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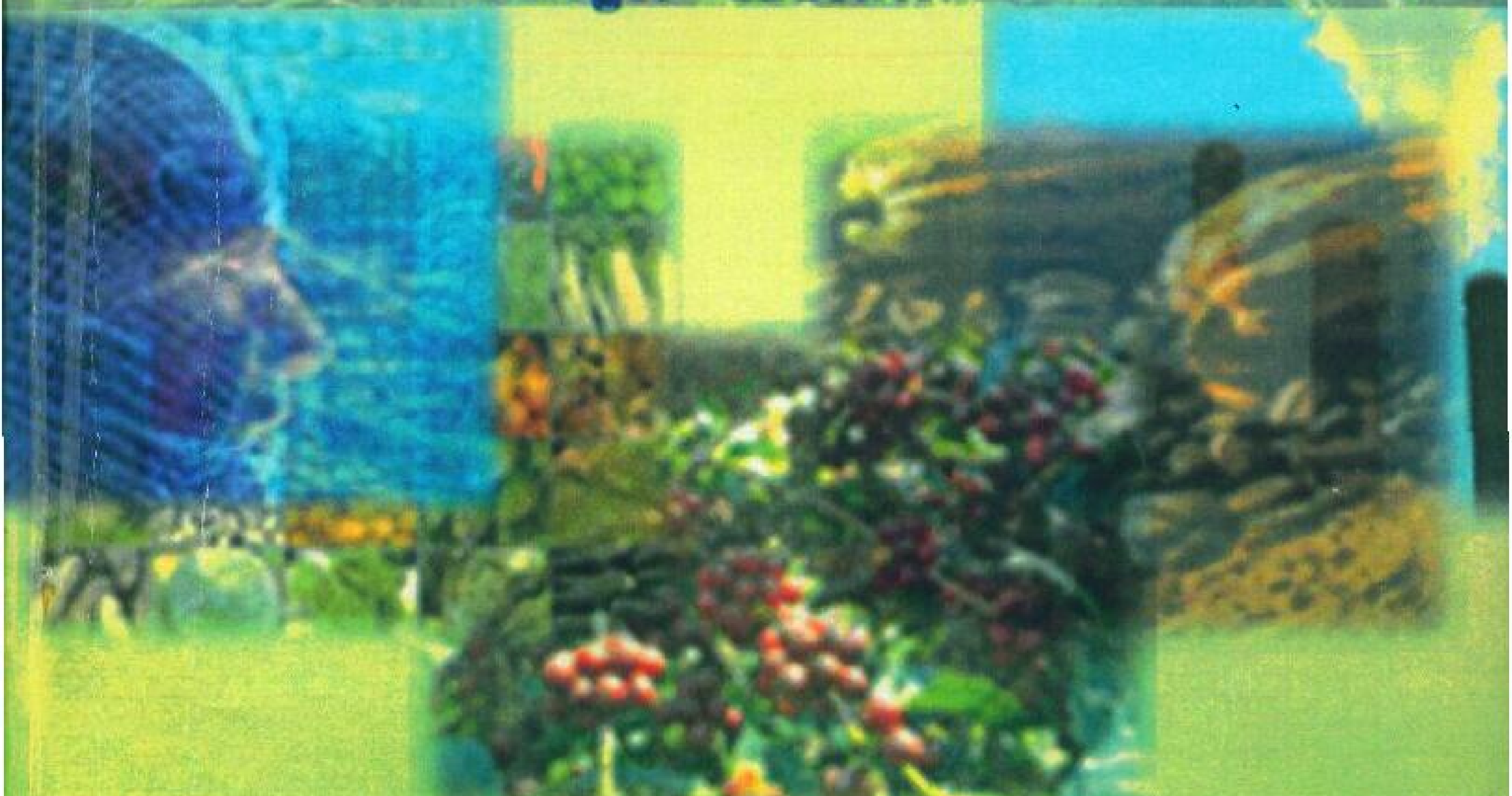

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Characterizing Temporal Dynamic Of Weather Variability To Support Decision Making On Weed Control

Rizky Mulya Sampurno
IT for Natural Resources Management,
Faculty of Mathematic and Natural Science, IPB

Kudang B. Seminar
Department of Mechanical & Bio-System Engineering,
Faculty of Agricultural Technology, IPB

