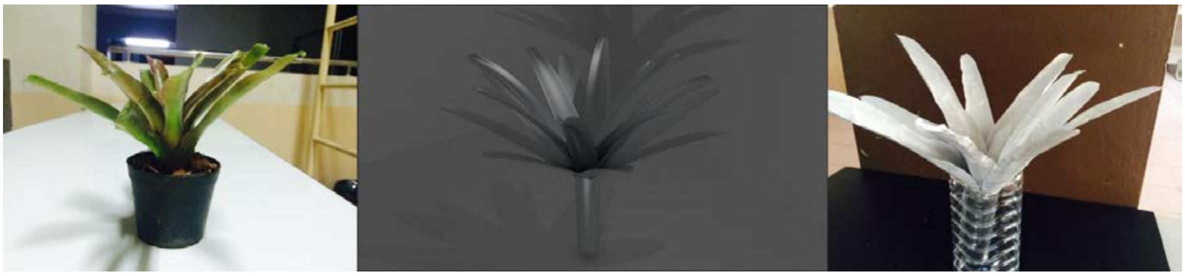
Entry to the Stockholm Junior Water Price (2016)

Natural Innovative Water Retention

Mimicry Bromeliad (*Aechmea aculeatosepala*)



Project by

Miss Sureeporn Triphetprapa

Miss Kanjana Komkla

MissThidarat Phianchat

Advisors

Mrs. Suwaree Pongtheerawan

Mr. Chalermporn Pongtheerawan

Suratpittaya School

Muang District, Surat Thani Province

Thailand

I. Abstract: **Innovative Water Retention of the Bromeliad** (*Aechmea aculeatosepala*)

The natural innovative water retention mimicry of the Bromeliaceae was aimed to examine the efficacy of the natural water collection by the plants regarding to the shape of the plants that can collect and capture the water. The literature review demonstrated that *Aechmea aculeatosepala* can grow in the barren area because of its suitable retention and entrapment structure. In present study, a water retention model has been developed in the mimicry of the Bromeliaceae.

The finding indicated that *Aechmea aculeatosepala* constitutes crucial multiple parts to retain water, the leaf which the two sides of the marginal leaf is thinner than the mid leaf, and leaf blade with U-shaped trough, enables the water flow to the catchment between leaf sheath (Rosette), tiny thorns around the leaf at the angle of 50 degrees to the marginal leaf draws the water, 2 mm away from the marginal, into the leaves. Front and dorsal surface of the leaves allows water to flow down and gather together at the trough because the adhesive force between the water and surface is greater than the cohesive force of the water. In addition, the mimic water retention of the *Aechmea aculeatosepala* is caused by the overlapping leaves; the lower part of the leaf blade extends and featured of cone-like storage basin at the mid trunk, and in the between leaf axils, water is retained much more than cone-like container by 17.28 percent.

In details, *Aechmea aculeatosepala* was adopted to model the mimic water retention device, made of aluminum sheet because of its less heat capacity. At the night, when influenced by the water vapor in the air, it is easier to condense into a drop of water. In the real application of the device, the unit is installed on the rubber tree, Thailand's economic crop, 3 units for each tree, a total of ten rubber trees. The salt tube is grounded 1 meter distanced from the stubs. It found that soil moisture when the device is installed represents 17.65 percent greater than that non-installation and non-watering. Also, it found that the soil moisture is close to the normal watering; 9.80 percent less than normal watering. In addition, the device-installed rubber tree is 57.50 percent more productive than non-installed rubber trees at unit cost of 25 Baht and break-even point is 6 days only.

II. Table of Contents

III. Abbreviations and Acronyms

Abbreviation

mm. - millimeter

cm. - centimeter

cm^3 - cubic centimeter

Definition

"*Aechmea aculeatosepala*" is in the family Bromeliaceae, monocot flowering plant grown up from the rainforest to drier weather.

"Cohesive force" is a force cohesive between the particles of the same substance.

"Adhesive force" is a force cohesive between the different particles

"Trichome" is a white scale arranged and overlapped like fish scales responsible for absorbing the moisture and nutrients from the air

IV. Acknowledgement

The science proposal entitled the "Natural Innovation Water Retention Mimicry of Aechmea aculeatosepela" has been successfully achieved under the supervision; advice and assistance of Mrs. Suwaree Pongtheerawan and Mr. Chalermporn Pongtheerawan. Gratefully thank the great support and contribution of all the school administrators and Science teachers of Suratpitaya School.

