while application of P fertilizer from 0 to 270 kg $P_2O_5.ha^{-1}$ linearly increased stem diameter of kangkong at 1 week to 5 weeks after planting (Table 5). Application of K fertilizer from 0 to 270 kg $K_2O.ha^{-1}$ increased quadratically the stem diameter of kangkong at 1 week to 5 weeks after planting (Table 6).

Table 4. Effect of N rate on Stem Diameter of Kangkong

N Rate (kg N ha^{-1})	Stem Diameter (cm)			
	1 WAT	2 WAT	3 WAT	4 WAT
0,00	0,492	0,918	1,481	3,179
50,00	0,534	0,998	1,612	3,460
100,00	0,553	1,033	1,670	3,581
150,00	0,580	1,085	1,754	3,762
200,00	0,590	1,102	1,779	3,817
Regression	Q**	Q**	Q**	Q**

** Significant at P = 0.01, Regression Q = Quadratic

Table 5. Effect of P rate on Stem Diameter of Kangkong

P Rate (kg P2O5 ha^{-1})	Stem Diameter (cm)			
	1 WAT	2 WAT	3 WAT	4 WAT
0,00	0,529	0,987	1,594	3,421
67,50	0,541	1,011	1,632	3,504
135,00	0,567	1,059	1,710	3,669
202,50	0,606	1,132	1,827	3,922
270,00	0,619	1,157	1,869	4,010
Regression	L**	L**	L**	L**

** Significant at P = 0.01, Regression L = Linear

Table 6. Effect of K rate on Stem Diameter of Kangkong

K Rate (kg K_2O ha^{-1})	Stem Diameter (cm)			
	1 WAT	2 WAT	3 WAT	4 WAT
0,00	0,485	0,906	1,459	3,135
50,00	0,506	0,945	1,523	3,273
100,00	0,611	1,142	1,842	3,955
150,00	0,625	1,167	1,884	4,043
200,00	0,597	1,116	1,802	3,867
Regression	Q**	Q**	Q*	Q**

** Significant at P = 0.01, Regression Q = Quadratic

3. Plant Yield

Application of N, P fertilizer from 0, 50%, 100%, 150%, 200% of the f recommended rate resulted in quadratic response on yield of yard long bean. However, application of K fertilizer from 0, 50%, 100%, 150%, 200% of recommendation rate resulted in linear response on yield of yard long bean (Table 7). Application of K of more than 200% of the recommended rate (>270 kg $K_2O.ha^{-1}$) still increased yield. However, application of N and P fertilizer at more than 200% of the recommended rate (>200 kg N .ha^{-1}, and >270 kg $K_2O.ha^{-1}$) reduced yield.

Table 7. Effect of fertilizer rate on Yield of Yard Long Bean

Recommended rate (%)	Yield		
	P_2O_5	K_2O	N
	…Ton/ha…		
0,00	2,720	3,200	2,507
50,00	3,173	3,200	3,227
100,00	3,680	3,413	4,107
150,00	3,653	3,733	4,160
200,00	3,547	3,600	3,760
Respon	Q**	L**	Q**

** Non significant or significant at P = 0.01, Regression L = Linear, Q = Quadratic

100% rate = 100 kg/ha N, 135 kg/ha P_2O_5 and 135 kg/ha K_2O)

4. Multi-Nutrient Response Interpretation

Multi nutrient response interpretation is one method to develop fertilizer recommendations using single-nutrient quadratic model. The recommendation choice was developed using N, P, K fertilizer response curve, where the first recommendation was calculated from the optimum relative yield,and the second, third, and fourth recommendations etermined from N, P, K threshold (0 application), respectively.

The N curve response regression equation was

$$Y = -0.0021x^2 + 0.572x + 56.957 \; ; \; R^2=0.9341$$

and the optimum N rate was 136 kg $N.ha^{-1}$.

Phosphor response regression equation was

$$Y = -0.0013x^2 + 0.3673x + 72.102 \; ; \; R^2=0.9569$$

and the optimum P rate was 191 kg $P_2O_5.ha^{-1}$.

Potassium response regression equation was

$$Y = -0.0001x^2 + 0.0959x + 84.102 \; ; \; R^2=0.7649$$

and the optimum K rate was 647 kg $K2O.ha^{-1}$.

Therefore, 4 fertilizer recommendations for yard long bean can be applied (kg $N\text{-}P_2O_5\text{-}K_2O,ha^{-1}$):

1) based on optimum yield = 136-191-647,
2) based on N threshold = 0-0-0,
3) based on P threshold = 24-0-0, and
4) based on K threshold = 41-40-0 (Figure 1).

5. Economic Evaluation of Fertilizer Recommendations

The economic evaluation of fertilizer recommendation was calculated based on price of Urea (45% N), SP36 (36% P_2O_5), and KCl (50% K_2O) which were Rp1700, Rp3000, and Rp8000, respectively. Based on increases in relative yield, the recommendation based on optimum yield was the best choice (100%).