Yuli Suharnoto
Department of Civil and Environment Engineering,
Faculty of Agricultural Technology, IPB

Mohamad Solahudin
Department of Mechanical & Bio-System Engineering,
Faculty of Agricultural Technology, IPB

ABSTRACT

Many factors should be considered before conducting weed control by spraying herbici Those factors are: type of main crop, age of main crop, type of weed, density of weed, availa herbicide, time for application, and weather factor. The objectives are to study of weather variat pattern of study area to determine the optimal time for spray application. Then develop an applicat to select sprayer setup for minimizing negative impact on the environment due to spray drift and ot potential waste. The main material is weather data that derived from satellite remote sensing suct NOAA, TRMM and MODIS. The methods conducted are data preparation, data processing includ image processing, and analysis. The results of this study are information that can be used as decis support on weed control. These are about suitable time for spray application and applicatior determine sprayer option based on weather data.

Keywords: weed control, weather data, decision support, supervisory controller, precision agriculture

1. INTRODUCTION

1.1 Background

Weed is harmful to agricultural crops because it competes against main crop for taking water, sunshine, nutrient, space and air. Furthermore, weed can decrease yield both quantity quality. Evans (1996) stated that loss due to weed are as follows: wheat 9.8%; rice 10.8%; maize sorghum 17.8%; potatoes 4% and groundnut 11.8%. Even, the uncontrolled weed on crops decrease 20-80% yield (Utami, 2004).

Weed control is a complex activity. Many factors should be considered before conducting \ control by spraying herbicide. Those factors are: type of main crop, age of main crop, type of w density of weed, available herbicide, and time for application. It gets more complex by the pres of weather factor such as atmospheric stability (including up and down air current), wind s direction and turbulence, air temperature, humidity, and rainfall (Tepper, 2012; Solahudin, 2(Wolf (1997) stated that the most important weather factors are wind speed and atmospheric stat but temperature and relative humidity also play a role.

Spraying herbicide is often facing the problem and the goal to be safe, efficient and effe Herbicides are applied diluted with water and sprayed onto the target weeds. Although po:

benefit of herbicide in terms of killing the target weeds, but it potential become a negative if some remains in the air and moves off-site. Off-site movement of airborne herbicide can cause economic damage for other surrounding sensitive crop and it can become pollution for environment. The damage can be in the form of yield loss, retarded development or market loss or downgrade because chemical substances of the crop have changes. In Nanseki (2010), if a misapplication of agrochemicals is discovered after the application then the disposal of the agricultural products will be done. This causes serious problems to farmers because food safety has increasingly become a forefront of consumer concerns, industry strategies, and government policy initiatives in many countries. Therefore, appropriate agrochemical such herbicide use is very crucial for farm operation and management.

Drift of airborne herbicide can happen due unsuitable weather factors. Spray drift is potentially occurred every time when sprayer turned on. Knowledge of weather condition will help farmer and decision maker to decide the appropriate technology and method for eradication weed, plan, and effectively execute spray applications to avoid spray drift and potential waste.

The progress of information technology has been applied many in agriculture. Application of information technology is expected to reduce production cost, increase productivity (Auernhammer, 2001), and the concern for environmental protection. Today, one approach to appropriate technology in agriculture is precision farming that applied on weed control. Astika et al (2011) designed a real-time data acquisition system using digital camera and image processing for mapping the closure rate and diversity of weeds on the field. Then, the map was used as a guide to spray weed using variable rate application. Rotinsulu (2011) develop a tool that can detect and determine weed density of an image and develop a sprayer pump controller system. Lack of precision in the analysis of weed control can lead to ineffective and inefficient, excessive use of cost, time and energy (Solahudin et al. 2010).

Solahudin (2013) developed a supervisory control system that is functioned as a central which ability for choosing type of tool, managing, coordinating, and integrating every element of system. This system consist of agents that work directly together to read the environmental condition changes and give a treatment based on the change itself.

Weather data strongly support the agricultural activities. On weed control weather data is used to setup sprayer and determine time for application. However, the weather data is often a barrier, especially in developing countries like Indonesia. Distribution of meteorological stations these are still little so that weather data is difficult to obtain. Therefore, in this study used previous weather data to generating weather patterns. Weather patterns can be used as input data and knowledge for decision support.