Chapter 1
Introduction

Statement of problems and significance

Water is recognized as an important factor to human life and is vital to all the living creatures and a perceived powerful energy to any mankind. That is why water conservation is so signficant. Currently there are various means of water retention by natural mimicry, for instances; Warka Water, an innovative fresh water retention in Ethiopia and Africa, developed to take advantage of gathering steam by the imitation of a local plant named “Warka” in Ethiopia. The structure is made of Juncus stem or bamboo woven together in vase shape, and there is inside the plastic mesh made of nylon and polypropylene as a tiny tunnel for a daily collection of water. The droplets flow along the mesh into a catchment at the stub. Water vapor is gathered to produce at least 25 gallons of drinking water. With the Warka Water, the rural communities have experienced the improved quality of life and invention method has been shared among the communities facing the same problems. In addition, there include the innovative water retention of the thirsty trees for utilization in the barren and tropical regions of Africa and America where the temperature is obviously different between day and night. It is characterized of a large tree which absorbs moisture from the air while folded and expanded surface of the roof leads the water particles into the middle of the trunk and fog trapper is utilized for agricultural purposes, wherein the mist in the air are utilized as droplets to feed the plants. At the observation of plant’s water retention plant when raining, each plant is capable of retaining water at varying degree; some are able to and some are unable to retain water. To this point, the authors have been of interest to examine the innovative water retention by imitating the *Aechmea aculeatosepela,* because this kind of plant can grow and found in the barren area as well as its suitable water retention and entrapment structure. In this study, the water retention device was developed by imitating the Bromeliaceae.

Research question: How is water retained in barren area?

Hypothesis: How does a mimic device of the *Aechmea aculeatosepala* structure retain water?

Objective: To develop the *Aechmea aculeatosepala* mimicry model that retains maximum water.

Scope of study: A case study of *Aechmea aculeatosepala*

Study site is Bangsawan Subdistrict, Prasaeng District, Suratthani.

Chapter 2

Literature Review

Aechmea aculeatosepala

Bromeliad is a Bromeliad in the family Bromeliaceeae which contains approximately 60 genera and over 2,000 species, monocot flowering plant, almost originated in Americas. It can grow up from the rainforest to dry weather, habitable along the branches of trees and cliffs and livable on soil, sand, seashore, desert, mangrove areas, and highland. Bromeliaceae family originated in Brazil, photophilic, but not strongly sunny, requires moderate humidity and water in small quantities. The rate of transpiration of moisture is moderate. Despite dominant features of toxic absorption, it emits oxygen at night and absorbs carbon dioxide so it is suitable to grow in the bedroom.

Botanical features

1. Leaf varies in characteristics from wide leaves to grass-like leaves; some are smooth at the edge, some are jagged or specular, some overlap leaf by leaf abundantly around the base resembling a puddle in the middle loosely or resembling a cup. The overlapping leaves are responsible for retaining water and during the dry weather; the puddle is called a "Rosette"
2. Root system is fibrous; some absorb foods and moisture and adhere to them, some roots of the Bromeliad serve as cohesion only, some have no roots. The root of the Bromeliad is located surrounding the stub; some have roots coming out of the trunk. Generally, roots and root functions of the Bromeliad are divided into two types.

2.1 Epiphytic bromeliad - this type of root is tough and hard, responsible for adhering the plants, usually grow in tropical or subtropical where moisture in the atmosphere is high, responsible for absorbing water and nutrients from the deposited organic materials. The Bromeliad of this type includes Aechmia, Cryptanthus, Tillandsia, Guzmania, Neoregelia, Vriesia , and so on.

2.2 Terrestrial bromeliad generally grows on land and on the cracks of rocks, usually in the open air and normal warm and light. Normally, the rosette of Bromeliad retains more water than the epiphytic group. The frequently seen Bromeliad of this type are those for consumption and commercial purpose; including Aanas, Quesnelia, Puya, Wittrockia, Portea , and so on.

