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Research Article

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The analysis infiltration Horton models around the Sago Baruk palm (*Arenga microcarpha* Becc) for sustainable land use

Marianus

Department of Physic Education, Faculty of Mathematics and Science, Manado State University. Indonesia
*Corresponding author: *marianus04@yahoo.co.id*

Abstract

Infiltration is one components of the hydrolocal cycle and very important in conservation of soil and water also contribute to sustainable land use. Sago baruk palm (*Arenga microcarpha* Becc) is an endemic plant and used as a source of local food to the citizen in Sangihe Island. This plant also known by locally people as plants to protect soil and water availability. The aim of this research was to analyze the rate of infiltration and gain empirical equation models infiltration capacity around sago baruk plants in different seasons and different altitude. The research was conducted at the Gunung village, District of Central Tabukan Sangihe in June to September 2016. Gunung village is spread from the coast to the top of the hill with an altitude of ±600 meters above sea level. Land used is mixed gardens, coconut, cloves nutmeg and Sago. Tools or material used are; a set of double ring infiltrometer, soil tester, GPS, clinometer and Stopwatch. The method used is survey methods, and techniques of data analysis is descriptive analysis, t-test, and F(ANOVA)-test. The results of this research showed that the infiltration rate near a cluster of Baruk sago is higher than the outside cluster in the second season, the infiltration rate is higher in the dry season than the wet season. The result Obtained by the model equations infiltration and the constant infiltration capacity around baruk sago plant in accordance with the model standard proposed by Horton and sago baruk plants very suitable for soil and water conservation.

Keywords: Horton model Infiltration, conservation, Sago Baruk and sustainable land use.

Introduction

Sagu baruk palm is the source of staple food for 88.33% population in Sangihe Island (Dinas Pertanian, Perkebunan, Peternakan dan Kehutanan, Kabupaten Kepulauan Sangihe, 1980). According to Barri and Allorerung(2001), the production of sagu baruk palm stem is around 13-15 kg/stem, while according to (Dinas Pertanian Rakyat Propinsi Dati I Sulut, 1980) it may reach 25-30kg/stem. Sagu flour can be used either directly as food or processed in industry such as the ingredient of cakes, noodles (Rostiwati, 1988), and artificial syrup (Balai Riset dan Standardisasi Industri Manado, 2006). Moreover, sagu flour can also be used as raw material for manufacturing biodegradable plastic, ethanol and other biofuel industries (Samad, 2002). Sagu baruk stems are strong enough to be used as construction material (concrete reinforcement material) and potential to be developed as furniture. Sagu waste residue can be used as animal feed and potential for cultivating mushrooms. The ability of plant roots to distribute rain water causes other crops to survive during the dry season. Infiltration capacity correlated with soil physical character, positively correlated to the porosity of the soil and organic matter content, while the content of clay and weight content of the soil negatively correlated (Gliessman, 2000). Rainfall and water content affect infiltration capacity.

Raindrops tend to damage the structure of the soil surface, the fine materials from the surface can be washed into the cavities of the soil, clogging pores, thereby reducing the rate of infiltration (Araghi,et all,2010). Vegetated lands generally absorb more water due to organic matter and micro-organisms and plant roots tend to increase soil porosity and stabilize soil structure (Garg, 1979).

Sagu baruk palm is not only used as a source of carbohydrates but it is also valuable for reforestation program (Mahmud and Amrisal, 1991; Samad, 2002). Sagu plant shows highly resistant to the drought. In the long dry season which other crops usually do not survive, the palm still can grow and productize. Sagu baruk palm can grow naturally to form 5 to 6 seedlings every month (personal Communication with sagu baruk farmers, 2016). In cultivating the plant, farmers do not particularly apply a special treatment but just cleaning when they cut down sagu trees from the cluster. Its economic value is one of the advantages of sagu baruk palm. Its ability which holds and distributes water into the soil as well as the ability to grow on dry land is highly reliable potential for utilizing sagu palms as superior carbohydrate plants(Marianus,2012).

The purpose of this study were to analyze the rate of infiltration and gain empirical equation models infiltration capacity around sago baruk plants in different seasons and different altitude.

