International Journal of Advanced and Innovative Research (2278-7844)/

Volume 7 Issue 7

Rainfall Interception of Salak Plants (*Salacca sumatrana* Becc) in North Sumatera Indonesia

Yusriani Nasution[1#], Azwar Rasyidin[#], Yulnafatmawita[#] and Amrizal Saidi[#]

1)Fakulty of Agriculture, Graha Nusantara University. Jl. Dr. Sutomo No. 14 Padangsidimpuan 22 718, North Sumatra. Tel. + 62-634-25292, Fax. + 62-634-28327,

#) Program Studies Agriculture Sciences, Graduate Program, Faculty of Agriculture, Andalas University E-mail: yusrianinasution30@gmail.com, rasyidin.azwar@yahoo.co.id, yulna_fatmawita@yahoo.com, amrizalsaidi@yahoo.com

Abstract- **Salak (*Salacca sumatrana*) is a profitable commodity with low and wide plant canopy that can retain rain and it roots could withstand the *runoff*. The purpose of this study was to determine the canopy interception of salak plant, tree canopy interception have a significant role in reducing the amount of rainfall that reaches the ground beneath the tree. The study has been tasted on the type of mineral soil in East Angkola District North Sumatera with an altitude of 350 - 880 m above sea level. The study period start from October 2016 to March 2017.**

The study was conducted by survey method with the calculation of *interception* based on the measurement of rainfall, *stem flow* and *throughfall.* Result showed that the maisured interception, throughfall and stemflow accounted was 71.96 mm (82.98 %), 15.19 mm (15.62%) and 0.78 mm (0.93%) of cumulative gross rainfall during 1 year. Simple and multiple linear regeresion was used to determine the interception relationship with rainfall, throughfall and stemflow factors. The multiple linear regression relationship between interception with rainfall, thrughfall and stemflow indicate a very strong regression relationship ie interception is strongly impact by three factors. The coefficient of determination (R2 = 0.938) indicate that there is a strong influence of the factors on interception. A very high number of interception of salak plants shows that salak plants can hold rainfall to fell the ground.

Key words : Rainfall Interception, *Salacca sumatrana* and conservation

I. INTRODUCTION

Salak Padangsidimpuan (*Salacca sumatrana* Becc) plant is a pre-eminent plant in southernTapanuli area. However, this plant threatened diverted to other annual crops because it is considered to have a low economic value. However, padangdsidimpuan salak plants have special features compared to other plants because they still produce on steep land [1]. Usually salak farmers in the area of South Tapanuli cultivate salak plants with salak-based agroforestry system, which grows salak plants along with other annual crops at the same time and land. Salak plants are intoleran to full irradiation and thus require shade plants [2].

Salak padangsidimpuan belonging to palm plants. The morphology of this salak plant has a sturdy stem, long and wide stems with fiber roots that have long vertical roots that can grow on the slopes without landslides. The morphology of this plant is very potential in retaining rainwater through interception thereby reducing runoff. Rainfall Interception by heterogeneous vegetation and multi layers cause reduction of the kenetic energy till the dispersion power of soil aggregates reduced. In addition, the effect of interception can reduce the rate of reception on the surface soil because melwati stem flow (stemflow) and canopy headings (troughfall) [3].

The increased power interception of a plant will be able to reduce the flood disaster. Interception is the process when rainwater falls on the surface of the vegetation, above ground level, stuck for a moment and then evaporated back into the atmosphere or absorbed by the vegetation. Rainwater falling on the surface of the vegetation canopy reaches the soil surface through two mechanical processes, namely *throughfall* and *stemflow* [4]. Canopy interception of a plant will affect the high amount of surface flow during rainfall. Runoff can carry sediment as a sediment material and flowed to a lower area and will eventually affect the flow of the river.

Thus, throughfall stemflow and canopy interception loss at salak plant were systematically measured in this study. The main influencing factors on rainfall partitioning were further exflored based on which simple and multiple regression model were developed to predict the partitioned rainfall component. This study aims to determine the quantity of canopy interception loss based on the amount of rainfall in the salak plants so it can be known how much water was retained by the salak plant that can reduce the amount of water flowing on the soil surface. The study also tended to have implication for water and soil conservation as the spreading of salak land in this area is widely planted on slopes land this can reduce the potential of erosion and resist landslide.