3. Trunks are solid; some are long, some are very short, thereby resulting that the leaves are overlapping and obviously seen as a broad cone. The height of the trunk is 2 to 9 meters, including both the upright and ivy trunks.

4. Flower - Bromeliad flower consist two petals, three sepals, six stamens and three pistils, three ovaries, generally is short-lived.

5. Fruit includes both capsule and berry.

Distinctive features of the Bromeliad - drought tolerance and ideal for landscaping that does not require much care.

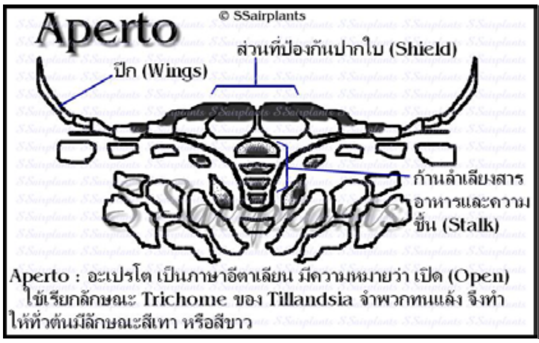
Scientific Classification

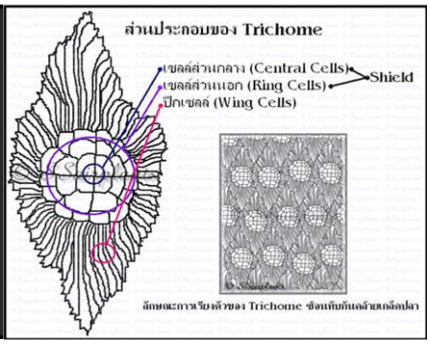
Scientific name : *Aechmea aculeatosepala*

Kingdom	Phylum	Class	Order	Family	Genus	Species
Plantae	Angiosperms	Monocots	Poales	Bromeliaceae	Aechmea	A. aculeatosepala

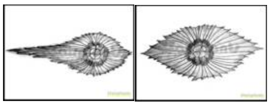
Trichome (or Peltate Scales)

Trichome is characterized of white scales in fish scale-like overlapping arrangement, responsible for absorbing moisture and nutrients from the air. The moisture is conveyed into and moved from the leaf surface to the inside cells and water is collected at the leaves, thereby causing a dehydration of the plants for a long time. The moisture is maintained in the retaining cells. In addition, the Trichome is responsible for releasing the heat and reflection, especially drought-resistant species to which the large extent of Trichome is produced, particularly; the open (Aperto) Trichome, which is obvious and prominent due to its white or silver gray color. They are mostly found in the drought-resistant plants where the wings of the Trichome bend up to absorb moisture particularly and releasing heat during the day. However, the non-drought-resistant or Chiuso species of the close Trichome is usually inconspicuous because of its slim and flat appearance attaching the leaf surface and does not reflect light and heat as effectively as the Aperto.





The bulging wing cell becomes perished. As cup-like it can accommodate incident humidity and mists and reflects the sunlight and heat effectively. When the wing cell is broken or loosens, it does not affect the trees, because the actual absorption of moisture is so-called schield (central cell, ring cell) and then transported down the stalk onto the cells in the leaf surface.



Epidermis is a simple permanent tissue wherein the outermost is exposed to the outside condition, covering all parts of the plant; roots, stems leaves, flowers, and seeds. It is originated from the Protoderm layer. As it grows, the second layer disappears because the layer of cork is formed under the epidermis pushing out. Epidermis has several functions; namely, protect a danger, prevent evaporation, concerning breathing, dehydration and photosynthesis, or develop new cells when wounded. With several functions of the epidermis cells, it has different shapes and structures, for example.

1. Transformed into Trichome – including root hair, leaf surface hair. Trichome can also drive out the substances, called "glandular Trichome" which includes different forms.

2. Transformed into stomata – two epidermis cells transforms the nut-like shape facing a concave at the middle to form 2-cell channel, called "guard cells" where inside contains a lot of chloroplasts. Both the guard cells and opening hole is called "stomata".

Water molecule consists of one atom of oxygen covalently bonded to two atoms of hydrogen in capacity to pulling on the shared electrons, causing a polar covalence wherein one end is slight negative charge and the other end is slight positive charge.

