International Journal of Agriculture Innovations and Research
Volume 6, Issue 3, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 21/11/2017 | Accepted on: 030/11/2017 | Published: 21/12/2017

Effect of Bed Directions and Conservation Techniques on Soil Fertility, Club Root Diseases and Yield of Cabbage

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Abstract **– The Effect of Bed Directions and Conservation Techniques on Soil Fertility, Club-root Desease and Yield of Cabbage. The experiment was conducted in the highland area at Cibodas Village – Lembang in the rainy season and 30% land slopes. The objective of this research was to improve the appropriate cultural technique in maintaining soil chemical properties, suppressing development of club-root disease and cabbage yield. A split plot design with 3 replicates was used. The treatment consisted of Bed Direction as main plot and Conservation Techniques as a sub plot. At each trench, waterfall was made which is lined with burlap sacks to accommodate the eroded soil. The results showed that the beds that cut slope or contour parallel gave significant effect in reducing erosion and loss of nutrients (organic C, N, P and K) of land. However, it did not give significantly increase in yield. The beds that cut slope or parallel contour tends to show the lower club root attack than the beds in the direction of the slope. Plastic mulching on single cabbage able to minimize erosion and loss of soil nutrients (organic C, N, P and K), increases the growth, and yield of cabbage by 52%. While organic mulching tends to increase the club-root disease (20.98%) in cabbage plants.**

Keywords **– Brassica oleracea, Cabbage yield, Plasmodiophora brassicae, Soil erosion.**

I. INTRODUCTION

Land degradation is the major challenge to improving agricultural production and productivity. Indonesian's highlands, especially in the western part have been recognised as one of the key hotspots where land degradation, due to soil erosion, is rampant. Highland area is an agrosystem that potential for developing commercial vegetables since either appropriate climate for vegetables or dominated by andisol soil type and its association. However, this kind of soil has great potential to become critical land due to its characteristic of soil which has very sensitive to soil erosion. Therefore, environmental damage (erosion) is frequently occured in the highland area. In Indonesia and Rwanda, crop productivity in the highland is decreasing as a result of intensive farming on the steep slopes which has causal soil loss and declining soil fertility [1][2]. Soil loss in Indonesia may reach 40 t/ha/year while in Rwanda is a range from 35 t/ha/year to more than 100 ton/ha/year [3]. Soil erosion in the wet tropics such as Indonesia was due to agroecosystem wich is conducive to soil degradation and stimulated by intensive soil cultivation [4]-[6].

At present, land management in farmer's level is being done by intensive soil cultivation regardless of environmentally friendly soil cultivation. Farmers were generally grow vegetable in the highland that has steepy slope with bed direction or bed parallel to the slopes. The reason is to facilitate drainage so that water drainage and aeration runs well and does not cause disease. However, with contributing climate condition such as high rainfall and high temperature all year round the use of bed system which is parallel to the slopes may accelerate speed of run off and increased eroded soil.

In order to improve conservation of natural resources and preserve the environment, some research concerning vegetable cultivation method in the highland for controlling erosion have been conducted. Result of the experiment indicated that the greatest erosion on potato cropping area occurred if bed direction is parallel to the slope (vertical) [7]. In tomato cultivation on sloping land, soil cultivation of 20 cm in line with contour line gives no significant difference from full tillage which is parallel to the slopes [8]. Either vegetable yield grown at parallel to the slope or in line with contour line are the same. Furthermore, several other conservation techniques, such as the intercropping system, the use of ground cover crops, and the use of mulch have also benefited greatly in controlling erosion [9]. The closer vegetation of crops and the rest of the plants as mulch will protect the soil surface from the impact of rainfall and can improve the soil physical properties so that the infiltration rate will increase and the soil eroded reduced. Doing soil cultivation as necessary and applying crop rotation with green manure crops is an example among several soil and water conservation techniques [10]. In maize crops, soil cultivation as necessary with the use of mulch can withstand soil erosion [11]. The use of cover crops as mulch also has a positive effect on crop yields and soil fertility [12][13].

Improved management of cropping systems in vegetable communities for erosion control has not been done. Easy, inexpensive and effective conservation techniques to control erosion should continue to be introduced to farmers in an effort to improve the saving of natural resources and maintain the continuity of vegetable farming. Creation of contour beds with the combination of intercropping systems or the most efficient and effective use of mulch should be investigated.

