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RESEARCH ARTICLE

NITROGEN BALANCE OF CABAGGE AT DIFFERENT SOIL CONSERVATION TECHNIQUES IN TALUN BERASAP, INDONESIA

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ABSTRACT

Usually, the use of nitrogen fertilizer in vegetables growing area by farmers is too high. Study on nitrogen balance of cabbage at different soil conservation techniques was conducted in Talun Berasap, a vegetables growing area in Kerinci District, Indonesia in 2011. The aimed of this study were to determine the nitrogen recommendation application rate at different soil conservation techniques and to estimate the nitrogen fertilizer at Kerinci district. Four treatments were tested including control, a farmers practices with the direction of planting in line with slop (KTA-1), modification of farmer practice by adding ridge terrace every 5 m of slope length (KTA-2), modification of farmer practice by adding ridge terrace and hill side ditch every 5 m of slope length (KTA-3), and (4) planting in line with contour (KTA-4). Nitrogen balance was calculated according to the differences between nitrogen gains and losses. To quantify total nitrogen input, nitrogen content in urea, dosage of urea, rate of compost, nitrogen concentration in compost, and nitrogen concentrations in rainfall were collected. Output parameters were cabbage yield, crop residues production, nitrogen concentrations in cabbage and crop residues as well as erosion. The results indicated that negative nitrogen balances were taken place in planting in line with slop (KTA-1) and planting in line with contour (KTA-4) treatments. Concerning the environmental, agronomical and economic point of views as well as to get higher cabbage yield and stabile, recommended urea application rate should be from 400 to 500 kg ha^{-1} $season^{-1}$ with adding more compost to 20 - 30 tons ha^{-1} $season^{-1}$.

INTRODUCTION

In Indonesia, vegetables are mainly grown in highland, from 750 m to 2800 m above sea level under big different management systems. They vary between traditional low input and excessive input, especially for nitrogen fertiliser. Usually, the farmers add nitrogen fertiliser too excessive, as much as 600 – 750 kg urea ha^{-1} $season^{-1}$. Furthermore, inorganic fertilisers application rate are based on their experiences, usually too high and has no relationship with inherent soil fertility, like done in many growing areas in Indonesia. Besides these conditions, crop rotations are also imbalanced. In addition, selecting crops to be planted is mostly deal with market demands in spite of climate and pest and diseases problems (Anonymous. 2007). Nitrogen is generally considered the most yield limiting nutrient, and is required in large quantities for maximum crop production. In last decade, fertiliser cost and concern for sustainable soil productivity and ecological stability in relation to chemical fertiliser use have indicated as important issues. Many factors including soil condition, crop rotation, N-content of manure, C:N ratio and rainfall involve in the estimation of fertiliser required by plant to grow well. Soil factors are mainly related to rate, time and way of fertilisers to be applied during the growing period. Proper fertiliser application rates does not only effect on the crop yields (quality and quantity), but also the environmental and economical aspects. By definition nutrient balance is the difference between nutrient gains and losses.

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The nutrient gains include nutrients coming from fertilisers, returned crop residues, irrigation, rainfall, and biological nitrogen fixation (Sukristiyonubowo *et al.* 2010; Sukristiyonubowo. 2007; Wijnhoud *et al.* 2003; Lefroy and Konboon. 1999; Miller and Smith, 1976). According to Sukristiyonubowo *et al.,* (2010), Sukristiyonubowo (2007) and Uexkull (1989), the nutrient losses include removal through harvested biomass (all nutrients), erosion (all nutrients), leaching (mainly nitrate, potassium, calcium and magnesium), fixation (mainly phosphate), and volatilisation (mainly nitrogen and sulphur). When the nutrient removals are not replaced by sufficient application of fertilisers or returning of biomass, soil mining takes place and finally crop production do not reach its potential yield and reduces.