Since water molecules have a small magnetic moment, it features high adhesion. Water is a polar molecule, because the oxygen has higher electronegativity (EN) than hydrogen. Oxygen is negative whereas hydrogen is positive, representing a dipole moment of the water. The reaction between polar molecules causes a gravity linked to the total mass of the water's surface tension. Other bonds causing one molecule linked to water molecule is called "hydrogen bond", and then water flows toward itself. Water has a high surface tension, caused by the strong coordination between the water molecules, because water is a polar flexibility obviously caused by the surface tension that forms the drifting wave.

Surface of the objects

There includes two type of the surface of the objects.

- When the surface reaches 0 degrees, the fluid spread across the surface (hydrophilic) and wash away impurities.

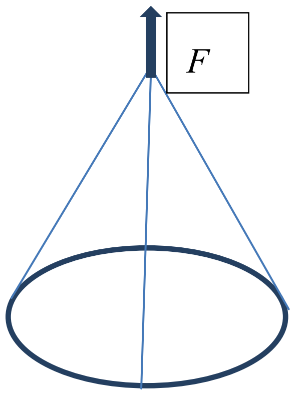
- When the surface reaches 180 degrees, the fluid is in droplet (hydrophobic) and removes the impurities.

All kinds of the fluid have properties of the intermolecular forces in two aspects; cohesive force and adhesive force.

Cohesive force is the intermolecular attractive forces of the same substances, for instances; attractive forces between water molecules and water, attractive forces between ethanol molecule and ethanol molecule.

Adhesive force is a force of attraction between two substances, for instances; attractive force between water molecules and particles as components in a glass tube containing the water, the adhesive force between water molecules and particles in wood. When water is poured on a piece of paper or wood, the paper and wood is wet, indicating that the adhesive force is less than the cohesive force. However, when water is poured on any objects and found the spherical droplets on the surface of the object, indicating that the cohesive force is stronger than the adhesive force.

Mathematically, the unit of the surface tension of the fluid per unit length can be written below.



$$Y = \frac{F}{2L}$$

Y = surface tension

F = surface tension

L = Length of circumference (outer and inner)

Surface tension is a force per length of the surface (an attempt to adhere to the fluid surface). Surface tension is a force formed at the fluid surface contacting with another liquid or solid surface with sufficient energy required to molecular bonds, relatively with the adhesive forces and cohesive force, forming a film that is slightly resistant to a tensile strength, in a parallel to the fluid surface and perpendicular to the marginal line where the liquid is exposed. When the temperature rises, liquid surface tension decreases.

The surface tension of the water at different temperatures; when temperatures rise, surface tension decreases.

Temperatures (^{o} C)	10	25	50	75	100
Surface tension (N/m)	0.0742	0.0720	0.0796	0.0636	0.0589

Chapter 3
Methods

Apparatus/Instruments

Beaker	cylinder	dropper	container of water
Syringe	micrometer	Steriomicroscope	Fog forming trial
Rainfall measuring equipment	microscope eye-piece camera		Soil pH tester

Method

Experiment 1: Examine catchment structure of *Aechmea aculeatosepela*

The paper examined the water catchment efficacy of the *Aechmea aculeatosepela* as follows;

1. Measure the circumference of the *Aechmea aculeatosepela*, measure the width and height from deepest to the edge of the catchment , calculate the volume of water catchment using the formula 1/3 $\pi r^2 h$ for the volume of cone
2. Fill up the catchment with water, and then poured out to measure the actual volume of water catchment
3. Put the plaster into the catchment fully and examine shape and measure volume
4. Experiment six trees , record and determine the average

Experiment 2: Examine leave structure of *Aechmea aculeatosepela*

In this study, the water catchment efficacy of the *Aechmea aculeatosepela* leaves is examined as follows;

1. Measure the size of the leaves, width and length of the leaves, nature of the marginal leaves, the tip of the leaves, and all arranging positions of the leaves at each layer and record
2. Sterio microscope *Aechmea aculeatosepela* leaves observe and record the results.
3. Measure the length from the stub to the tip of the leaves, measure the thickness of the leaves at the positions; one centimeter distanced using the micrometer on both the leaves and leaf sheath covering the catchment.