On the basis of the above, it is necessary to do research with the aim to determine the effect of bed directions and conservation techniques on the soil erosion, incidence of *Plasmodiophora brassicae* (club-root) and cabbage yield.

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It is expected to obtain a conservation technique to control erosion in the highlands without reducing crop yield.

II. Materials and Methods

Experiment was conducted in rainy season in the highland at Cibodas village Lembang District. Vegetable was grown at steep land with the sloop of about 30%. Vegetable used is cabbage with plant spacing of 50 cm x 70 cm. Area of plot experiment is about 21 m^2. A split plot design was used with three replicates. As a main plot (P) raised bed direction (parallel to the slope and cut the slope direction or contour line). Sub plot (T) consisted of conservation techniques (mono crop cabbage without mulch, Cabbage intercropped with tomato without mulch, cabbage intercropped with chines cabbage without mulch, mono crop cabbage + organic mulch, mono crop cabbage + plastic mulch). Tomato plants and chines cabbage are grown simultaneously with cabbage plants among cabbage plants in rows. Organic mulch used is the reeds as much as 5 tons/ha. To neutralize the acidity of soil, soil was limed by dolomite lime at a rate of 4 tons/ha.

To neutralize the acidity of the soil, dolomite lime was given at a rate of 4 t / ha. NPK fertilizer is given as much as 1 t / ha as basic fertilizer, while chicken manure is given as much as 20 t / ha. To accommodate eroded soil volume, ditch is made at the end of cabbage field. Basic ditch dialed with gunny sack. Pest and disease control is done based on conditions of the cabbage crop in the field. Variables collected from the field consisted of eroded soil weight, soil chemical properties, nutrient loss, growth and yield of cabbage, percentage of diseases attack. Data collected were analyzed by F test and continued by DMRT Test at five percent level. Variables included initial soil chemical analysis and eroded soil weight, plant growth and yield components, and plant disease attacks were also measured.

III. Results and Discussions

A. *Soil Chemical Properties and Eroded Soil Weight*

From Table 1. It similar trend on cucumber and and chili pepper crops this kind of soil is quite loose and is usually sensitive to erosion [14]-[17]. Looking at some chemical properties, the soil has a very low nutrient content of total N and available P as well as very low soil pH, but the organic-C, C/ N and soil potassium content is sufficient well as very low soil pH, but the organic-C, C/ N and soil potassium content is sufficient.

Table 1. Soil Chemical Properties before experiment

Soil chemical content	Value
Texture	
Sand (%)	25
Silt (%)	27
Clay (%)	48
pH H_2O	4.1
pH $_{KCl}$	3.8
C –organic (%)	2.04
N total (%)	0.19
C/N	11
P_2O_5 (Bray1) (ppm)	10.4
K (oks.) ppm	338
Exch. Al	0.54

Soil chemical content was analyzed in the soil laboratory of Indonesia Research Institute for vegetables.

Eroded soil weight is greatly affected by raised bed (Fig. 1). With an average rainfull of 328,42 mm per month during the experiment (appendix 1) and supported by fairly steep land slope (45-49^0) causing eroded soil in the direction of sloping beds is high and significantly different from beds which is cutting slope (contourbed).

Eroded Soil Weight

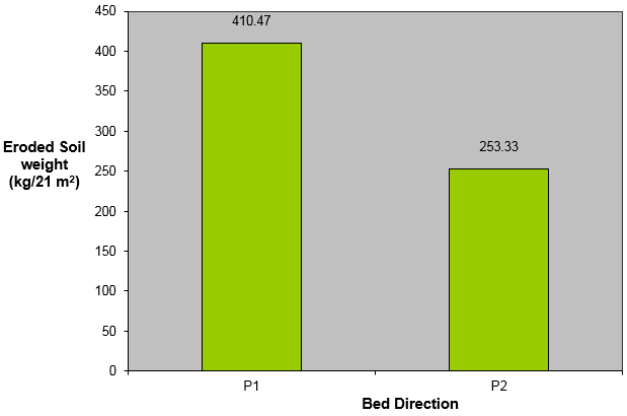

Fig. 1. The amount of eroded soil weight per plot as affected by raised bed direction