Nutrient balances can be developed at different scales, including (a) plot, (b) field, farm or catchment, (c) district, province, and (d) country scale, and for different purposes (Sukristiyonubowo *et al.,* 2010; Leroy and Konboon. 1999; Bationo *et al.,* 1998; Hashim *et al.,* 1998; Van den Bosch *et al.,* 1998a and 1998b; Syers .1996; Smaling *et al.,* 1993; and Stoorvogel *et al.,* 1993). Many studies indicate that at plot, farm, district, province, and national levels, agricultural production is characterised by a negative nutrient balance (Sukristiyonubowo *et al.*, 2011; Sukristiyonubowo *et al.*, 2010; Sukristiyonubowo. 2007; Nkonya *et al.* 2005; Sheldrick *et al.,* 2003; Harris. 1998; Van den Bosch *et al.,* 1998b). A long-term nitrogen experiment at plot scale in the dry land sloping area of Kuamang Kuning, Jambi Province, Indonesia provided confirmation that the balance in the plots without input was - 4 kg N ha^{-1} yr^{-1}. However, this do not happen in the plots treated with a combination of high fertiliser application rates and *Flemingia congesta* leaves planted in a hedge row system (Santoso *et al.,* 1995). Study on plot scale nitrogen balance of newly opened wetland rice indicates that positive nitrogen balances are taken place in all treatments and the best is NPK with recommendation rate + Compost + Dolomite (N and K were split 3x). Concerning the environmental, agronomical and economic point of views, recommended urea application rate should be reduced from 250 to 200 kg ha^{-1} season^{-1} with adding more compost to 3000 kg ha^{-1} season^{-1}(Sukristiyonubowo *et al.,* 2011). Basically, a complete study of nutrient balances is very complicated. In a simple way, nutrient loss is mainly calculated based on removal by harvested products and unreturned crop residues, while the main inputs are organic and mineral fertilisers. So far, it is reported that most assessment is partial analysis of these in- and output data (Wijnhoud *et al.,* 2003; Drechsel *et al.,* 2001; Lefroy and Konboon, 1998). The aimed of this study were to determine the nitrogen recommendation application rate at different soil conservation techniques and to estimate the nitrogen fertilizer at Kerinci district. It was hypothesized that by determining the proper nitrogen fertiliser application rate, the nitrogen requirement at district level and optimal cabbage production can be reached as well as nitrogen fertiliser stock at the Kerinci District was met every planting season.

MATERIALS AND METHODS

Field experiment on nitrogen balance of cabbage was conducted on farmer field in Talun Berasap, a vegetables growing area in Kerinci District, Jambi Province with the coordination S:01^{o} 41’ 58.3”, E:101^{o} 20’ 50.3”. The soil was classified as Andisols. The area was sloping with altitude 1500 m above sea level. The treatments were control, a farmers practices with the direction of planting in line with slop (KTA-1), modification of farmer practice by adding ridge terrace every 5 m of slope length (KTA-2), modification of farmer practice by adding ridge terrace and hill side ditch every 5 m of slope length (KTA-3), and (4) planting in line with contour (KTA-4). They were arranged into Randomized Complete Block Design (RCBD) and replicated three times. The plot size was 20 m in length x 5 m in width. The distance among plot was 100 cm and between replication was 150 cm. The application rate of fertilisers was 180 kg N ha^{-1}, 54 kg P_2O_5 ha^{-1} dan 60 kg K_2O ha^{-1} or equivalent with 400 kg urea ha^{-1}, 150 kg SP-36 ha^{-1} dan 100 kg KCl ha^{-1}. Nitrogen and potassium were split two times, 50 % at a week after transplanting and 50 % at 35 DAT (days after Planting), while for P was given one time at a week after transplanting time. Compost of about 10 tons ha^{-1} were broadcasted a week before planting. Before broadcasting the compost, one kg composite compost were taken and brought to Bogor for nutrient analysing.