The spatial and temporal variability weather conditions are important sources when applying on farming operation. Integration meteorological satellite with National Weather Prediction (NWP) product are promising to get timely weather variables as an input to determine appropriate technology for weed control. NWP product from NCEP/NOAA such as temperature, relative humidity and wind are used for input temporally. Weather model is the methods are done by experts to generate the data. Until now many methods have developed to generate weather data both temporally and spatially. Generation of weather data using satellite imagery data modeling as did by NASA and JAXA.

1.2 Objectives

Objectives of this research are:

- Study of weather variables pattern of study area to determine the optimal time for spray application.
- Design an application to select sprayer setup for minimizing negative impact on the environment due to spray drift and other potential waste.

1.3 Problem Statement

In addition to the effectiveness and efficiency issues, drift of chemical substance on herbicide application can cause the damage to other agricultural product and can pollute the environment. Utilization of weather data to resolve these problems is much needed. However, the availability of data in real-time is still difficult to achieve. Therefore, with the use of remote sensing data is expected can help to resolve these problems.

1.4 Research Benefits

- Provides the information about characteristics of weather conditions of study area.
- Develop a method that utilizes weather data for agriculture application.
- Provide the direct consultation for selection of spraying technology on weed control.

2. METHODOLOGY

2.1 Time and Location

This research was conducted from June - September 2013 including the data preparation, data processing, and analysis. The research is conducted in laboratory of GIS/Remote Sensing, IT for Natural Resources Management IPB, Bogor. The study area is Jonggol located at 6°31'32.23"S and 107° 0'52.59"E, an agricultural area and as a rice producer of Bogor district, West Java Province, Indonesia. Figure 2.1 illustrates the location of study area.

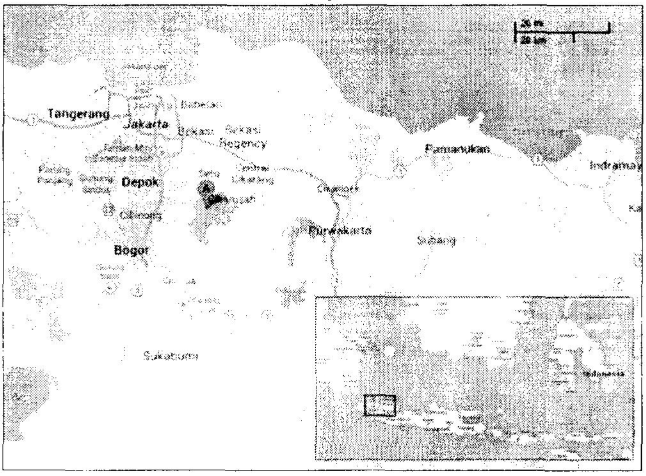

Figure 1 : Location of study (Point A)

2.2 Materials

The basic materials which are used and considered in this research are listed below:

- Temperature, humidity, U-wind and V-wind from 2003 – 2012, source NCEP (The National Centers for Environmental Prediction) Reanalysis 1 NOAA, 2.5 x 2.5 degree of spatial resolution.
- Precipitation daily from 2006 – 2008, source Tropical Rainfall Measuring Mission (TRMM), 3B42 product, 0.25 x 0.25 degree.
- Precipitation 3-hourly 2012, source TRMM, 3B42 product, 0.25 x 0.25 degree.
- Vegetation Index from 2010 – 2012, source MODIS Terra, Enhanced Vegetation Index (VI) Composite 16-day, MOD13A1 product, 1 x 1 km of spatial resolution.

2.3 Methods

There are some important stages of working with data: the first one is data preparation and entry in which data about the study area is collected and prepared to be entered and/or used into the system, data processing, and analysis. The methodology is showed as follow in figure 2.2.