P1 = parallel to the slope bed
P2 = contour bed

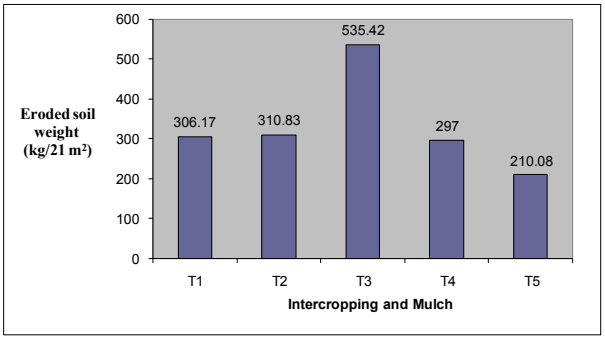

Fig. 2. The Amount of the eroded soil as affected by intercropping and mulches

T_1 = mono-crop cabbage without mulch,
T_2 = cabbage intercropped with tomato,
T_3 = cabbage intercropped with chines cabbage,
T_4 = cabbage with organic mulch,
T_5 = cabbage with plastic mulch

In the direction of the bed slope (P_1), the rate of run-off is probably high so that soil carried by waterways either

soil derived from the bed or from drains or ditches is pretty much. The amount or weight of eroded soil from the treatment is almost double compared with bed treatment that cuts the slope (contour direction). This is due to the beds that cut the slope or contour direction can withstand the rate of run off so that erosion can be controlled. A different results obtained from [9][18], where yield (fresh weight and dry weight) of lettuce, carrot and leek are the same between slope bed and counter line bed direction.

The use of organic mulch and plastic mulch can suppress soil erosion (Fig. 2). From Fig. 2 it appears that the use of silver plastic mulch produces the lowest eroded soil weight of 210.08 kg / 21 m^2, followed by organic mulch of 297 kg / 21 m^2. This is because on both treatments, the use of mulch on the bed is able to protect the soil from the destructive power of rainfall [19][20]. While the intercropping system especially between cabbage and chines cabbage was not able to suppress soil erosion. The possibility of intercropping systems is that the run off rate is not hampered as a result of much of the open ground surface due to the lack of close canopy between the plants so that the aggregation of the soil surface is damaged by the collision of the rainwater and drains of the grains of soil into the water channel. One of the conservation techniques to control erosion is by the use of vegetation [21][22]. The more dense plants that can cover the soil surface, the less erosion will occur. Conversely, if land cover by plants is less then erosion will be difficult to control. While the highest erosion occurred in the treatment of T_3 (intercropping of cabbage and chines cabbage). This is because the chines cabbage plant is not able to survive from high rainfall so it can only grow until the age of two weeks. In the treatment cabbage plants also have small growth and development even smaller than cabbage in the treatment of T_1 (monocrop cabbage without mulch).

B. Nutrients Lost of Eroded Soil

The amount of nutrients on eroded soil and soil in the bed/conservation technique treatments is presented in Table 2.

Results of the analysis show that bed treatment which is parallel to the slope (P_1) tend to have higher nutrient losses (organic-C, total-N, P and K) than treatment which is Cut the slope or contour direction (P_2). This is in line with the amount of eroded soil, where the higher the soil erodes the higher the loss of nutrients carried by erosion. In contrast, nutrient content in the field of raised beds which is parallel to the slope is lower than the field of bed which cut the slope (contour direction). This means that the nutrients lost by erosion can also be related to nutrient residue in the field. From Table 2 shows that the higher nutrients lost by erosion, the lower the nutrient residue in the field.

The mean nutrient losses transported by erosion in the cabbage treatment with intercropping or cabbage and mulch indicated that cabbage treatment and plastic mulch (T5) is the lowest nutrient lost due to erosion (Table 2). This is closely related to the low weight of eroded soil on the treatment. However, from Table 2 it appears that nutrient losses carrying large erosion are inconsistent with the amount of eroded soil for each treatment. This means that the amount of erosion does not guarantee the amount of nutrient loss as well, as seen in T3 treatment. This may be due to soil part eroded is different amount from each treatment, such as soil from the top of the plane or from the drains. This may be due to erosion of eroded soil is different amount for each treatment, such as soil from the top of the plane or from the drains, while nutrient residues that vary in the field if can be caused by nutrients in the field transported by erosion or already absorbed by plants. In the bare soil the highest eroded soil occurs in the bare soil, however the lowest erosion occurs on treatment bench terraces [18]