However this recommendation also caused the relative cost unit to be at 178.344. Based on the fertilizer price the most economic fertilizer recommendation was 41-40-0 (kg N-P_2O_5-K_2O,ha^{-1}) which had the lowest relative unit cost (90.904). However, this choice leads to only 84.10% relative yield. The economic evaluation of fertilizer recommendations for Kangkong in *Ultisol* Jasinga is shown in Table 8.

Conclusion

From this study it can be concluded that:

1. The fertilizer recommendation for Kangkong in *Ultisols* Nanggung-Bogor with soil P_2O_5 concentration of 19.2 ppm, N-total of 0.12%, K and content of 0.29 me/100 g. based on optimum yield was 136 - 191 - 647 (kg N-P_2O_5-K_2O,ha^{-1}).
2. The most economicfertilizer recommendation for yard long bean in *Ultisols,* Nanggung-Bogor was 41 - 40 - 0 (kg N-P_2O_5-K_2O,ha^{-1}) However, this choice resulted in 84.10 % relative yield only.

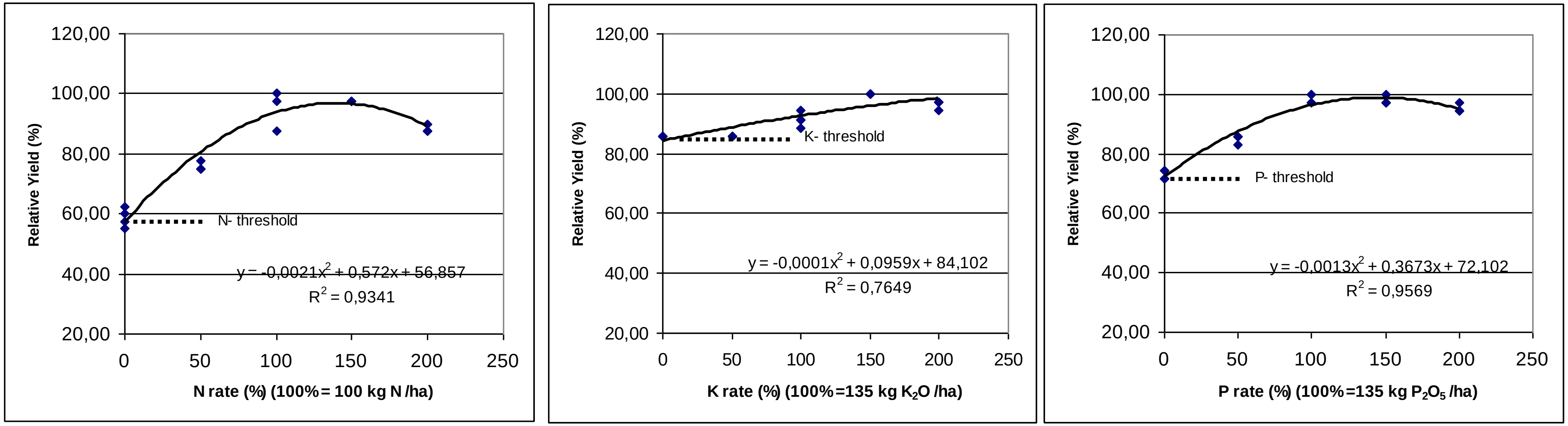

Figure 1. Multi-nutrient Response Interpretation and Development of Fertilizer Recommendation Using Single-nutrient Quadratic Model: Kangkong in *Ultisols* Nanggung-Bogor. Fertilizer Applied (kg $N-P_2O_5-K_2O$/Ha) for Recommendation Choice : to optimum yield = 161-208-309, to N threshold = 0-4-0, to K threshold = 15-28-0, to P threshold = 0-0-0

Table 8. Economic Evaluation of Fertilizer Recommendation for Kangkong in *Ultisols* Nanggung-Bogor

Fertilizer Recommendation Choice	Yield Data			Cost Data				Relative unit Cost 3)
	Relative Yield at each nutrient threshold	Change from next lower recommendation choice		Fertilizer Cost	Total Production Cost	Change from next lower recommendation choice		
		Increase in Relative Yield	Percentage increase in Yield 1)			Increase in Cost	Percentage increase in Cost 2)	
			(%)	(Rp)	(Rp)	(Rp)	(%)	
0 - 0 - 0 (N-threshold)	56,90	-	-	0	7.156.000	-	-	125.764
24 - 0 - 0 (P-thershold)	72,10	15	26,71	92.367	7.248.367	92.367	1,3	100.532
41 - 40 - 0 (K-threshold)	84,10	12	16,64	488.986	7.644.986	396.619	5,5	90.904
136 - 191 – 647 (optimum)	100,00	16	19,28	10.734.776	17.890.776	10.245.790	134,0	178.344

1) Increase in relative yield divided by the relative yield at each nutrient threshold
2) Increase in cost divided by total production cost for previous recommendation choice
3)Total production cost divided by relative yield at each nutrient threshold

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