II. MATERIALS AND METHODS

A. Site Discription

The study was conducted in the East Angkola district, with a height of 350 - 880 m asl (representing the production center of salak). The study period started from October 2016 to March 2017. Soil type is classified as dystropepts with andesitic rock formations of volcanoes. The area of eastern angkola is 184.86 km lies on 01^o 27' 19" to 01^o 28' 48" N and 99^o 18' 55" to 99^o 04' 00" E. Tropical research location with rainfall every month throughout the year. Mean annual precipitation is 1896 (2016-2017). The topography of the area is sloping and hilly 720 m above sea level. Observations were made on 5 sample plant replications at each site. Location determination based on land unit. Salak plant be elected are 20 years old, start out date 1-30 per month during one year (from Oktober 2016 to September 2017).

B. Collection of gross rainfall

Measurement of gross rainfall employed the equipment gauge of rainfall be assembled around the salak plant [5]. Rain gauges standed in location around the plant exempt from obstacles or shelter. The number of water in the equipment then be devided by wide the section of container. The calculation of rainfall be calculated by formulation as :

$$R = \frac{X}{A} \qquad (1)$$

Where R is the number of rainfall (mm), X (the number of rainfall in the container, m^3) and A (wide of container, mm^2).

C. Collection of throughfall and stemflow

The throughfall (mm) was collected by five container located beneath the salak plants. The provision of gathering waters is as wide as the projection of crown salak plants. Throughfall volume was measured manually righ after the cessation of individual rainfall [6]. The relative throughfall was defined as the ratio between throughfall and rainfall. The throughfall can be calculated using following the equation :

$$TF = \frac{X2}{A} \qquad (2)$$

Where TF is the rainfall get away from the crown (mm). X2 is the number of rainfall collected beneth the plant canopy on the plastic mulch (L). A (The extensive of mulch that contain rainfall (m^2).

The stemflow (mm) [7] was collected using collars constructed from metal plates be assemblade form a circle of the salak stem and a slot with a transfer hose was designed to drain to the stemflow water (Figure 1). The stemflow volume was measured using graduated cylinder after each rainfall event. The number stemflow was derived using the following equation :

$$SF = \frac{X3}{\Pi r^2} \qquad (3)$$

Where SF is the stemflow depth (mm), X3 is the number of the stemflow volume (l) and r is the average ground area occupied by a salak plant. The relative stemflow (SF, %) was defined as the ratio of stemflow with rainfall.

Figure 1. Photograph showing the method of collecting stemflow

The calculation of rainfall interception by salak canopy (I) for each rainfall event can be calculated using the following equation :

$$I = R - (TF + SF) \qquad (4)$$

Where I is rainfall interception (mm), R is the number gross rainfall, TF is Throuhfall (mm) and SF is stemflow (mm). The relative interception loss was defined as the ratio of interception loss to gross rainfall.

D. Statistical Analysis

Interception relationship with rainfall, stemflow and throuhfall can analysis by using regression linear, as well be used to determine correlation coefficient, Interception as depend factor and throughfall, stemflow and rainfall as independent factor. Regresion were performed using the SPSS 16.0 Statistical softwere (SPSS Inc, Chicago USA).

III. RESULT AND DISCUSSION

A. *Conditions meteorogical research area*

The amount of rainfall from October 2016 to September 2017 was in the amount of 444.57 mm whilst the average per month was in the amount of 37.05 mm. Day rain was 121 days for 1 year research. Identification of measurement the wide of salak crown upper was greatly be required to find potentiality the salak plant to hold rainwater with the result that causing interception process. The peak of rainfall was in February and the lowest was July and the amound of rain is very influential on the interception process.

The calculation of rainfall in the study sites is presented in Figure 1 with the two highest peak rainfall in one year ie in October and February. Nearly 60% of the total rainfall occurs from October to February for a year. This case affects the total interception of rainfall of salak plants. March to September the rainfall is decreasing, this occurrence has the potential to increase the potentiality of salak plants to hold rain water in the shape of interception thereby reducing the runoff.