The nutrient inputs were the sum of nutrients coming from mineral fertiliser (IN-1), rice straw compost (IN-2), irrigation (IN-3), and precipitation (IN-4). Outputs were sum of nutrients removed by cabbage production (OUT-1) crop residues (OUT-2), erosion (OUT-3) and surface runoff (OUT-4). Because the area was sloping and mainly planting with vegetables, during the wet season there was no irrigation supply. Therefore, the formula became

Nitrogen Inputs (IN) = IN-1 + IN-2 + IN-4 ………………..……... (1)

Nitrogen Outputs (OUT) = OUT-1 + OUT-2 + OUT-3 + OUT-4....(2)

Nitrogen Balance = IN – OUT ………………...…………..... (3)

To quantify nitrogen gain, data included nitrogen content in urea, rate of urea application, amount of organic fertiliser, and in rainfall were collected. The output parameters were cabbage yield, crop residue production, erosion, nitrogen concentrations in cabbage and crops residue as well as nitrogen concentration in erosion. IN-1 and IN-2 was calculated based on the amount of mineral and organic fertilisers added multiplied by the concentration of nitrogen in urea and compost, respectively. IN-4 was estimated by multiplying rainfall volume with nutrient concentrations in the rain water. In a hectare basis, it was counted as follow (Sukristiyonubowo *et al*., 2011):

$$\text{IN-4} = \frac{\text{A x 10.000 x 0.80 x B x 1000}}{1000 \text{ x } 10^6}$$

Where:

- IN-4 is nitrogen contribution of rainfall water in kg N ha^{-1} season^{-1}
- A is rainfall in mm
- 10000 is conversion of ha to m^2
- 0.80 is factor correction, as not all rain water goes in the soil
- B is nitrogen concentration in rainfall water in mg l^{-1}
- 1000 is conversion from m^3 to l
- 1000 is conversion from mm to m
- 10^6 is conversion from mg to kg

To monitor rainfall events, data from rain gauge and climatology station of Kerinci were considered. Rain waters were sampled once a month from a rain gauge in 600 ml plastic bottles and was also analysed according to the procedures of the Laboratory of the Soil Research Institute, Bogor. Theoretically, the nitrogen loss can be through harvested product (cabbage yield), leaching, erosion and ammonia volatilization. Due to leaching and ammonia volatilisations as well as surface runoff were not yet measured, thus the nitrogen loss was calculated only from harvested products and erosion. Consequently, the total nitrogen output was bit underestimated. As all cabbages are consumed, OUT-1 was estimated based on cabbage yield multiplied with nutrient concentration in the cabbage. OUT-2 was calculated according to the total crop residue production multiplied with nutrient concentration in the crop residue. It was considered as output because all crop residues was taken out from the field for making compost and the compost will be applied for coming planting season. Out-3 was calculated based on the total erosion multiplied with nutrients consentration. Cabbage were sampled at harvest and were collected from every plot, one plant per plot. After pulling out, the plant roots were washed with water. For the laboratory analyses, the samples were treated according to procedures of the Analytical Laboratory of the Soil Research Institute, Bogor. Samples were washed with deionised water to avoid any contamination, and dried at 70^0 C. The dried samples were ground and stored in plastic bottles. Nitrogen was determined by wet ashing using concentrated H_2SO_4 (97%) and selenium (Soil Research Institute. 2009).

Chemical analyses included the measurement of pH (H_20 and KCl), organic matter, phosphorus, potassium, base saturation, and cation exchange capacity (CEC). Organic matter was determined using the Walkley and Black method, pH (H_2O and KCl) was measured in a 1:5 soil-water suspension using a glass electrode, total P and soluble P were measured colorimetrically using HCl 25% and Olsen methods, respectively. The total K was extracted using HCl 25% and subsequently determined by flame-spectrometry. The CEC was determined using an Ammonium Acetate 1 M, (pH 7.0) extraction and expressed in cmol$^+$ kg^{-1} soil. Base saturation was computed based on the sum of Ca^{++}, Mg^{++}, K^+, and Na^+ relative to CEC (Soil Research Institute. 2009). Physical analyses included the measurement of water level, particle density (PD), bulk density (BD) and total pore space. Water level was measured using Gravimetric method, particles density was used Richards and fireman method (1943), bulk density was measured using Ricards method (1947) and total pores space was measured using De Boodt method (1967). All measurement of physical analysis were adopted by Indonesian Soil Research Institute (2009). The data were statistically examined by analysis of variance (ANOVA), using SPSS software. Means were compared using the Duncan test (5%).