Experiment 3: Examine water catchment efficacy of the *Aechmea aculeatosepela* leaves

The influence of leave structure of *Aechmea aculeatosepela* on catchment is examined.

1. Drip water at the front of the leave, marginal leave, the tip of the leaves and the dorsal leaves, observe the droplets using the Sterio microscop, measure angle of the droplets using the camera, and observe the flow of water at the incidence area.
2. Install droplets kit to the stand; 3 mm higher than the marginal leaves, distanced between the marginal leave and the tip of the leaves at 0, 1, 2 and 3 mm, observe the nature of falling droplets.

Catchment efficacy of rainfall is examined as follows;

1. Leave the Bromeliad with a diameter of 14 cm and 14 cm diameter cone on the open space while raining for 15 and 30 minutes
2. Measure the rainfall by catchment of the Bromeliad and cones.
3. Examine the internal structure of the Bromeliad leaf under the microscope at the following positions; epidermis at the dorsal leaves, the front of the leaves, the front of the sheath, the dorsal sheath and the cross-section.

Experiment 4: Examine the model of mimic catchment for *Aechmea aculeatosepala*

To model the mimic catchment for Achaea aculeatosepala

1. Cut a sheet of aluminum sheet to the size and shape of the *Aechmea aculeatosepala*, and create small thorns supporting each leaf to be the Bromeliad tree, and space at the bottom so that the water is conveyed to collect at the catchment.
2. Test the model performance for retention comparing the *Aechmea aculeatosepala* with the container with the same diameter, measure the volume of water collected.
3. Prepare the fog forming trial by putting hot water and cold water into a glass cabinet with a lid, heat the cold steam is then condensed into fog.
4. Put the *Aechmea aculeatosepala* and experiment into the closed system for 30 minutes.
5. Measure the volume of water collected and records the results.

Experiment 5: Test the performance of the implementation

Test the performance of the water retention device mimicry of the *Aechmea aculeatosepala* as follows.

1. Prepare three set of green bean trees; each set contains five trees, measure the soil moisture prior to the experiment

2. Install the water retention device mimicry of the *Aechmea aculeatosepala* into the first set of five green bean trees and non-watering. Second set contains no retention device mimicry and non-watering. Third set is watered normally.
3. Measure soil moisture by using Soil pH Tester (TAKAMRA Electric Works Co., Ltd.) following the experiment for seven days
4. Install the water retention device mimicry into the rubber trees, three sets installed on each tree, saline tube is grounded at a distance of 1 meter away from the stub of the rubber tree, measure the soil moisture while experimenting, determine mean of the relative humidity, measure the volume of latex tapped and compared to those non-installation trees.
5. Expand the results by allowing five rubber growers to go on trial use, three rubber trees are allowed for one plantation and three sets for one rubber tree, examine the satisfaction of users.

Chapter 4
Results

Experiment 1: Examine catchment structure of *Aechmea aculeatosepela*

In examining the shape of the catchment *Aechmea aculeatosepala*; the catchment area includes two parts; catchment and the spaces between the leaves. The geometric shape is an obtuse cone and the spaces between the leaves are like a semi-circle with the more retention capacity in the catchment by 32.6 percent. A ratio between the volume of actual water retention and calculated volume of water by geometric shape was 1.326 times (Table 1).

Table 1 Relationship between the calculated volume of water and the volume of actual water retention

Mean	Radius of the catchment width (cm)	Height of the catchment (cm)	The calculated volume of retained water (cm^3)	volume of actual water retention (cm^3)	The volume of actual water retention and calculated volume of water ratio
Mean	1.53	3.28	24.18	32.08	1.326

Statistic difference between the volume of actual water retention and calculated volume of water of *Aechmea aculeatosepala*

		N	Correlation	Sig.
Pair 1	real & calculate	6	.840	.036

Figure 1 Geometric Model of the Catchment of *Aechmea aculeatosepala*

Experiment 2: Examine leave structure of *Aechmea aculeatosepela*

The results found that the shape of the leaves varies from layer to layer; the innermost layer is the shortest averaged 6.2 cm, mid layer is the longest averaged 14.8 cm and the outermost layer is short averaged 12.2 cm (Table 2). The shape is long and oblong while the width gradually increases. The leaf sheath is the widest. The thickness of each leaf in the parallel to the ground varies; the middle is thicker than the marginal leave, an average of 1.86, enabling the two sides of the marginal leaves are convergent; the leaf U-shaped. The marginal eaves surrounding the leaf sheath covering the catchment is wide and thinnest that can cover other leaf sheathes firmly with drifting waves at the o sides of the marginal leaves, the tip of the leaves is mucronulate, the thorns are bent inward angled 50.53 degree averagely, the surface of the leaves are smooth and reflective.