Table 2. Effect of Bed Directions and Conservation Techniques on Soil Chemical Properties

Treatments	C (%)	N (%)	C/N	P_2O_5 HCl 25%	K_2O HCl 25%	P_2O_5 Bray 1	K_2O Morgan
				mg/100 g		ppm	
Bed direction							
P1	1.59	0.23	7.1	323.7	37.3	23.96	346.28
P2	1.62	0.24	7.1	348.0	37.8	23.68	364.99
Conservation techniques							
T1	1.67	0.23	7.5	347.0	36.5	23.00	332.63
T2	1.62	0.24	7.0	349.8	39.3	23.80	377.03
T3	1.67	0.24	7.3	326.3	36.8	21.83	347.25
T4	1.51	0.22	6.8	302.5	40.0	23.60	377.90
T5	1.57	0.23	7.3	353.8	45.3	26.88	332.53

Note: The data are not statistically analyzed.

C. Growth and Yield of Cabbage

The effect of bed direction on the plant growth and yield of cabbage is presented in Table 3 and Figure 3. Until the age of 57 days after planting, the growth and yield of cabbage plants did not show any significant difference among treatment, although there is a tendency that bed treatment that cut the slope or parallel to the slope or contour direction gave higher growth compared to cabbage grown on the bed parallel to the slope. At the Age of 71 days, different in plant height is significantly appeared between treatment of bed which is parallel to the slope (P_1) and bed which is parallel to contour (P_2), however different from that of growth did not affect on different in yield per plant and per plot. Thus, between beds parallel to slopes and cutting slope does not give any different effect

on the harvest. These results are in line with the previous research results on potato plants [23].

Intercropping treatment and the use of mulch significantly influenced on both growth and yield of cabbage (Table 3 and Figure 4). Table 3 showed that from the age of 29 days up to 71 days, there is different response on growth of cabbage plants between intercropping system, mulch treatments and control. At the age of 29 days, intercropping of cabbage with tomatoes showed no significant difference with cabbage + plastic mulch treatment and both treatments gave the highest growth of cabbage plants. Planting cabbage by using plastic mulch (T5) from early growth shows the most prominent plant height compared to others. At the age of 71 days, the treatment of cabbage + plastic mulch still showed the most prominent treatment in terms of growth response among others, even this has a good impact on high yields (Figure 4). Treatment of intercropping cabbage and chines cabbage indicates the lowest growth which is similar to the growth of monocrop cabbage, without mulch. In line with its growth, yield of cabbage per plant and per plot on cabbage treatment + plastic mulch (T_5) was the highest and significantly different from other treatments (Table 3 and Figure 4). The treatment increases the yield by 200 percent of the control. Plastic mulch applications can reduce nutrient leaching in the rainy season and can improve fertilizer use efficiency [24].

The application of plastic mulch in the rainy season can increase the soil temperature [25][26]. If the temperature of the environment increases then photosynthesis activity increases. The results reported that the growth and yield of plants increased with the use of plastic mulch. Furthermore, the application of plastic mulch in the rainy season can increase the soil temperature [27][28]. If the temperature of the environment increases then photosynthesis activity increases. The results showed that the growth and cabbage yield increased as much as 52% with the use of plastic mulch and as much as 27% with the use of rice straw mulch [28][29].

Table 3. Effect of Conservation Techniques on the Growth of Cabbage and Percentage of Died Plant)

Treatments	Plant Height (cm)				Weight of Cabbage per sample (kg)
	29 dap	43 dap	57 dap	71 dap	
P = Bed direction					
P1 = parallel to the slope bed	9.99 a	13.54 a	15.95 a	17.41 b	1.45 a
P2 = cutting the slope/contour bed	9.54 a	14.31 a	17.31 a	18.83 a	1.46 a
T = conservation technique					
T1 = monocrop cabbage without mulch	8.72 b	12.92 cd	15.12 bc	16.47 b	1.11 b
T2 = cabbage + tomato					
T3 = cabbage + chines cabbage	11.13 a	14.92 ab	17.38 ab	17.70 b	1.18 b
T4 = cabbage + organic mulch	8.42 c	12.33 d	14.60 c	16.37 b	1.14 b
T5 = cabbage + plastic mulch	9.55 b	14.10 bc	16.15 bc	18.08 b	1.53 b
	10.77 a	15.92 a	19.88 a	21.98 a	2.32 a

