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Natural Chili *(Capsicum frutescens* L.) Cultivation to Mitigate Chili Leaf Curl Complex in North Sulawesi, Indonesia

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Abstract - *Farmers in North Sulawesi have experienced trauma in chili cultivation because epidemic of chili leaf curl complex (CLCC) have been occurred since 1982. This study aimed to determine the natural chili cultivation is more resistant to invasion of CLCC than monoculture chili cultivation. Experimental farms located in the village of Esandom, East Tombatu Subdistrict, Southeast Minahasa District, North Sulawesi. The trees that grow in the land fallow thinned, then made planting holes with a distance of about 2.5 meters and around the planting hole is cleaned. Monoculture of chilli cultivation in marshland. The number of sample units for sampling CLCC as much as 20% of the number of plants per farm. Population density monitoring of the insect predators and parasitoids that fly during the day performed using traps yellow sticky card and hand collection method, nocturnal insects were collected using pitfall traps. Density of other predators such as spiders, lizards, or garden-lizards calculated at five sample points on the diagonal sampling pattern. Species of plants in the natural farm identified and analyzed. CLCC severity on natural farming and monoculture, 0% and 100%, respectively. CLCC severity on natural farming systems is very low due to concentrations of sources were low and natural enemies have existed in the experimental farm.*

Index Terms - *chili leaf curl complex, disease severity, natural agriculture, Southeast Minahasa, North Sulawesi*

I. INTRODUCTION

Pest and disease epidemics on chili plants in North Sulawesi has been going for about 15 years (author observations). This phenomenon may occur due to the planting of chili and / or other hosts, especially the members of the family *Solanaceace* take place continuously. Negative aspects of *monocropping*, among others, the destruction of biological diversity, increased use of pesticides, and increase the sensitivity of plants to pathogens. Low biological diversity causing pests chance to find its host higher stimulus for vision, taste and smell are not confounded by other plant species, as well as insect predators and parasitoids populations is lower than in the natural farming system [1].

In July 2011 and May 2012, the author has conducted surveys of cropping conditions in some gardens chili peppers cultivated in monoculture farming system in Raringis, Tumaratas and Ampreng Villages (there are villages in the district of West Langowan, Minahasa regency), Kulo Village (North Tondano District, Minahasa Regency). Almost all of the trees in the area peppers suffered severe damage due to attack CLCC, and also because of the combination attacks between *Nezara viridula* L. and *Colletorichum gloeosporioides* (Penz.) Penz. & Sacc. CLCC associated with four insect pests, namely aphids, whiteflies, thrips and mites, and some viruses [2]. Planting conditions like this chili can also be found in the gardens of chilies in Ranowangko Two Village Two, District Kombi, Minahasa Regency and Modayag Village, Modayag District, East Bolaang Mongondow Regency. It is this factor which makes the farmers "advanced" in Minahasa reluctant to cultivate them*(the press. comm.).*

Observations of the author in March-May 2011 on wild chilies under banana trees and coconut in PTPN XIV (location contained in the District Tenga and Sinonsayang, South Minahasa Regency), showed healthy growth. This phenomenon also occurs in wild chilies trees in Pinili Village, District Dimembe, North Minahasa Regency; and in the village of Ranowangko Two, District Kombi, Minahasa Regency. Observations of wild chili were conducted by the author in Southeast Minahasa Regency in 2012 showed normal growth and free from CLCC. Based on this phenomenon, the research conducted cultivating chili peppers mimic wild habitat to mitigate the CLCC. Cropping patterns like this are included in the system of natural farming. Understanding natural farming system or natural agricultue system based on multiple sources as follows: (1) agricultural systems based on processes found in nature [3], (2) paragdima produce food by imitating nature [4], and (3) the system agriculture which does not cultivate the soil, compost made not ready, not weeds as plants penganggu,

and do not use pesticides because nature can create a balance so that pests and plant pathogens remain alive but never reaches a state that requires the application of pesticides [5].

Pests and plant pathogens in farms managed naturally reduced because it can create better conditions for predators and parasites, they will be less likely to leave this habitat because of the availability of nectar and pollen, ground cover (as habitat for some nocturnal insect predators) [6]. In addition to this, any pests landing on its host, the pest can not detect its host because the host volatile compounds are very small or substituted with volatile compounds from non-host plants, the source of inoculum dispersal and pest hampered, favorable microclimate, and soil health continuous [7, 8, 9, 10, 11].

This study aims to determine that natural chili cultivation more resistant to invasion CLCC than monoculture chili cultivation.

II. MATERIALS and METHODS

2.1 Time and Place of Research

Studies were conducted during the period October 2012 to August 2013 in of Esandom Village, East Tombatu Distric, Southeast Minahasa Regency, North Sulawesi, Indonesia (10^{0} 1`43.69``N, $124^{0}$ 72`53.48``E, elevation 311 m). The gardens are used for natural systems agriculture is the former garden planted with vanilla but have been left for 10 years so that in addition to the tree Gamal, *Glyricidia sepium*, also covered with various species of trees, shrubs and weeds. Topography of the garden range from 0^{o} to 30^{o} with an area of about 0.5 ha. North, West and South bordering the garden fallow *(fallow)* is the eastern border with irrigation channels and rice fields. monoculture chili farm are flat marshland that had been left for two years.