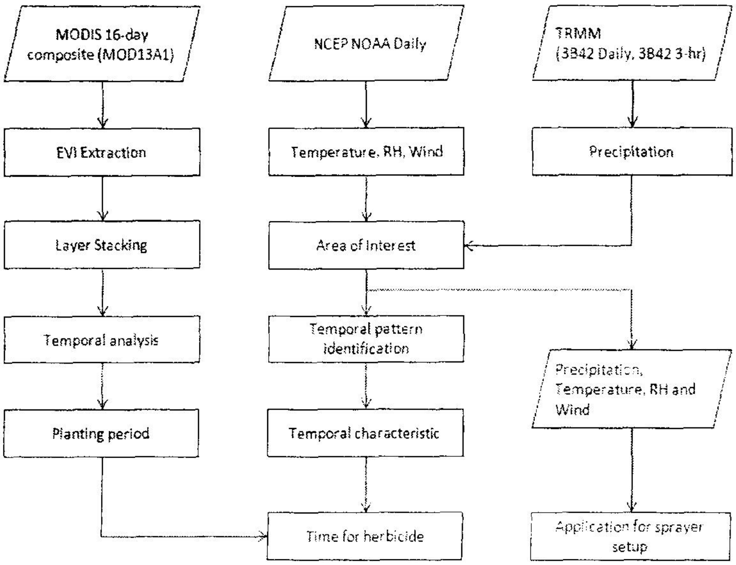

Figure 2 : General framework of this study

2.4 Data Collection

Weather data derived from daily meteorological observations NOAA and TRMM. The acquisition of those weather data are downloaded with free of charge from specific website. One requirement specification to make weather data available is the availability of high speed internet connection to download them. The study area has a small area and covered only by one single pixel both of NCEP and TRMM data. Besides that, enhanced vegetation index are derived from MODIS. Data from MODIS is studied to know the growing season or planting period of rice.

2.3 Data preprocessing

Generally meteorological data that used are store in netCDF and GRIB format, the appropriate software is needed to process them. Climate data operator is used to open and manipulate netCDF and GRIB data. Climate data operator (cdo) is a collection of operators to manipulate and analyze climate and forecast model data (https://code.zmaw.de/projects/cdo). Simple script to determine wind speed is showed as follow:

bash$ cdo sqrt -add –sqr uwind.nc –sqr vwind.nc wind_spd.nc

that mean is wind speed = $\sqrt{(u^2+ v^2)}$ and the direction is vector from both u wind and v wind.

Weather data from NOAA are ordered for several years and these are subset based on study area. Different with MODIS data that store in HDF and Image, preprocessing data are: (a) re-projection, (b) layer stacking, (c) re-order data, (d) subset area, and (e) identification pattern

2.4 Data Analysis

Generally, spray application is conducted several days or weeks after planting before main crop growing up. Competition of weed and main crop is high during growing time and it determines the next grow step of the crop. To support decision making, vegetation dynamic need to recognize. Vegetation dynamic can reflect the pattern of planting to see planting session. Moreover, vegetation phenology, as used and studied by remote sensing, refers to the relationship between climate and periodic development of photosynthetic biomass. Characterization of vegetation dynamics has often been made by using vegetation index value (Setiawan et al. 2011).

Time Series Analysis (TSA) can produce and analysis many input images, providing both spatial and temporal outputs. Long temporal sequence of regularly acquired data (Hyper temporal image data), such as Enhanced Vegetation Index (EVI) time series, have been used for monitoring anomalies, drought, vegetation phenology, land cover characteristics and to estimate crop yields.

The growing season of rice are divided into eight phases where each phase have different time span and also depends on crop species. Before the rice seed being planted, rice field needed to be flooded. Once the seed planted or at germination phase, it will take 25-30 days to reach tiller initiation phase and the rice leaf starting to grow. The leaf color then turning from yellow into green in the early tillering phase and mid tillering phase. The growth will reach maximum at the panicle initiation where for early variety rice it will take 55-60 days from germination phase and for late variety it will take 65-75 days. The next phase is the flowering phase, where rice plantation started to grow flowers and the leaf color started to turn into yellow. For the early variety rice, this phase were reach in 85-100 days after germination phase and for the late variety rice it needs 100-115 days. The last phase is harvesting, where rice is already developed and ready to be harvested. The early variety rice need 130-145 days after germination phase to be harvested, while for the late variety it needs 140-165 days.

Based on the rice growth phases, the green color that produced by rice leaf were at the panicle initiation phase. This phase will be detected by the EVI value as the highest value or in the other word is where the crop has the greenest color. The EVI value will decrease when the rice plant started to flowering and then harvested.