RESULTS AND DISCUSSION

Inherent soil fertilityof vegetables growing area: Chemical and physical soil properties of the cabbage growing area at Talun Berasap are presented in Table 1 and 2. In general, the soils were similar each other, no significant different in soil fertility parameters. The pH(s) of soils was very acidic, varying between 4.77 and 4.93. The cation exchange capacities (CEC) values ranged between 27.12 and 28.31 $cmol^+ kg^{-1}$ suggesting uniformity in clay mineralogy and high in organic matter contents. The CEC may be categorised as medium to high. The levels of soil organic carbon and total nitrogen were high, ranging from 5.43 to 5.71 % and from 0.52 to 0.57 %, respectively. This may be due to the fact that in the past, the management was pretty good for example all crop residues were returned and use more compost to the field and or crop residues were not burnt. Sommerfeldt *et al.* (1988) and Clark *et al.* (1998) also observed higher soil organic matter levels in soils managed with animal manure and cover crops than in soils without such inputs. The total P varied from 205.50 to 232.40 mg P_2O_5 kg^{-1}. These values were classified as very high. Furthermore, available P was also considered high, ranging between 25.30 and 40.00 mg P_2O_5 kg^{-1}. It can be suggested that application of 100 kg SP-36 ha^{-1} $season^{-1}$ is enauogh to enhance the availability of P. Total K extracted with HCl 25% was classified low, varying from 10.93 to 14.09 mg K_2O 100 mg^{-1}. This also suggested that application of fertiliser rate as much as 100 kg KCl ha^{-1} $season^{-1}$ will increase available K in the soil. Clark *et al.* (1998), Rasmussen and Parton (1994) and Wander *et al.* (1994) also reported similar findings.

Table 1. The influence of soil conservation techniques on chemical soil fertility parameters of cabbage growing areas at Talun Berasap Village, Kerinci District, Jambi Province in 2011 (soil composite were sampled one day before cabbage was harvested)

Soil parameters	Soil conservation techniques			
	KTA-1	KTA-2	KTA-3	KTA-4
pH				
H2O	4.77 a	4.77 a	4.80 a	4.93 a
KCl	4.64 a	4.21 a	4,69 a	4,75 a
Organic Matters				
C-organic (%)	5,44 a	5,77 a	5,43 a	5,47 a
N Total (%)	0,56 a	0,59 a	0,52 a	0,56 a
C/N ratio	9,93 a	9,97 a	10,49 a	9,98 a
Bray I (P2O5) (mg/kg)	30,14 a	40.00 a	25,30 a	28,30 a
Extract HCl 25 % (mg/100 g)				
P2O5	205,95 a	232,40 a	205,50 a	211,41 a
K2O	10,93 a	14,09 a	11,74 a	12,83 a
Extractt Ammonium acetate				
K (cmol+/kg)	0,10 a	0,11 a	0,11 a	0,08 a
Ca (cmol+/kg)	12,65 a	11,92 a	10,49 a	10,55 a
Mg (cmol+/kg)	0,67 a	0,75 a	0,64 a	0,59 a
Na (cmol+/kg)	0,04 a	0,03 a	0,04 a	0,04 a
CEC (cmol+/kg)	27,45 a	28,31 a	27,12 a	27,43 a
Saturated Base (%)	48,93 a	45,73 a	41,56 a	41,01 a

Note: The mean values in the same row or line followed by the same letter are not statistically different

Base saturation is categorised between low and medium, varying between 41.01 and 48.30 %. This is mainly due to the ratio among the concentrations of exchangeable Ca (10.49 – 12.65 $cmol^+ kg^{-1}$) and K (0.08 – 0.11 $cmol^+ kg^{-1}$) as well as exchangeable Mg concentrations were not balanced. So far, exchangeable Mg concentrations (0.59 - 0.75 $cmol^+ kg^{-1}$) and K (0.08 – 0.11 $cmol^+ kg^{-1}$) were relatively low, while for the concentrations of exchangeable Ca (10.49 – 12.65 $cmol^+ kg^{-1}$) was very high. In normal conditions, the ratio ranges from 60 to 65 % of calcium, 10 to 15 % of magnesium, and 5 to 7 % of potassium (Sukristiyonubowo. 2007). Looking at the value pH and K concentrations, only both elements were in problem meaning that to minimize that problem application of K fertiliser as well as lime is a must to enhance crop (cabbage) growth and yield. Therefore, it may be concluded that in general the chemical soil fertility is considered good due to high organic matter (C-organic and N total) content, available P and only had problem in pH and exchangeable potassium concentration. In addition, the soil properties variability was small as indicated by range of parameters values. Recommendation of agronomic practices to enhance crop yield include application of soil ameliorant like addition of compost, lime, besides addition of mineral K fertiliser.