Materials and Methods

The research was conducted from June to September 2016 at Gunung Village, Tabukan Tengah, Sangihe Island District. The materials of the experiments from mixed farm land with an altitude of ± 600 m above sea level. The tools used for this experiment were GPS, clinometers, set of double ring infiltrometer and stop watch. The altitude in this research was divided into 3 levels, namely high altitude (400-600 m), the medium altitude (200-400 m), and the low altitude (0-200 m) based on the type and soil physical properties. The method of this research was a survey with a purposive sampling method (Surybrata, 1983). Data analysis techniques included descriptive analysis, T test and F test (ANOVA) using SPSS 16.00.

The Infiltration rates near the cluster (<0.5 m) and outside the cluster (2.5 m) were calculated using Horton equation model of $f\ t = fc + (fo - fc)\ e^{-kt}$ where; ft = infiltration capacity at time t, fc = infiltration capacity when the price reaches a constant value; fo = the value of the initial infiltration capacity (at t = 0); k = a constant that varies according to soil conditions and the factors that determine the infiltration; t = time; and e = 2.71828 (Seyhan, 1977; Garg, 1979).

The rate of infiltration and infiltration constant were obtained using descriptive analysis, which is a table the average value of the infiltration rate and infiltration constant based on season and altitude position. T test at Sig t <0.05 (level of error 5%) was performed to compare values observed in the rainy and dry seasons. Differences in infiltration rates and infiltration constants of the three altitudes (508 m, 330 m and 44 m) were tested using F test or ANOVA at Sig F <0.05 (level of error 5%).

Results and Discussion

Horton formula models around Sagu baruk palm

Model equations and the constant infiltration capacity at around baruk sago palms in various soil conditions obtained from the measurement data and calculation of the rate of infiltration. Infiltration capacity equation form as a function of time from the model developed by Horton are:

f t = fc + (fo - fc) e-kt

where:

ft = infiltration capacity at time t,
fc = infiltration capacity when the value reaches a constant .
fo = the value of the initial infiltration capacity (at t = 0)
k = a constant that varies according to soil conditions and the factors that determine the infiltration.
t = time (Seyhan, 1977; Kumar 1979)
e = 2.71828 (the base of natural logarithms)

The results of the equation is as follows ....

Infiltration equations near the cluster of the rainy season:

Ft = 0.01 + 6.20 e-0, 463 t

Infiltration equation out cluster of the rainy season:

Ft = 0.01 + 1.72 e -0.197 t

Infiltration equation near the cluster of dry season:

Ft = 2.23 ++128.45 e-0, 251 t

Infiltration equations outside the cluster during the dry season:

$$ft = 1.24 + 11.06\ e - 11.06\ t$$

The infiltration capacity curve during the rainy season as shown at figure. 1 below

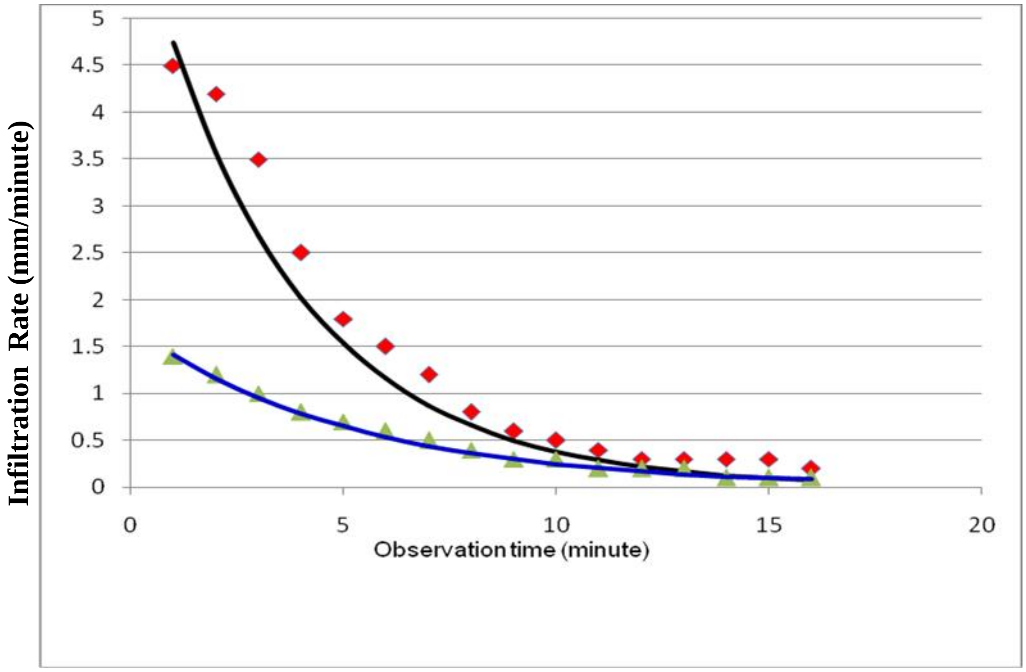

Figure 1.Infiltrationcapacity curve during the rainy season

The infiltration capacity curve during the dry season as shown at figure .2 below