In general, the phenological pattern of rice has an almost symmetrical bell shape. The vegetative growth stage will correlated with the increasing EVI value until it reaches the maximum value in between 55 – 65 Day After Planting (DAP). It should be understand that the peak of the bell shape pattern is not the phase where rice are ready to be harvested, but the phonological pattern were based on EVI value or based on green index of rice. The peak on the phenological pattern means that the EVI value reaches maximum and the objects shows very green color from it leafs. In rice phenology, the greenest leaf color happens in the panicle initiation phase before the rice start to flowering (Semedi, 2012).

3. RESULT

The first objective of this research was study of weather in study area. Weather is close related to determine which technology should be selected to avoid spray drift and other potential waste. Therefore, knowing weather condition on the field is very useful. Not only weather data, but also vegetation condition should be considered to reach effectiveness of spray application. Weather data and vegetation index are acquired through remote sensing technology.

3.1 Characteristic weather of study area and its utilization to support weed control

Temperature and RH are acquired from NCEP NOAA. NOAA is coarse in spatial resolution but high resolution in temporal. The graph below shows the temperature of study area (Jonggol) at intervals of ten years. The first is started in January 2003. Every year have same characteristic, the pattern is upward and downward. Over ten years, minimum and maximum temperatures are respectively 23.5°C and 30°C.

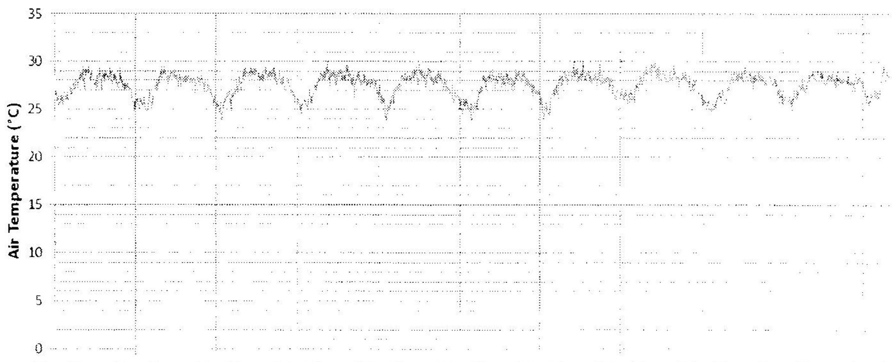

Figure 3 :Temperature condition over ten years at study area

As can be seen in Figure 4 generally relative humidity is high when air temperature is decrease. Relative humidity at study area is about 70 – 90%, high in year-end to March every year. At that time, Indonesia area is wet season so humidity tends to high.

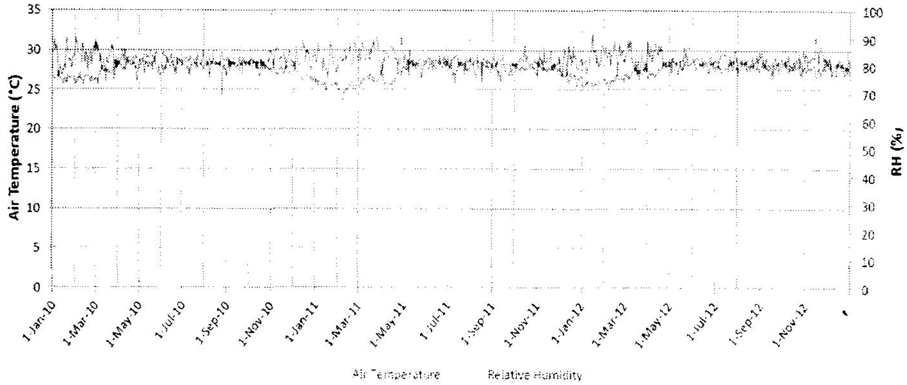

Figure 4: Temperature and RH over three years observation at study area

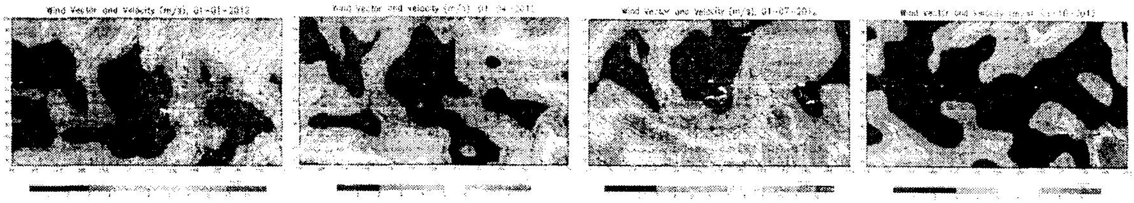

Figure 5 Representation of wind directions (Jan, Apr, Jul and Oct of 2012)