2.2 Research Procedure

2.2.1 Natural Cultivation of Local Chili Varieties

The trees that grow thinned, then the canopy is too dense reduced, and carried out selective logging in the bush - the flower is left. Just hoeing weeds around the planting holes with a diameter of 1 m. Weeds around the planting hole when trimmed up too high about 50 cm high at the beginning of the planting and approximately 100 cm by the time the plant will enter the generative phase. Weeds are cut into small pieces to be used as mulch around the planting hole.

Planting hole spacing is 2, 50 m, and the planting hole is made with size 30 x 30 x 30 cm, then left for one month. Mulch should not touch the trunk, especially on young plant stage.

Preparation of work procedures chilli seeds as follows:

(1). Choosing a ripe chilies (already colored red), fresh, perfect shape, unblemished and not disease.
(2). Slice the fruit lengthwise and remove the seeds and then put in a small pan of water. The seeds were taken and distributed settles over newsprint for dried for one to two days.
(3). Selecting a seed that has the shape, size and color of uniform, clean the skin surface, no wrinkles and no defects.

Seedling phases namely:

(1). Determine the seeding spot in the garden that is hard to find research by pests and pathogens.
(2). Cleaning brush and weeds then dug as deep as 25-30 cm to the soil becomes loose.
(3). Make the beds with a length of 7 m, a width of 2 m and a height of about 20 cm and let seven days.
(4). The day before and after sowing the seeds sown 50 cm shredded coconut around the beds so that the ants are not attracted to the seeds that will be planted.
(5). Watering the seed then sown seedbed evenly, then the seeds are covered with a thin layer of ash from the hole where the drying copra.

Chilli seeds was three months removed by plugging a small shovel around the seedlings to below the rooting then removed the seeds with soil and place in a plastic pan.The seeds are planted in the planting holes that had been prepared earlier. Planting is done in the afternoon of the rainy season. Plants die or grow poorly stitched after 1 - 1,5 months planted.

Plant maintenance includes weeding the weeds growing around the plants. Plants that have entered the phase of developments tied to the wooden pieces around plants or wood that is attached around the plants so as not to fall down. In the maturation phase of the pieces of fruit spread rat poison bait Petrokum 0,005 BB in the entire garden experiment. The distance between the pieces of this poison is about six meter.

2.2.2 Planting Monoculture Local Chili Varieties

Procedures chili cultivation in monoculture in wetlands as described by [12]. The difference is only in maintenance because the study was not performed pesticide applications, and to drive away the birds eating chilies installed a scarecrow.

2.3 Observation, Sampling, Parameter and Data Analysis

2.3.1 Analysis of Vegetation

Observations and sampling of plant species as yet unknown species carried on observation plots measuring 1 x 1 m were located along the Z-shaped intersek lines at intervals of 10 m [13, 14]. The specimens were sent to the Herbarium Lab Studies Program Agroecotechnology to be identified.

Parameters were calculated that plant species diversity and uniformity. Measurement of diversity of plant species using the formula proposed by Shannon and Wiener [15], and the uniformity of plant species is calculated based on the formula Peilous Index [16].

2.3.2 Density Plant Pest Organisms

Sampling pattern on natural farming system using zig-zag pattern or Z because the garden like a trapezoid shape [14], and the frequency of sampling is done every week for four months. The total sample of 20% of the population of chilli plants.

Observations made by closing the morning with a chilli tree suddenly and enter hand to reveal if there are pests that hide in certain plant organs. Variables include the observation of the presence or absence of pests on each unit of the sample, the number of nymphs and adults.

The pattern of sampling, sample size, sampling frequency, hours of observation, sampling techniques and variable insect observations on monoculture farming systems as natural farming system, except in the sampling pattern by using a garden because the U-shaped pattern of squares [14].

2.3.3 Quantification of CLCC

Observations of damage CLCC by category damage done one week after planting with a time interval of one month. Planting peppers in monoculture and naturally each done in December 2011 and February 2013, respectively. Category damage used according to the formula proposed by [2], namely:

$$SP/H = \frac{\sum (v \times n)}{N \times Z} \times 100\% \quad \text{..... 1}$$

where, SP / H: severity of disease and / or pest

v : The numerical value of each category of damages

n : Number of trees chillies in a category of damage

N : The total number of trees observed chili

Z : Number of scale or the highest damage category

Damage category	Description of Damage
0	No symptoms
1	10% canopy showed symptoms of illness
2	11-40% canopy showed symptoms of illness
3	41-70%% canopy showed symptoms of illness
4	> 75% canopy showed symptoms of illness