Table 2 the width and length of the leaves at each layer

Position of Leaves	Average Size (cm)							
	The first layer (innermost layer)		Layer 2		Layer 3		Layer 4 (outermost layer)	
	width	length	width	length	width	length	width	length
Tip	1.3	6.2	1.2	14.8	1.3	14.5	1.6	12.2
Mid	2.5		2.5		2		2.5	
Base	2.9		3		2.8		3.2	
Margin	8		12		14.5		13.8	

Table 3 the thickness of each position on average 10 leaves

Distanced from tip (cm)	Thickness of Leaves (mm)		
	Left margin	Mid leaf	Right margin
0	1.02	1.10	1.00
1	1.03	1.30	1.00
3	1.05	1.15	1.00
5	1.04	1.10	1.03
7	0.30	1.14	0.28
9	0.24	1.10	0.23
11	0.17	1.01	0.19
Average	0.69	1.13	0.67

Table 4 Shape of the leaves

Shape of the leaves	Layer 1	Layer 2	Layer 3	Layer 4
Tip	Sharp-pointed thorns	Sharp-pointed	Sharp-pointed thorns	Sharp-pointed

	bent inward	thorns bent inward	bent inward	thorns bent inward
Margin	Small thorns bending 50 degrees	Small thorns bending 51.2 degrees	Small thorns bending 51.1 degrees	Small thorns bending 49.8 degrees
Surface	Glossy, smooth, reflective	Glossy, smooth, reflective	Glossy, smooth, reflective	Glossy, smooth, reflective

Experiment 3: Examine water catchment efficacy of the *Aechmea aculeatosepela* leaves

The Bromeliad tree was observed using the microscope (Figure 2), showing that when water is dropped on the frontal leaves of the *Aechmea aculeatosepala*, the water is flat and becomes spherical convex, not broken out, the top surface is hydrophobic, the droplets flow on the surface of the leaves. When water is dropped on the different positions; namely, on the tip of the leaves, the droplets are rolled into the U-shaped trough before entering the storage catchment owing to the cohesive force between the particles of water is stronger than adhesive force between water and the surface of the leaves. Meanwhile the water at the dorsal side of the leaves does not bunch up into the droplets, indicating that the dorsal leaves are hydrophilic, the water then flows downward the reservoirs faster than the frontal leaves, yet the water did not fall out of the leaf. The marginal leaves are little spiny twisted upward, thereby the falling water forms droplets between the thorns, and the drops of water are twisted inward the trough while the droplets are 0-2 mm distanced from the marginal leaves bunched up into droplets inside the surface of the leaf blade.

The epidermis of the frontal leaf blade has been characterized of coating; the epidermis of the dorsal leaves includes stoma overlapped in the multiple layers. The epidermis of the catchment at the frontal and dorsal leaves include the wing cells bulged into the panels. With cup-like shape, it accommodates the incident moisture and fog effectively. The scale-like overlapping arrangement of Trichome of the *Aechmea aculeatosepala* is categorized into tank-absorbing Trichome; the main function of the roots is not to absorb water and nutrients, but to hold Trichome, the surface of the leaves can absorb water and nutrients.

Thus, all the shapes appeared on the Bromeliad leaves at any positions facilitate the receipt of water to be transported and collected. The glossy surface of the leaves results in the increased water retention. When the Bromeliad is used to collect rainfall, compared an open-conical container of the same cross-sectional space , the Bromeliad is more effective to collect water than the open conical container by 17.28 percent (Table 6), because the Bromeliad structure is conducive to water retention, the water splashed onto all parts can be retained.