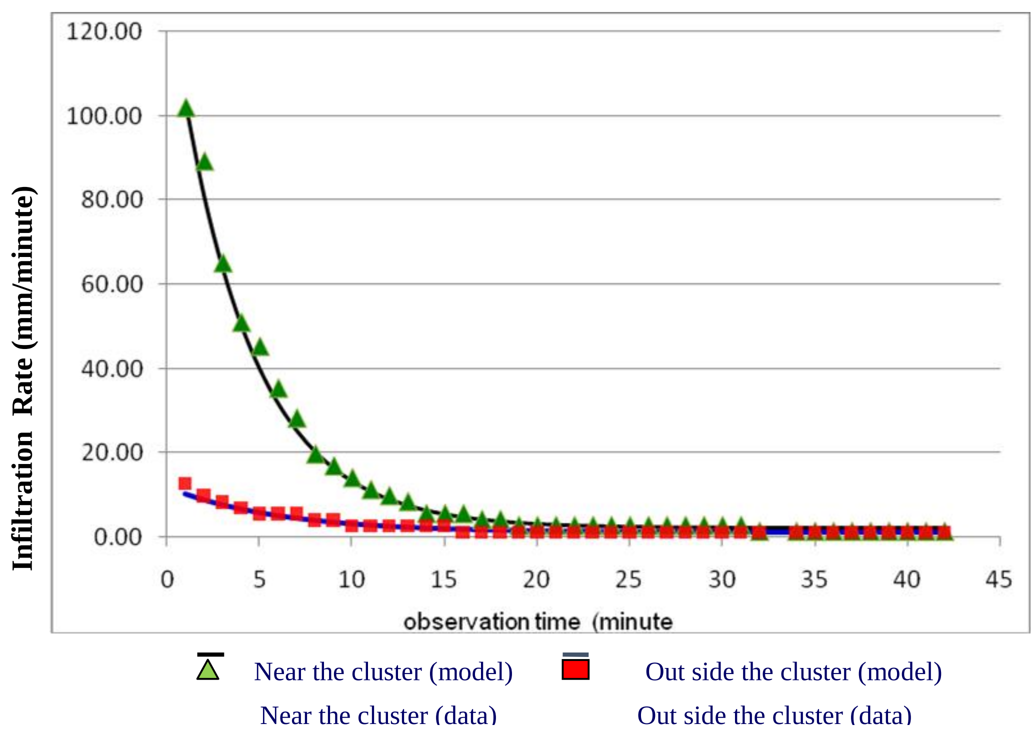

Figure 2. Infiltration capacity curve in the dry season

Next the initial infiltration rate is presented comparison, the final infiltration rate, the average infiltration rate, and the constant infiltration in both seasons (dry and wet), and three height positions (top, 508 meters above sea level, the center, 330 meters above sea level, and below 44 meters above sea level), under conditions close to and outside the cluster. Analysis tools used in the observation of the physical condition of the environment around the plant sago baruk are (1) descriptive statistics, (2) t test, and (3) ANOVA test (Suryabrata, 1983).

In the data presented and the calculation of the rate of infiltration, and the constant infiltration capacity, divided into two seasons, namely dry and rain. There are four variables that were observed in the data measurement and the calculation is the initial infiltration rate (fo), the final infiltration rate (fc), the average infiltration rate (f), and the constant infiltration (k) in both conditions (near the cluster of <0.5 m, and outside the cluster 2.5 m. These variables are presented comparative value of each season:

Table 1.Comparison between the infiltration rate of Season

Variable	Dry season	Rainy season	Sig t	Remarks
fo near cluster	130.68	6.21	0.001	Significan
fo out cluster	12.30	1.73	0.001	Significan
fc near cluster	2.23	0.01	0.001	Significan
fc out cluster	1.24	0.01	0.001	Significan
f near cluster	102.90	51.19	0.001	Significan
f out cluster	11.97	6.44	0.001	Significan
K near cluster	0.251	0.463	0.002	Significan
K out cluster	0.166	0.197	0.001	Significan