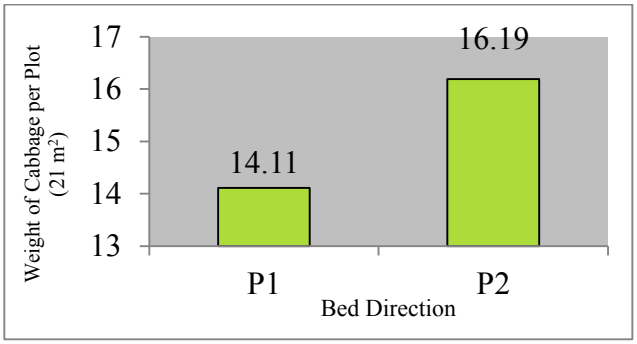

Fig.3. Effect of the raised bed direction on weight of cabbage per plot (21 m^2)

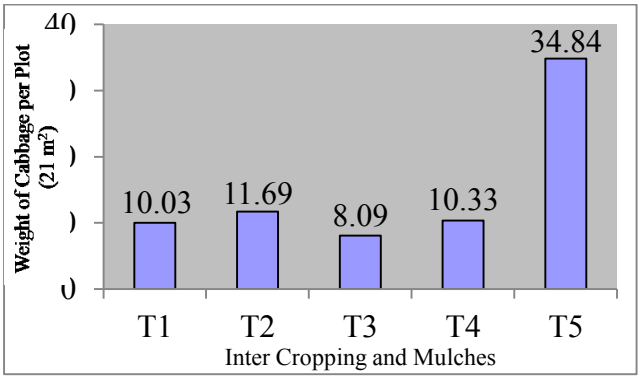

Fig. 4. Effect of Conservation techniques on weight of cabbage per plot (21 m^2)

D. Percentage of Club Root Attack of Cabbage

The disease that attacks the cabbage crop found in this experiment is a club root disease caused by *Plasmodiophora brassicae* fungus. The average of cabbage crops that died attacked by club root disease in the treatment of beds with parallel to the slope is higher than the treatment of beds cutting slopes or contour direction. This suggests that sloping beds or contours are not always positively associated with the high intensity of disease affecting cabbage crops. Cabbage treatment with organic mulch showed the highest mortality of plants due to club root disease. This is probably because organic mulch is easy to decompose to play a role in creating unfavorable environmental conditions for the spread of the disease. Similar results on potato was reported by [30] [31].

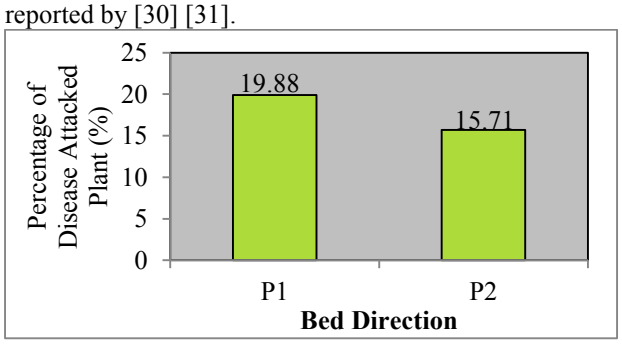

Fig. 5. Effect of the raised bed direction on percentage of disease attacked plant

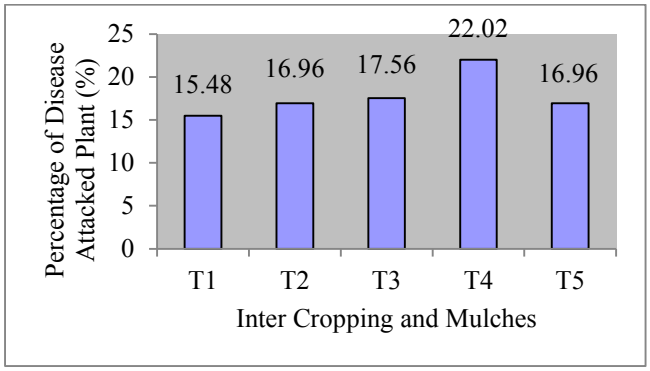

Fig. 6. Effect of conservation techniques on percentage of diseases attacked plant

III. Conclusions

The bed that cut the slope or the beds that are contour direction have a significant effect on suppressing erosion and nutrient loss (organic C, N, P and K) of soil, and produce crops that are not significantly different from contour beds, although growth is higher than sloping beds. Sloping beds or contour slopes tend to show a lower club-root disease than a sloping bed.