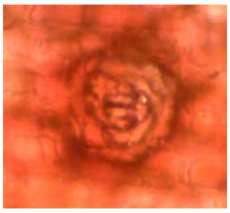
Table 5 Flow of droplets at the different positions of the leaves

Dropped area	Nature of droplets	Nature of water flow
Tip	Round droplets at angle of 23 degrees to the surface of the leaves	dropped and rolled at the front of the leaves before entering the trough and flow down to the basin catchment
Front	Round droplets at angle of 23 degrees to the surface of the leaves	dropped and rolled at the front of the leaves before entering the trough and flow down to the basin catchment
Ventral	Flat droplets	stream flowing to the basin catchment
0 mm distanced from margin	Round droplets between thorns	droplets between thorns and droplets twisted inward in U-shape
1 mm distanced from margin	Round droplets between thorns	droplets between thorns and droplets twisted inward in U-shape
2 mm distanced from margin	Round droplets between thorns	droplets between thorns and droplets twisted inward in U-shape
3 mm distanced from margin	-	Dropped downward the leaves

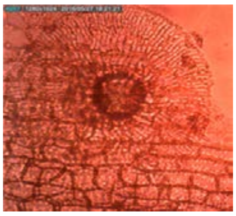
Table 6 Rainfall retention capacity of the Bromeliad

No.	Volume of water collected (cc)		The difference in the volume of water collected (%)
	Bucket	Bromeliad	
Average	81	95	17.28

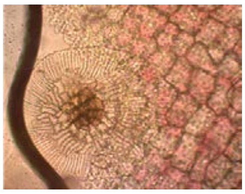
Epidermis – front leaf



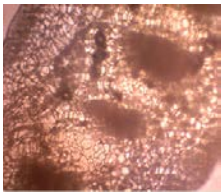
epidermis –dorsal leaf



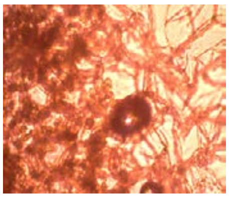
Epidermis – front leaf sheath



Epidermis – dorsal leaf sheath



Tissue - cross-section leaf



Tissue - cross-section leaf sheet

Figure 2 Structure of leaves at microscopic level

Experiment 4: Examine the model of the mimic catchment for *Aechmea aculeatosepala*
The mimic catchment model for *Aechmea aculeatosepala* is shaped like the *Aechmea aculeatosepala*. It is made of aluminum sheet. At experiment, it is used to collect fogs; it can collect water from fog wherein the water falling on parts of the leaf blade are gathered into the drainage basin and into the catchment through adhesive force. The marginal retention model includes tiny thorns twisted upward; thereby the incident water forms the drops of water between the thorny cavity and droplets twisted into the trough. Thus, all the shapes included are conducive to collect water and conveyed to the reservoirs (Table 7). At experiment of the rainfall collection, the amount of rainfall collected is only 5.99% less than the Bromeliad (Table 8).

Table 7 Flow of droplets at the positions of the catchment model

Aare of droplets	Observation
Tip	While the water drips at the tip of the retention model, the water is gathered in droplets and rolled onward the model before entering the receiving trough and flow onto the storage basin
Front	Water is taken as drop, but not permeates into the retention model. When the droplets are plentiful, the water is gathered into stream and flows down to the storage basin
Ventral	Splashing water surrounding the ventral model is taken as droplet, not permea into the retention model and flows down to the storage basin
Margin	Marginal model with small thorns make the incident water become a drop of water the thorny cavity, and twist the drops of water into the U-shape.

Table 8 Water retention capacity of the mimic retention device of *Aechmea aculeatosepala*

Rainfall collecting structure	Average rainfall collected for 30-minutes (cc)
Model of *Aechmea aculeatosepala* mimicry	80.53
Aechmea aculeatosepala	85.67
Conical frustum container	72.46

Table 9 Steam collected from the mist by the mimic retention model of *Aechmea aculeatosepala*

Rainfall collecting structure	**Average rainfall collected for 30-minutes (cc)**
Model of *Aechmea aculeatosepala* mimicry	7.96
Aechmea aculeatosepala	10.67
Conical frustum container	4.32

Experiment 5: Test the performance of the implementation

The implementation of the mimic retention model results that soil moisture content is 17.65 percent higher than that of non-watering (Table 10), and the soil moisture is close to that of regular watering, 9.80 percent less than that of regular watering at the relative humidity of 65.4 percent. When the mimic retention model is applied to the rubber trees in the non-raining condition at the relative humidity of 75 percent, the amount of latex collected is 57.5 percent higher than that of non-installation rubber trees (Table 11). Therefore, the developed model can increase soil moisture at cost price of 25 Baht, latex price of 56 Baht per liter. Investment capital is 75 Baht per a tree. The earning increases 13 Baht daily per a tree. The break-even point is 6 days.