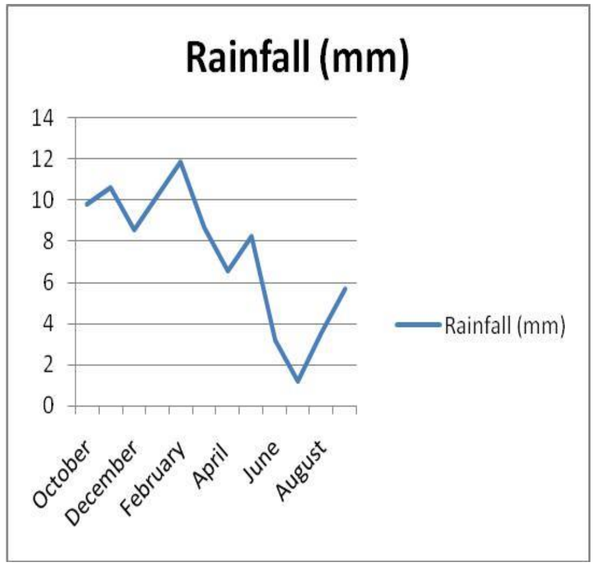

Figure 2. Rainfall for a year

The calculation of rainfall in the study sites is presented in Figure 1 with the two highest peak rainfall in one year ie in October and February. Nearly 60% of the total rainfall occurs from October to February for a year. This case affects the total interception of rainfall of salak plants. March to September the rainfall is decreasing, this occurrence has the potential to increase the potentiality of salak plants to hold rain water in the shape of interception thereby reducing the runoff.

B. Rainfall partitioning in relation to interception characteristic

In this paper plant samples amount 5 plants, average height is 3.75 m, diameter of stem was 95 cm, canopy diameter is 5.5 m and the wide of canopy was 24 m^2. The following Table 1. describes the number of interception of rainwater (%) obtained on the reduction in the number of interception with stemflow and throughfall. Measurements on a rainy day by measuring the water beneath the canopy, flowing in stems and gross rainfall.

Tabel 1. Rainfall partitioning by salak canopy for a year

NO	Month	Rain-fall (mm)	Throughfall		Stemflow		Interception	
			mm	%	mm	%	mm	%
1	Oktober	9.78	1.89	19.34	0.03	0.33	7.85	80.33
2	November	10.59	2.1	19.83	0.04	0.40	8.44	79.76
3	December	8.53	1.4	16.41	0.04	0.46	7.09	83.12
4	January	10.19	1.9	18.64	0.04	0.39	8.25	80.96
5	February	11.85	2.3	19.41	0.35	2.95	9.20	77.64
6	March	8.67	1.50	17.30	0.04	0.46	7.13	82.24
7	April	6.57	0.9	13.69	0.04	0.61	5.63	85.69
8	May	8.2	1.3	12.25	0.04	0.49	6.86	83.66
9	June	3.17	0.4	12.62	0.04	1.26	2.73	86.12
10	July	1.17	0.1	12.62	0.04	1.26	1.03	88.03
11	August	3.56	0.5	12.67	0.04	1.26	3.02	84.83
12	September	5.67	0.9	12.63	0.04	1.26	4.73	83.42
		Average	15.19	15.62	0.78	0.93	71.9	82.98

Figuring Interception of rain in salak plants (table1) is influenced by 3 factors namely rainfall, throughfall and stemfow. The higher the rainfall, the interception of the salak plants is lower and vice versa. February has the highest rainfall during 1 year of observation and affects the number of interception so that in this case the number of interception is the lowest. The month of February has the highest rainfall during 1 year of observation and affects the number of interception with the result that this is the lowest number of interception. The July rainfall is very low it turns out that in this month the salak plants potentially hold interception as much as 88.03%.

The amount of rainfall affects the number of interception in the salak plant. the morphology of salak plants as palm trees has a long leaf stem that is wrapped in the base of midrib so it is very potential in holding rain fall directly to the soil surface. The rain water that befell the salak plants first stuck the crop until it was able to withstand interception with an average of 82.98% of the gross rainfall (table1). The observed on oil palm gauge of interception was influenced by the amount and the intensity of rainfall and the outpouring of the canopy and the flow of stems. Interception per rain event varies from 0.41 to 11.98 mm or 4.11 to 76.18% of the total daily rainfall, which was generally in accordance with previous studies [8].

Rainfall interception in salak plants (Table1) are high when compared with other plants or vegetation as rainfall interception in Lore Lindu National Park precisely in Babahaleka was 36.34% of gross rainfall with a crown capacity of 1.172 mm^2 in [9], pine has a high interception value that was 34.23% of rainfall in [5], interception mahogany plants only amounted to 7.31% of gross rainfall in [10], rubber plant age 25 years have interception value was 51.8% in [11], *Eucalyptus pellitta* was 18.7 % [12] and on coffee for 72.12% of gross rainfall in [13].