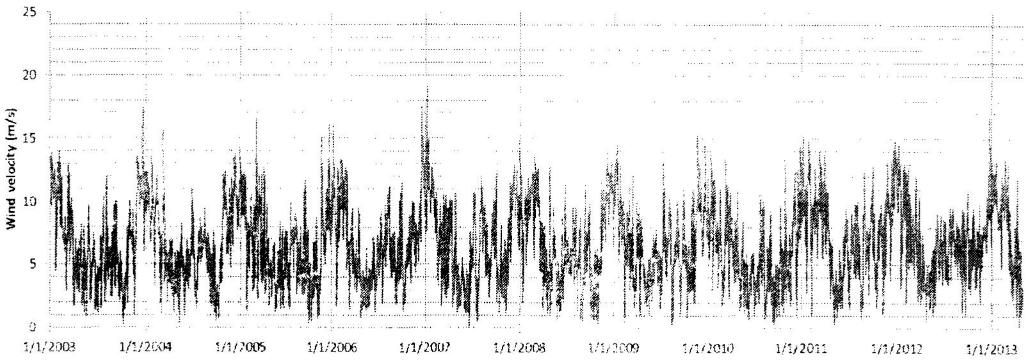

Figure 6 : Wind velocities over ten year observation at study area (m/s)

Figure 5 show the direction of wind. There are two data of wind that acquired from NCEP NOAA, there are U-wind and V-wind respectively for northern and southern wind. Wind direction is resultant of these two of wind. Direction of wind at study area generally move from south east to north and west (April to December) while wind move from north to south east (January to March). From Figure , wind velocity is fluctuates. Generally high in year-end to January every year, it is about more than 10 m/s.

Good spraying is done at low temperature conditions and high humidity. Or not spraying when the relative humidity is less than 40 percent and temperatures above 25°C in order to reduce drift caused by temperature in versions or evaporation, also increases the target deposition and coverage (Jason, 2009). From Figure 3.1 and Figure 4 its can shows, although temperature not reaches less than 25°C, lower temperature about January until March every year. That time is suitable for spraying herbicide. Rice in Indonesia generally is harvested twice a year (80-90 growing days) in well irrigated areas and harvested once a year (100-130 growing days) in non-irrigated areas (Indonesian Agency for Agricultural Research and Development, 2009). The need of sufficient water to grow makes rice plantation vulnerable to drought and flood (UNCTAD, 2009).

As can be seen at Figure 7, rice planting period of study area is twice a year, sign by two peaks in year. Vegetation index from MODIS EVI can describe phenology of rice crop from flooding until harvesting. In rice phenology, the greenest leaf color happens in the panicle initiation phase before the rice start to flowering. Low index that mean greenness of leaf is low approximated as harvest time and first period of growth crop. Based Figure 7, first the growing session is from February to May and second growing session is from July to October.

Weed control on precision farming normally is conducted twice, pre-planting and post growth or several days after planting (Solahudin, 2013). Based on the pattern of planting period (Figure 7) and consider the phenology of the crop, January until March is suitable for spraying while the temperature is lower. But it should be considered when do spray application during second period of planting, July to September. At that time temperature is higher and it can easy caused drift due to evaporation.

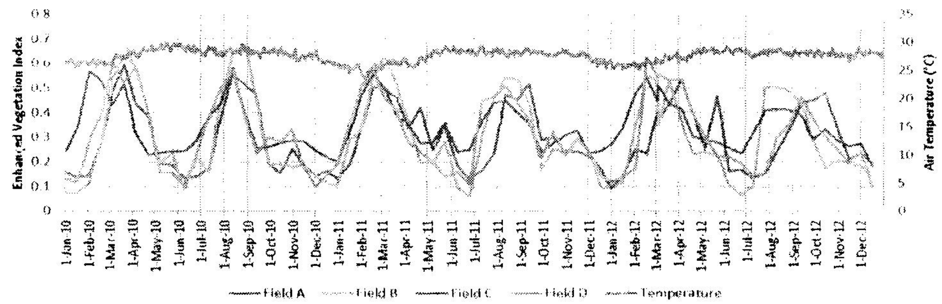

Figure 7 : Vegetation index in four different areas against temperature

Rainfall from TRMM can be used to complete decision support before spray application. Figure 8 show rainfalls at study area, rainfall is high every year on October to March. So, rainfall should be considered before conduct spraying herbicide on January to March, the rainfall is high. Because of position near equator, Indonesia generally has higher rainfall than other area at higher latitude.