Table 10 Soil moisture and the application of retention device of the *Aechmea aculeatosepala*

Trial	Average Relative Humidity (%)	Soil moisture at the beginning of the trial	Soil moisture of 7-day trial
Regular watering	65.4	6	5.1
non-watering	65.4	6	6.8
Device-installed	65.4	6	5.6

Note: * High soil moisture readings by the Soil pH Tester (TAKAMRA Electric Works Co., Ltd.) indicates low soil moisture.

Table 11 Application and content of latex obtained

Trial	Trial Relative Humidity while tapping rubber (%)	Soil Moisture (cc.)	Content of latex tapped/Tree. (cc.)
Rubber trees without regular watering	75 %	4	400
Rubber trees watered by device	75 %	3	630

Table 12 Level of satisfaction of the rubber farmers implementing the device

Items	Satisfactory Level		
	Strong	**Fair**	**Slight**
1. Easy to use	80	20	0
2. Effective to improve productivity	100	0	0
3. Suitable cost to the quality of device	80	20	0
4. Satisfactory implementation	100	0	0
5.Make equipment by yourself	80	20	0
Average Satisfaction	88	12	0

Chapter 5
Conclusion and Discussion

In present study, the water catchment structure of the *Aechmea aculeatosepala* was examined, consisting of two parts, basin catchment between the overlapping leave sheathes (Rosette) and the spaces between leaves. In geometric shape, the former part is straw-like conic frustum and the latter part is like semicircle, with the greater capacity of retention than calculated volume by 32.6 percent. The ratio between the volume of actual retention and the calculated volume of water by geometric shape was 1.326 times, because the actual shape includes both the basin catchment and spaces between leaves that can collect water. Unlike the calculation based on the pointed cone formula, the statistically significant difference at .05 confidence level was found. Therefore, the basin catchment of the *Aechmea aculeatosepala* is effective to retain water.

The physical structure of the *Aechmea aculeatosepala* is characterized of long leaves that vary between layers. The innermost layer is the shortest, followed by the outermost and the mid layer 6.2, 12.2, and 14.8 cm. respectively. All leaves are common; long and oblong and curved into U-shaped and retention trough-like. The marginal leaves are thinner than the mid leaves. The leaf sheath is wide and slim covering the overlapping sheathes, bent into U-shaped, forming the basin catchment.

With the physical structure of the *Aechmea aculeatosepala* above-mentioned, its water-capturing structure includes leaves that are effective to collect water at both the front and the dorsal leaves. Small thorns at the marginal leave have high adhesive force between water molecules and water. At the basin leaf sheath, the overlapping Trichome acts as absorber of moisture and steam. The shape of the trough-like leaves with drifting margin facilitates drainage. The U-shaped spreading leaf sheath and the overlapping marginal leaves cause a basin catchment to collect water more effectively than conical container by 17.28 percent.

The mimic catchment model of the *Aechmea aculeatosepala* is as effective as the real *Aechmea aculeatosepala* and the retention capacity is 5.98% less than that of the *Aechmea aculeatosepala*, because it is made of aluminum with less heat capacity. So, the droplets clinging to the leave sheathes can be obvious at the night and it is the same capability of mist retention to the *Aechmea aculeatosepala*. It is therefore ideal to be used in the water scarcity area.

The mimic water retention device of the *Aechmea aculeatosepala* is capable of collecting water from the air and released into the soil ground, thereby resulted that the soil moisture is 17.65 percent higher than non-watering and helps improve the greater productivity of rubber latex than non-installation rubber trees by 57.50 percent at the unit cost of 25 Baht and break-even point is only 6 days.

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VI. Appendix

Water at the thorn of Bromeliad can capture water.

Water at the thorn of Bromeliad can capture water.

Rea Application

Mimic Water Retention Device *of Aechmea aculeatosepala*