The amount of stem flow and throughfall in salak plants is lower than the number of interception (Table 1), this occur because the salak plants can withstand rainwater before falling to the soil surface. Small amounts of rainfall contributed to a lower percent of net rainfall and higher percent of interception loss with previous studies [14]. [15] pointed out the result of comparative studied under different canopy management practices that interception values were higher during small sized GR (Gross Rainfall) events.

In this study the relative average stemflow (0.93%) was lower than throughfall (15.62%) and interception (82.98%), a low value occurs because rain water is retained by many salak plants from leaf, midrib to stem. [16] measured that stemflow was less in amount and frequency for the rough barked *E. nicholii* as compared to the smooth barked *E. saligna*. Measurement of interception in the semi-mature forest [17] resulted in comparison of relative numbers of throughfall, stemflow and interception as follows 71.0%, 1.7% and 27.3%. Generally the amount of stemflow be effected by the type of plant withstand the rain falling.

Measurement of through stages along with stemflow during rainy days (Table1) has an increased throughfall with increasing gross rainfall. [18] pointed out that the amount of rainfall was recognized as the most influential variable, followed by rainfall intensity and the number of raindrops. The other factors in addition to the rain did not have substantial influence on the through fall of the same case examined by [19] that canopy openness did not appear to be the main factor that affected the amount of throughfall and stemflow.

Figuring from thoughfall and stemflow (Figure3) indicate the proportion of amount each one observation. The relative amount of throughfall and stemflow is calculated from the amount of gross rainfall.

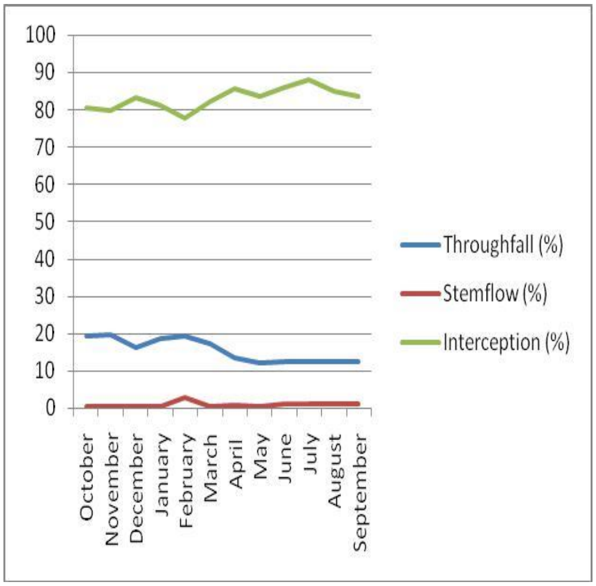

Figure 3 Number of interception, throughfall and stemflow in salak plants

The amount of water interception (Figure3) is greatly upper around 75-88% of gross rainfall. The loss of water from the interception process in salak plants is really significant in reducing runoff rate at the soil surface. The vegetation coverage of 40% would help protect soil from splash erosion. nce, but rose with increasing rainfall intensity [20].

C. *Simple Regresion Analysis*

Statistical analysis of regression used to determine interception relationship with throughfall (Figure 4.a) showed negative correlation with determination coefficient 75.70% and signifant on test of F 0.05. Similar conditions (Figure 4.c) the regression relationship between interception and rainfall showed a negative correlation with the coefficient of determination of 86.90%. A slight difference in the interception relationship with stemflow resulted in a negative but not significant correlation in the F test (Figure 4.b).