The use of plastic mulch on mono-crop cabbage is able to suppress the erosion and loss of soil nutrients (organic C, N, P and K) has significant effect on increasing growth and yield of cabbage. The application of organic mulch increases the incidence of club root disease on cabbage crops.

The results obtained in this study have practical implications for soil and water conservation in cabbage culture. Firstly, it is important to grow cabbage as soon as possible after the plastic mulch is laid in the field. Secondly, sufficient amount of soil should cover the plastic mulch edges to guide water through the holes where cabbages are grown. Because this study was conducted on a relatively mild slope, the benefits of the combined plastic mulch treatment can only be assured in this slope range. For land with steeper slopes, furrow and plastic mulch layouts must be installed at contours and mild slopes to assure these benefits.

Acknowledgment

The Authors thank the Director of Indonesian Center for Horticulture Research and Development, Indonesia for financial support of this study. Special thanks to those people involved in the location of study sites: Deddy Markum, Memed. Thanks also to reviewers of the manuscript and our helpful colleagues at Lembang Bandung, Jakarta and Bogor.

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AUTHORS' PROFILES

Yusdar Hilman was born in Bandung, Indonesia on April 24th, 1956. He hold a Bachelor and master degrees in Plant science at Padjadjaran University in Bandung in 1980 and 1985 respectively. In 2000 he continued his doctoral education at Agricultural University, Malaysia (UPM) and completed in 2003. Short-term education that supports the profession include: Applications of Isotopes and Radiation in Nuclear Energy Agency of Jakarta, vegetable growing at AVRDC Taiwan 1985, vegetable cultivation at IAC the Agricultural University, Wageningen, The Netherlands in 1985-1986, Eco-friendly Agriculture in Kyusei Nature Farming Thailand and UPM Malaysia in 1997 and Participatory Breeding Program between ICHORD and Sakata Seed Corporation Yokohama Japan in 2009. In 2013 the author conducted scientific oration and hold Research Professor in the field of Agronomy. The Author also plays an active role as a resource person and speaker in some seminars, workshops in national and international forums. The structural positions that held include the Director of Indonesian Legume and Tuber Crop Researh Institute (2004-2005), the Director of Indonesian Ornamental Crop Research Institute (2005-2007), and the Director of Indonesian Center for Horticultural Research and Development (2007-2013).

Rini Rosliani was born in Tasikmalaya on April 8, 1964 as the second of five children, from the couple of Daan Jusuf Suradimadja (Alm.) And R. Siti Salamah. The author works as a Researcher in the group of Agronomy Section at the Research Institute for Vegetables (RIV) Lembang-Bandung, West Java since 1992. She graduated from the Agronomy Department, Faculty of Agriculture, Bogor Agricultural University (IPB) in 1991. The author gets a chance to continue her study at Faculty of Graduate School in Master of Science Programs IPB in 2010 which is funded by the Agency for Agricultural Research and Development, Ministry of Agriculture of the Republic of Indonesia. The Author also plays an active role as a resource person and speaker in some seminars, workshops in national and international forums.

Appendix 1. Climatic Data during Experiment di Lembang from September to January 2015/2016)

Climatic Factors	Sept 2016	Oct. 2016	Nop. 2016	Dec. 2016	Jan. 2017
Daily Temperature					
- Average (^{0}C)	19.18	19.74	19.75	19.57	19.04
- Maksimum/Max.(^{0}C)	25.00	24.26	24.43	25.00	23.52
- Minimum/Min. (^{0}C)	14.94	16.03	16.97	15.84	14.71
Rainfall per month (mm)	118.1	452.3	593.3	72.0	406.4
Number of rainy day per month	9	20	20	4	19