Table 2. The influence of soil conservation techniques on soil physical parameters of cabbage growing area at Talun Berasap village, Kerinci District, Jambi Province in 2012 (soil composite were sampled on day before cabbage was harvested)

Physical parameter	Soil conservation techniques			
	KTA-1	KTA-2	KTA-3	KTA-4
Water level (% vol)	28,8 a	26,2 a	24,8 a	26,8 a
Bulk Density (g/cm3)	0,7 a	0,7 a	0,7 a	0,7 a
Particle Density (g/cm3)	2,0 a	2,1 a	2,0 a	2,0 a
Total pore space (% vol)	66,8 a	67,1 a	65,7 a	66,7 a

Note: The mean values in the same row or line followed by the same letter are not statistically different

The result of physical analisis are presented in Table 2. Like the chemical analisis, there were not statistical diferren in the physical parameters as treated by different soil conservation techniques. All parameters indicated the similar results, no statistically different.

Nitrogen Balance

The nitrogen balance at plot scale was constructed according to the different between nitrogen input and nutrient loss.

Nitrogen Input

The nitrogen input originated from application rate of urea (IN-1), compost (IN-2) and rainfall water (IN-4) and their nutrient contribution was presented in Table 3 and Table 4. The IN-1 (contribution of inorganic fertiliser) was + 180 kg N ha^{-1} $season^{-1}$. It can be said that the higher the rate of urea fertiliser, the higher the nitrogen contribution to the input (Table 3). Meanwhile, the IN-2 (contribution of compost) was about 97 kg N ha^{-1} $season^{-1}$ from the average of nitrogen contents in compost of 1.25 %, 0.95 % and 0.70 % N. Hence, besides the application rate of organic fertiliser or compost, the nitrogen concentration in compost will also influence its contribution. So far, the nitrogen input from rainfall water was about 5.88 kg N, equal to 11 kg urea (Table 4). This contribution is classified low, about 2 % from total nitrogen input (Table 7). Whereas the significant contribution of rain fall to N input is reported in Belgium (Demyttenaere. 1991).

Nitrogen loss

To compute the nitrogen loss, data of cabbage production namely cabbage yield, resudues (roots, steam, and 'unqualified leaves') production, erosion and nitrogen concentration in cabbage, crop residues (roots, steam, and leaves) and erosion were collected. The nitrogen loss was estimated from nitrogen taken away from cabbage (OUT-1) as all cabbage was consumed and nitrogen taken out by crop residues (OUT-2). The nitrogen loss is presented in Table 5. The nutrient loss due to erosion (OUT-3) is presented Table 6. Because the run off was not sampled, therefore nutrient loss due to surface run off was not measured and nitrogen balance was little bit underestimated

Output-Input Assessment

The N balance of cabbage at different soil conservation techniques at Talun Berasap village, a vegetables growing area in Kerinci District is presented in Table 7. In general, the results indicated that inorganic fertiliser (IN-1) contributes considerably to total nitrogen input in all different soil conservation techniques. Because this experiment was at soil conservation techniques, the amounts of inorganic fertiliser was the same namely 400 kg urea ha^{-1} or 180 kg N ha^{-1} $season^{-1}$. It can be said that inorganic fertiliser is the most important nitrogen sources to enhance yield and manage the field. This means that the needs for mineral fertilisers may be greater when we grow leafy vegetables.