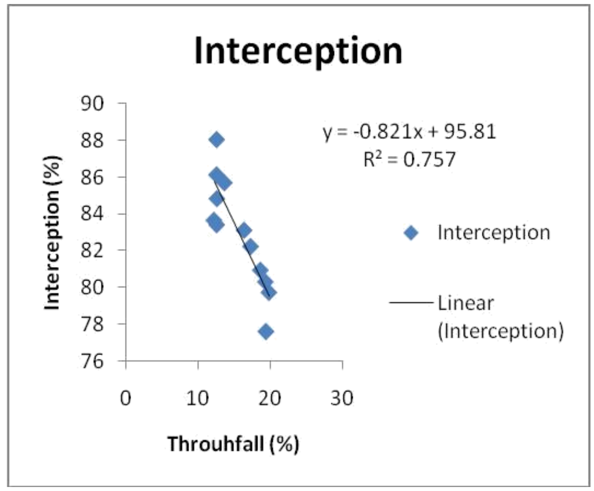

Figure 4.a Relationship between interception with trhoughfall

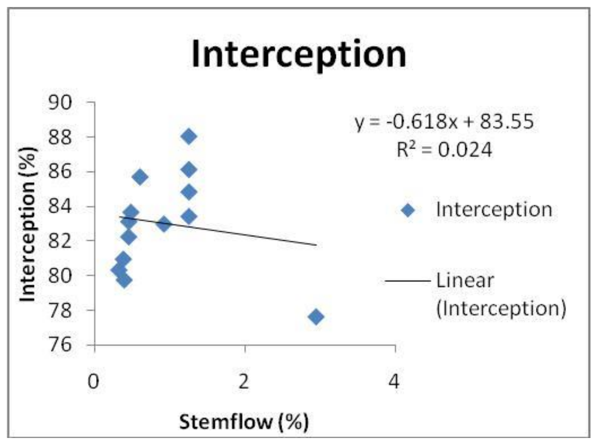

Figure 4.b Relationship between interception with stemflow

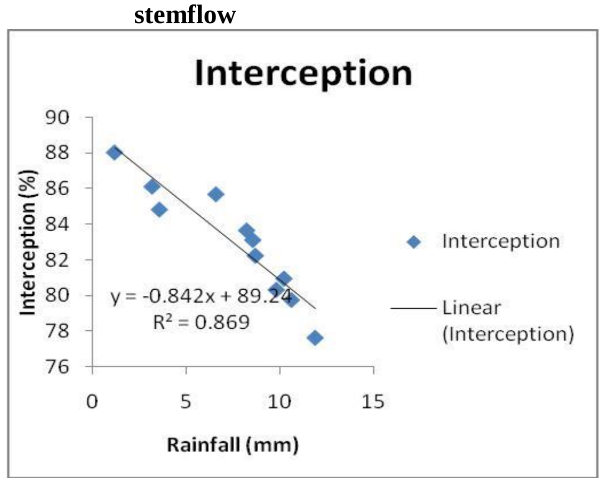

Figure 4.c Relationship between interception with rainfall

The calculation of the rainfall interception in salak plants is obtained by subtracting the gross rainfall with throughfall and stemflow for a year. The relative calculations of interception and throughfall are based on the gross rainfall was analyzed by simple regression to obtain correlation of both factors (figure 4.a). The coeficient of determination of the regresion equation (R^2=0.757) shows that the independent factor (throughfall) influence the intercept (depended factor) with a value of 75.7%. Results of analysis with similar cases [21] an alternative management model based on canopy area and gross precipitation predicted effective precipitation with similar accuracy (R^2 = 0.741, P <0.0001).

The relative calculations of interception and stemflow are based on the gross rainfall was analyzed by simple regression to obtain correlation of both factors (figure 4.b). The result of interception factor regression analysis with stemflow factor resulted in low coeficient determination value (R2 = 0.024). This shows that the relationship between the two factors has a low effect. Stem diameter are the most influential factors for the stemflow amount [22].

The interception relationship with gross rainfall has a close relationship because the higher the rainfall the lower the interception (R2=0.869). Coefficient determination of gross rainfall with interception indicated a close relationship however have possession of a negative correlation. This indicates that considering the variation in annual rainfall is critical for assessing the difference in rainfall interception amounts induced by forest properties [23].

E. *Multple Regresion Analysis*

The regression relationship between interception with rainfall, thrughfall and stemflow (Table 2) exhibit that exist a very strong regression relationship ie interception is strongly impact by three factors. The coefficient of determination (R2 = 0.938) indicate that there is a strong influence of the three factors on interception.

Table 2. Regression relationship Interception with rainfall, throughfall anf stemflow

Regresion	r	R^2	Anova
Y= 92.747 - 0.620 (rf) - 0.898 (sf) – 0.281 (sf)	0.968	0.938	Significant

The interception factor relationship (dependent) with all other factors as well as rainfall, throughfall and stemflow (independent) possess a close relationship with negative correlation namely if the value of all independent factors increases then the value of interception is decreased. All the factors simultaneously affect the number of interception in the salak plants (Table2).

Interception is influenced by several factors, including the type of plant that withstand the rain falling to the surface the wider the crown of the plant the more water can be retained. The complexity of the interception process and tree characteristics may be more important in controlling interception than rainfall characteristics in [24]. The percentage value of the interception is inversely proportional to the percentage value of the rainfall that becomes surface runoff. The greater the value of the percentage of interception results in a smaller percentage of surface runoff [25].