Remarks: fo: initial infiltration rate; fc: the final infiltration rate; f: the average infiltration rate; K: constant infiltration

1. Analysis of the results of the dry season

In this study, the study site is divided into three positions. First, the top position with a height of 508 meters above sea level. Second, the center position with a height of 330 meters above sea level. Third, the down position with a height of 44 meters above sea level. There are four variables that were observed in the data measurement and the calculation is the initial infiltration rate (fo), the final infiltration rate (fc), the average infiltration rate (f), and the constant infiltration (k) in both conditions (near the clump of <0.5 m, and outside the clumps 2.5 m. These variables are presented comparative value of each position in the dry season:

Table 2. Comparison between the position of the infiltration rate of the dry season

Variable	Position			Anova Result	
	Hight	Midle	Low	Sig F	Description
fo near cluster	130.51	130.52	131.02	0.017	Significan
fo out cluster	12.27	12.36	12.26	0.512	Notsignifican
fc near cluster	2.20	2.24	2.24	0.039	Significan
fc out cluster	1.24	1.24	1.24	0.412	Notsignifican
f near cluster	102.57	103.49	102.63	0.242	Notsignifican
f out cluster	11.96	11.91	12.03	0.964	Notsignifican
k near cluster	0.245	0.245	0.264	0.022	Significan
k out cluster	0.168	0.165	0.164	0.062	Significan

Remarks: fo: initial infiltration rate; fc: the final infiltration rate; f: the average infiltration rate K: constant infiltration

From the above results in the dry season, seen a difference in the initial infiltration rate, the final infiltration rate, and significant infiltration konsntantan between the three positions. Position the top with a height of 508 meters above sea level is characterized by initial infiltration rate is lower, the rate of infiltration of the lower end, and a constant infiltration low position with a height of 330 meters above sea level was characterized by high initial infiltration rate, infiltration rate of the high, and constant infiltration is low. In the low position with a height of 44 meters above sea level is characterized by high initial infiltration rate, and constant infiltration is low.

2. Analysis of the results of the rainy season

Table 3.Comparison of infiltration rates between the position of the Rainy Season

Variable	Position			Anova Result	
	Hight	Midlle	Low	Sig F	Description
fo near cluster	6.15	6.13	6.35	0.004	Signifikan
fo out cluster	1.74	1.71	1.73	0.008	Signifikan
fc near cluster	0.0100	0.0042	0.0043	0.022	Signifikan
fc out cluster	0.0077	0.0080	0.0077	1.000	Notsignifikan
f near cluster	55.21	49.54	48.83	0.001	Signifikan
f out cluster	7.08	6.72	5.52	0.001	Signifikan
f near cluster	0.2827	0.2832	0.8233	0.001	Signifikan
f out cluster	0.1975	0.1970	0.1963	0.010	Signifikan

Remarks: fo: initial infiltration rate; fc: the final infiltration rate; f: the average infiltration rate
K: constant infiltration

From the above results in the rainy season, see the difference in the initial infiltration rate, the final infiltration rate, the overall infiltration rate and infiltration consntant significant between the three positions. Position the top with a height of 508 meters above sea level is characterized by initial infiltration rate (near the cluster) is, the final infiltration rate (outside the cluster) is high, the final infiltration rate (near the cluster) is high, the overall infiltration rate (near and outside the cluster) is high, consntant infiltration (near the cluster) is low, and constant infiltration (outside the cluster) is high. Middle position with a height of 330 meters above sea level is characterized by initial infiltration rate of speed (near and outside the cluster) is low, the final infiltration rate (near the cluster) is low, the overall infiltration rate (near and out the cluster) was, consntant infiltration (near and out the cluster) . Low position with a height of 44 meters above sea level is characterized by initial infiltration rate (near cluster) is high, the final infiltration rate (outside cluster) is low, the final infiltration rate (near cluster) was, overall infiltration rate (near and outside the cluster) is low , consntant infiltration (near cluster) is high, and consntant infiltration (outside the cluster) is low.

Conclusion

The results of this research showed that the infiltration rate near a cluster of Baruk sago is higher than the outside cluster in the second season, the infiltration rate is higher in the dry season than the wet season. The result Obtained by the model equations infiltration and the constant infiltration capacity around baruk sago plant in accordance with the model standard proposed by Horton and sago baruk plants very suitable for soil and water conservation, thus contributes to sustainable land use.

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