Table 3. The contribution of inorganic fertiliser (IN-1) and compost (IN-2) to nutrient input at Talun Berasap village, a vegetables growing area in Kerinci District

Code	Treatment	Rate and contribution of urea ($kg\ ha^{-1}$)		Rate and contribution of compost ($kg\ ha^{-1}$)	
		Rate	IN-1	Rate	IN-2
KTA 1	Control, a farmers practices with the direction of planting in line with slope	400	180 kg N	10 000	97 kg N
KTA 2	Modification of farmer practice by adding ridge terrace every 5 m of slope length	400	180 kg N	10 000	97 kg N
KTA 3	Modification of farmer practice by adding ridge terrace and hill side ditch every 5 m of slope length	400	180 kg N	10 000	97 kg N
KTA 4	Planting in line with contour	400	180 kg N	10 000	97 kg N

Table 4. The contribution of rainfall water (IN-4) to nutrient input to nutrient input at Talun Berasap village, a vegetables growing area in Kerinci District

Code	Treatment	Rainfall		
		Rainfall ($mm\ yr^{-1}$)	$NH4^+$ ($mg\ l^{-1}$)	IN-4 ($kg\ N\ ha^{-1}$)
KTA 1	Control, a farmers practices with the direction of planting in line with slope	1 039	0.91	5.88
KTA 2	Modification of farmer practice by adding ridge terrace every 5 m of slope length	1 039	0.91	5.88
KTA 3	Modification of farmer practice by adding ridge terrace and hill side ditch every 5 m of slope length	1 039	0.91	5.88
KTA 4	Planting in line with contour	1 039	0.91	5.88

Table 5. The nitrogen lost through cabbage (OUT-1) and crop residues production (OUT-2) at different soil conservation techniques at Talun Berasap village, a vegetables growing area in Kerinci District

Code	Treatment	Cabbage production, N concentration and N loss			Crop residues production, N concentration and N loss		
		Cabbage Production	Con N (%)	OUT-1	Crop Production	Con N (%)	OUT-2
KTA 1	Control, a farmers practices with the direction of planting in line with slope	9.43	2.66	250.84	1.23	2.14	26.32
KTA 2	Modification of farmer practice by adding ridge terrace every 5 m of slope length	7.33	2.56	187.65	0.81	2.11	17.10
KTA 3	Modification of farmer practice by adding ridge terrace and hill side ditch every 5 m of slope length	6.67	2.94	196.10	0.80	1.93	15.44
KTA 4	Planting in line with contour	10.56	2.91	310.46	1.48	2.15	31.82

Table 6. The nitrogen lost through erosion (OUT-3) at different soil conservation techniques at Talun Berasap village, a vegetables growing area in Kerinci District

Code	Treatment	Erosion and nitrogen loss (OUT-3)		
		Erosian ($t\ ha^{-1}$)	N Con. (%)	OUT-3
KTA 1	Control, a farmers practices with the direction of planting in line with slope	14.70 a	0.53 a	77.91
KTA 2	Modification of farmer practice by adding ridge terrace every 5 m of slope length	11.30 c	0.56 a	63.28
KTA 3	Modification of farmer practice by adding ridge terrace and hill side ditch every 5 m of slope length	10.90 c	0.49 a	53.41
KTA 4	Planting in line with contour	12.70 b	0.52 a	66.04

Note: The mean values in the same column followed by the same letter are not statistically different