Vegetation includes factors that affect the interception of salak plants. canopy shape and broad can prevent rain on the soil surface. Vegetation affects the soil water input process by altering the canopy rainfall interception, hydraulic lift, and soil organic matter content and so on [26]. [27] found that a positive correlation between vegetation cover and rainfall could decrease with increased interception. Permanent land cover such as grasslands and forests can protect the soil from rain splashes and erosion. Having a high surface vegetation cover was the most important factors in reducing soil erosion in [28]. Average canopy interception was dependent both on altitude and vegetation type, due to different tree architecture and leaf shape [29].

E. Implications for water and soil conservation

The results of the study indicate that rainfall in the salak (82.98%) could prevent rain fall directly to the soil surface. the lower the rainfall conduced in increased interception. Interception in plants constitute process of water retention into runoff so as water into the soil through infiltration. Vegetation restoration plays a key role in controlling soil erosion [30]. Rainfall is one of the factors of erosion, when rainfall is low then the potential for erosion is as well low [31].

Interception value indicates the amount of water that has the potential to be evaporated into the atmosphere. The gross rainfall that touches the ground floor will seep into the soil and become a source for increasing the amount of ground water. The magnitude of the rain interseption of a vegetation is also affected by the age of vegetation stands. In its development, certain parts will experience growth and development. The growth of the vegetation parts having an influence on the magnitude of the interception is the development of density of canopies, stems and branching of vegetation [32]. The larger the crown density the more rainwater that can be retained temporarily evaporated back into the atmosphere.

This study indicate that the interception of rain in salak plants is influenced by rainfall, throughfall, stemflow and also plant characteristics. The results of multiple regression analysis describe that in the coincide Padangsidimpuan salak plants have different morphology with other types of salak, salak is longer and wide and the stems are large and sturdy so as to hold the fall of rain water to the soil surface, there are 3 factors influencing the number of interception (R2 = 0.938) in Table 2. Padangsidimpuan salak plants have different morphology with other types of salak,salak is longer and wide and the stems are large and sturdy so as to hold the fall of rain water to the soil surface therefore vegetation coverage was the primary factor controlling soil erosion. Having a high surface vegetation cover was the most important factors in reducing soil erosion [28].

The salak Padangsidimpuan belongs to the palm plant has a wide roots and deep penetration, the leaves of long and wide leaves greatly affect the amount of interception of rainfall in this plant. The number of intercept of a plant greatly influences the hydrologic cycle and the inundation of water in the soil. [33] found that forests reduce stream sedimentation from landslides by enhancing slope stability with roots and protect water quality by minimizing stream temperature fluctuation, regulating nutrient.

Generally Tapanuli south communities cultivate salak plants with agroforestry system in [1]. The advantage of agroforestry system is to preserve the environment and improve the welfare of the community. This system is a cultivation technique with land cover as an effort to protect the soil from runoff and erosion. Rainwater is retained by vegetation by interception resulting in rainwater entering the soil by infiltration process. The ground cover is an important factor in controlling soil and water loss and vegetation measures with high ground cover should be strongly recommended for soil erosion control.

IV. CONCLUSIONS

As presented in this work, seasonal gross rainfall was partitioned by salak canopy as follows 82.98% canopy interception 15.62 % throughfall and 0.93% stemfow. Measurement of through stages along with stemflow during rainy days has an increased throughfall with increasing gross rainfall. The amount of water interception is greatly upper around 75-88% of gross rainfall. The loss of water from the interception process in salak plants is really significant in reducing runoff rate at the soil surface. The results of multiple regression analysis describe that in the coincide Padangsidimpuan salak plants have different morphology with other types of salak, salak is longer and wide and the stems are large and sturdy so as to hold the fall of rain water to the soil surface. The number of intercept of a plant greatly influences the hydrologic cycle and the inundation of water in the soil. The ground cover is an important factor in controlling soil and water loss.

ACKNOWLEDGEMENT

We are thankful to Directorate of Community Service Research (DRPM) Ministry of Research and Technology of Advanced Education Republic of Indonesia was supported this study. We also thank the editor and an anonymous reviewer for their constructive comment on the manuscrip.

REFERENCES

[1] Nasution Y., A Rasyidin., Yulnafatmawita and A Saidi. 2017. Root length density Relation of salak padangsidimpuan plant with land effective depth in west Angkola district. LPPM Journal. Graha Nusantara University. Volume 8 No. 2. Desember 2017. p-ISSN 2087-3131. eISSN 2541-5522.Pages 44-48.