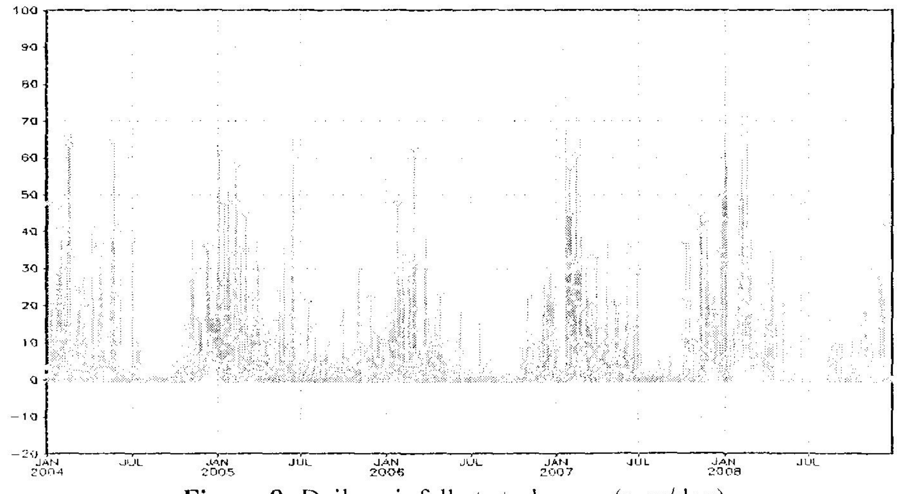

Figure 8 : Daily rainfall at study area (mm/day)

3.2 Aplication to determine sprayer setup to minimize spray drift

This application was developed to determine noozle size for sprayer. It expected can minimize drift on weed control. This simple application can be combined to agen of weed control system (Solahudin, 2013) to improve precision of spray application. The rule (IF – THEN) to decide which noozle that prefer to choose are acquired from weather criteria including temperature, humidity, wind speed and rainfall. Then experience weather data are stored in database.

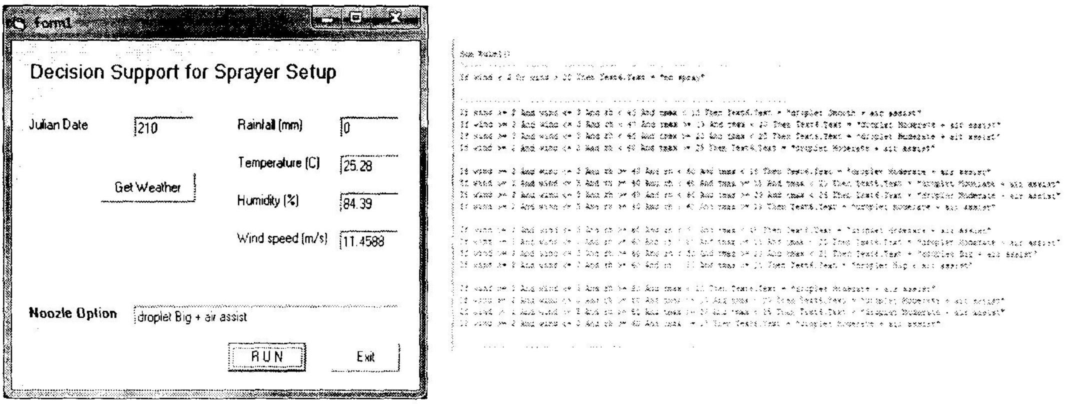

Figure 9 : Determination of sprayer setup using weather data

4. CONCLUSION

Weather data from satellite remote sensing can be used as decision support on complexity of weed control. Suitable times for spray application to avoid drift are January – March and July – September. But these are should be consider weather condition at these time. January – March have lower temperature with high rainfall and July – September have higher temperature with rare rainfall.

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