Like N fertiliser rate, the rate of compost was also similar in all treatments, namely 10 t ha^{-1} $season^{-1}$. The contribution of compost (IN-2) was also an important nutrient source, covering about 97 N kg ha^{-1} $season^{-1}$. The IN-2 inputs are getting more important, when less or no inorganic fertilisers are applied and more organic fertiliser is added, like in organic agricultire (rice and vegetables) farming system. The N supplied by compost was equivalent to 105 kg of urea ha^{-1} and will be more when the rate of compost application increases. IN-4 (contribution of rainfall water) was about 5.88 kg N ha^{-1} and also an important nutrient source, particularly for N during the wet season, covering 2 % of the total N input. With respect to the output, depending on the treatment, around 70 % - 76 % of total N was taken up by cabbage yield, erosion about 10 – 24 % and the rest by crop residues. This means that N was greater removed by cabbage yield followed by erosion. Assessment of nitrogen input and output shows positive balances for KTA-2 and KTA-3 treatments (Table 7). The surplus ranged between + 14 and +18 kg N ha^{-1} $season^{-1}$. This were happened because their yields were considered low, 7.33 for KTA-2 and 6.67 t ha^{-1} $season^{-1}$ for KTA-3. In contrast, the N balances in the KTA-1 and KTA-4 were negative (-72 kg N ha $^{-1}$ $season^{-1}$ for KTA-1 and 125 kg N ha $^{-1}$ $season^{-1}$ for KTA-4 equal to around 160 kg urea and 270 kg urea). This may be explained by increasing of cabbage yields and the fertilisers' rate should be increased. It should also be noted that the N output will even be higher, when NH_3 volatilisation, surface runoff and leaching are taken into account. The negative N balances in KTA-1 and KTA-4 treatments also demonstrated that the application rates of inorganic were insufficient to substitute N removed by cabbage yield and erosion. However, we do believe that when the fertilisers application rates (organic/compost and inorganic), cabbage yield increase and NH_3 volatilisation, surface run off and leaching are taken into account, the balance will move. Therefore, nitrogen fertiliser application rate could be between 560 and 670 kg of urea ha^{-1} $season^{-1}$, when compost rate was not increased. To protect environment as well as to reduce the production cost, compost

Table 7. Output-input analysis for nitrogen of cabbage at different soil conservation techniques at Talun Berasap village, a vegetables growing area in Kerinci District (kg N ha^{-1} season^{-1})

Parameter	Soil Conservation techniques			
	KTA-1	KTA-2	KTA-3	KTA-4
N INPUT (kg N ha^{-1} season^{-1}) :				
IN-1	+180,0	+ 180,0	+ 180,0	+ 180,0
	64 %	64 %	64 %	64 %
IN-2	+ 97,0	+ 97,0	+ 97,0	+ 97,0
	34 %	34 %	34 %	34 %
IN-4	+ 5.9	+ 5.9	+ 5.9	+ 5.9
	2 %	2%	2 %	2 %
Total N Input	+282.9	+ 282.9	+ 282.9	+ 282.9
	100 %	100 %	100 %	100 %
N OUPUT (kg N ha^{-1} season^{-1}):				
OUT-1	- 250.8	- 187.7	196.1	310.5
	72 %	70 %	74 %	76 %
OUT-2	- 26.3	- 17.1	15.4	31.8
	7 %	6 %	6 %	8 %
OUT-3	- 77.9	- 63.3	53.4	66.0
	21 %	24 %	20 %	16 %
OUT-4	-	-	-	-
Total N Output	- 355.0	- 268.9	- 264.9	- 408.3
	100 %	100 %	100 %	100 %
N Balance	- 72.1	+ 14.0	+18.0	-125.4

should be increased from 10 to tons ha^{-1} season^{-1} to 20 to 30 tons ha^{-1} season^{-1} of compost and urea can be reduced to 400 to 500 kg ha^{-1} season^{-1} to increase and sustain a higher cabbage yield, at least it is higher than normal yield (18 t ha^{-1} season^{-1}season^{-1}). As sometime it was not easy to get the urea during planting time and the price was considered higher than normal price, providing urea based on total planted areas or existing and urea application rate is very important. According to anonymous (2010) the total cabbage areas in Kerinci District is about 619 ha, therefore, total urea should be available is about 247 - 310 tons district $^{-1}$ season $^{-1}$ (400 – 500 kg x 619 ha).

Conclusion

Evaluation of nitrogen input and output of cabbage at different soil conservation techniques in Talun Berasap, Kerinci District indicated the surplus (from +14 to +18 kg N ha^{-1} season^{-1}) and negative nitrogen balances from - 72 to - 125 kg N ha^{-1} season^{-1}. These mean cabbage yield were not stabile and considered lower than normal yields. To enhance the cabbage yield and to consider the environmental, agronomical and economic aspects, the rate of urea application can be increased around 400 – 500 kg urea ha^{-1} season^{1}. with adding more compost from 20 to 30 tons ha^{-1} season^{-1}.

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