[2] Siregar. I., A Rauf and Rahmawaty., 2013. Classification of salak-based agroforestry system in South Tapanuli district. Journal of agricultural science. Kultivar. Volume 7. No.1. ISSN 1979-9721. Pages 1-51.

[3] Noordwijk. Mv., F Agus., K Hairiah., G Pasha., B Verbist and Farida. 2004. Role Agroforestry in MaintainingWatersheedHydrologycal Functions. Functions Agrivita Vol 26.1 March 2004 Bogor. Pages 1-8.

[4] Asdac. C. 2007. Hydrology and watersheed management. Gajah Mada University. Yogyakarta.

[5] Chairani and D Jayanti. 2013. Rainfall interception on Pine Tree Stands. Agricultural techniques. Vol. 6 No.1 April 2013.1- 8.

[6] Tanaka. N., Levia D., Igarashi Y., Nanko K., Yoshifuji N., Tanaka K., Tantasirin C., Suzuki M., Kumagai TO. 2015. Throughfall under a teak plantation in Thailand: a multifactorial analysis on the effect of canopy phenology and meteorological conditions. Int. J Biometeorol. 50 (9). 1145-1150.

[7] Dinata. RJ. 2007. Interception on various Classes of Age of Rubber Stands (Hevea brasiliensis) [Thesis]. Ministry ofForestry. Faculty of Agriculture. University of Northern Sumatra. Medan.

[8] Ridwan. BM. 2009**.** Aplication of gash model forrainfall interception estimation on palm oil plantation (case study inrejosari PTPN VII Lampung. Soil Science Agriculture Institute of Bogor. 2009.70 pages.

[9] Rauf. A., H Pawitan., T June., C Kusmana and G Gravenhorst. 2009. Rainfall Interception Effects on Energy and Mass Transfer in Tropical Raiforest"Case Study in Lore Lindu National Park. J. Agroland 15 (3) : 166 - 174, September 2008. ISSN : 0854 – 641X.

[10] Mechram. S., S Chairani and A Zaki. 2012. Comparison of Interception Value of MahoganyTree (Swietania mahagoni)and Pine Tree (Casuarina cunninghamia). Rona Teknik pertanian Journal. ISSN 2085-2614.

[11] Slamet. B., AS Thoha and RJ Dinata. 2012. (Hydrological Function of Rubber Plantation(Hevea brasiliensis Muell. Arg) to Reducing the Magnitude of Net Rainfall. FORESTA Indonesian Journal of Forestry 1 (2) 2012: 49-57 ISSN: 2089-9890.

[12] Supangat**.** AB., P Sudira., H Supriyo and E Poedjirahaju. 2012. Study of rainfall interception at *Eucalyptus pellita* Plantation forest in Riau. Agritech Vol 32. No.3 Agustus 2012.

[13] Basri. H., Manfarizah and A Salasa. 2012. Rainfall interception in the peoples coffee in the Kebet village Bebesen district central Aceh regency. Floratek Journal. Volume 7 No.1. 2012. ISSN 1907-2686. Agriculture Faculty. Syiah Kuala University.

[14] Zhang. YF., XP Wang., R Hu., YX Pan and M Paradeloc. 2015**.** Rainfall partitioning into throughfall, stemflow and interception loss by two xerophytic shrubs within a rain-fed re-vegetated desert ecosystem, northwestern China. Journal of Hydrology. Vol 527. August 2015. Pages 1084-1095.

[15] Kaushal R., A Kumar., NM Alam., D Mandal., J Jayaparkash., JMS Tomar., S Patra., AK Gupta., H. Mehta., P Panwar., OP Chaturvedi and PK MIshra. 2017. Effect of different canopy management practices on rainfall partitioning in *Morus alba.* Ecologycal Engineering. Vol. 102. May 2017, Pages 374-380.

[16] Livesley S.J., B Baudinette and D Glover. 2014. Rainfall interception and stem flow by eucalypt street trees – The impacts of canopy density and bark type. Journal urban forestry and urban greening. Vol. 13. 2014, Pages 192-197.

[17] Ghimire C.P., LA Bruijnzeel., MW Libezynsky., M Ravelona., BM Zwartendijk and HJV Meerveld. 2017. Measurement and modeling of rainfall interception by two differently aged secondary forests in upland eastern Madagascar. Journal of Hydrology. Vol. 545. 2017, Pages 212-225.

[18] Zabret K., J Rakovec and M Sraj. 2018. Influence of meteorological variables on rainfall partitioning for deciduous and coniferous tree species in urban area. Journal of Hydrology. Vol. 558. March 2018. Pages 29-41.

[19] Limin SG., H Oue., Y Sato., IW Budiasa and BI Setiawam. 2015. Partitioning Rainfall into Throughfall, Stemflow, and Interception Loss in Clove (*Syzygium Aromaticum*) Plantation in Upstream Saba River Basin, Bali. Procedia Environmental Sciences. Vol. 28. 2015, Pages 280-285.

[20] Yao JJ., JH Cheng., ZD Zhou., L Sun and HJ Zhang. 2018. Effects of herbaceous vegetation coverage and rainfall intensity on splash characteristics in northern China. Catena. Vol.167. August 2018, Pages 411-421.

[21] Stringham TK., KA Snyder., DK Snyder., SS Lossing., CA Carr and BJ Stringham. 2018. Rainfall Interception by Singleleaf Piñon and Utah Juniper: Implications for Stand-Level Effective Precipitation. Rangeland Ecology and Management. Volume 71 Issue 3. May 2018, Pages 327-335.

[22] Zhang YF., XP Wang., R Hu and YX Pan. 2017. Stemflow volume per unit rainfall as a good variable to determine the relationship between stemflow amount and morphological metrics of shrubs. Journal of Arid Environments. Volume 141. June 2017, Pages 1-6.

[23] Komatsu H., Y Shinohara., T Kume and K Otsuki. 2008. Relationship between annualrainfall and interception ratio forforests across Japan. Journal Forestcology and Management. Volume 256. 20 August 2008, Pages 1189-1197.

[24] Li X., Q Xiao., J Niu., S Dymond., NS Dorn., X Yu., B Xie., X Lv., K Zhang and J Li. 2016. Process-based rainfall interception by small trees in Northern China: The effect of rainfall traits and crown structure characteristics. Agricultural and forest Meteorology. Volume 218-219. 5 March 2016, Pages 65-73.

[25] Khafidz S., M Soeprapto and S Susilowati. 2013. Influence of rainfall interception Avocad (Persea Americana) on suface runoff. Matriks teknik sipil Journal. Vol.1 No.1. eISSN 2354-8630.

[26] Yu XN., TM Huang., EG Li., XY Li and WH Guo. 2018. Effects of rainfall and vegetation to soil water input and output processes in the Mu Us Sandy Land, northwest China. Catena. Volume 161. February 2018, Pages 96-103.

[27] Zhang DH., XR Li., F Zhang., ZS Zhang and YL Chen. 2016. Effects of rainfall intensity and intermittency on woody vegetation cover and deep soil moisture in dryland ecosystems. Journal of Hydrology. Volume 543. December 2016, Pages 270-282.

[28] Wang ZJ., JY Jiao., S Rayburge., QL Wang and Y Su. 2016. Soil erosion resistance of “Grain for Green” vegetation types under extreme rainfall conditions on the Loess Plateau, China. Catena. Volume 141. June 2016, Pages 109-116.

[29] Prada S., MM Sequiera., C Figueira and MO Silva. 2009. Fog precipitation and rainfall interception in the natural forests of Madeira Island (Portugal). Agricultural and Forest Meteorology. Volume 149. 15 June 2009, Pages 1179-1187.

[30] Chen H., X Zhang., M Abla., D Lu., R Yan., Q Ren., Z Ren., Y Yang., W Zhao., P Lin., B Liu and X Yang. 2018. Effects of vegetation and rainfall types on surface runoff and soil erosion on steep slopes on the Loess Plateau, China. Catena.Volume 170. November 2018, Pages 141–149.

[31] Gu ZJ., XX Wu., XL Wang., SY Peng., H Luo., XZ Shi and DS Yu. 2013. Using live vegetation volume to analyze the effects of plot *Pinus massoniana* Lamb on water and soil conservation under natural rainfall events. International Journal of Sediment Research. Volume 28. December 2013, Pages 579-587.

[32] Heryansah EL. 2008. Rainfall interception in plant forest Agathis loranthifolia Sal.in the Hulu Sukabumi watershed.Geophysical department and meteorology faculty of math and science Bogor agricultural institute.

[33] Hight. MJ., JS. Rawat and SK. Bartarya. 1988. Environmentalcorrelationsoflandslide frequency along new highways in the Himalaya: Preliminary results. Catena. Volume 15. December 1988. Pages 539-553.