2.3.4 Population Density Insect Predators, Parasitoids and Collections

Monitoring insect population density of predators and parasitoids that fly during the day performed using traps *"yellow sticky cards"*. This efficient trap for monitoring population density of aphids, thrips, white-flies, fruit flies, leafhoppers, beetles, and insects such as predators and parasitoids useful [17]

Insects are particularly active night crawling and walking can be collected using *pitfall traps* [18, 19]. Trap is a third small plastic pots filled with soapy water and buried in the soil up to the brim. The top of the trap is given a zinc roof so that rain water does not enter the *pitfall.*

These traps were placed at five points according to the diagonal line, the four near the ends of the diagonal line and one at the intersection of the diagonal line for about 14 hours. Laying pitfall traps made on the vegetative growth stage and the stage of the fruit reaches its final size *(reaching the final fruit size).* Insects caught cleaned of dirt, then put in a pot containing 70% alcohol to be identified in the laboratory.

Sampling insect predators and parasites are also performed in conjunction with the sampling of insect pests (sample unit is covered with an insect net suddenly) and using*hand collection method.* Trapped insects and parasitoids that emerged from the host preserved and / or packed by way of collection and preservation of insects found in "How to Collect and Preserve Specimens for Identification" [20]. Insects larger than aphids or hard-bodied insects are placed in an appropriate sized plastic containers such as drug bottles after turned off in

the killing bottle. These drug bottles were sealed with cottons. Soft-bodied organisms such as aphids and mites taken with a paint brush and put into small drug bottles containing rubbing alcohol (70% alcohol).

Density of other predators such as spiders, lizards, or garden-lizards calculated based on sampling at five sampling points diagonal pattern examples. Sampling is done on vegetative and generative phase (the fruit reaches its final size).

III. RESULTS AND DISCUSSION

Analysis of the vegetation in natural chili garden is done by estimating the diversity and uniformity of plant species. The total number of plant species were sampled on natural chili garden is 20, and the total number of individuals of all species of these plants is 268. Plant diversity index Shannon-Wiener (H ') in natural chili garden is 2.30, meaning that plant diversity in this garden is classified as medium level. The diversity of plant species (E), which is 2.30, meaning that each plant species spread evenly.

Infestation *M. persicae* on chili as a sample of 80 trees in the garden cultivating chili peppers with the natural system is presented in Table 3.1, and the infestation of *A.dispersus* occurs only on one tree that is 35 individuals in June 2013, while in July 2013 left behind by one individual and in August 2013 was not seen again. In the garden chili with monoculture system, infestation *M. persicae* and *A. dispersus* continued to increase until the last months of observation (Appendix 3.1 and 3.2).

TABLE 3.1
INFESTATION DYNAMICS *M. persicae* ON NATURAL CHILI GARDEN
FROM MAY - AUGUST 2013

Chili Tree to:	Population Density of *M. persicae*(Nymphs + Adults) at:			
	May	June	July	August
18		26	0	
19		52	0	
28		9	0	
35	6	0		
45			108	0
71			30	0

Information from Table 3.1 is the number of trees attacked by *M. persicae* only six trees or only 7.50%, but in the next month observation aphid population was not seen again, and the trees were attacked this chili is recovered growth and no symptoms of a virus attack. This phenomenon occurs also in *A. dispersus.* Assessment of CLCC severity on chili farming with the cultivation of the natural pattern is 0%, a stark contrast when compared with the monoculture farming system that is 100%.

Some researchers suggested that the higher diversity of plants in a garden, the lower the pests and pathogens [21, 22, 23]. Such gardens, pests and plant pathogens remain alive but never reaches a state in which toxic chemicals must be applied [5].

Phenomena in the natural chillies cultivation system could occur because of the possibility of (1) pest miss-landing, (2) the concentration of *volatile* compounds (volatile) of chilli plants are very small or substituted with volatile compounds from non-host plants, (3) natural enemies more, (4) the spread of diseases and pests cause stunted, (5) favorable microclimate, and (6) continuous soil health.

Most of the cultivated plants that originated from wild plants that are not normally visible to herbivorous (plant-eating) in a variety of community [8]. Agriculture supports the concentration of a particular plant species, meaning plants that previously was not seen to be very visible. High density planting and weeding strongly contribute to the appearance of a higher plant [11]. Further explanation of the herbivores can not see the host proposed by [9] that herbivorous insects landed indiscriminately on green surfaces but avoid surface-brown like the ground surface, so there is a possibility of this insect landed on its host plant instead. Therefore, high plant with another plant species around it needs to be higher so that the insect pests can not find the host plant.

The principle is similar to the vision hypothesis "resource concentration", ie, in the case of monoculture cues from the source (plant) longer diluted or mixed with cues from other plant species, whereas the composition of the natural farming system allows the host *volatile* compounds substituted with compounds of non-host plants and / or from other sources so that insect pests can not detect the presence of its host [7]. According to [24] that a mixture of volatile compounds with a host plant volatile compounds from plants lead to a non-host herbivores do not recognize its host [25, 26].

In accordance with the observations of natural enemies showed that the natural enemies of insect pests more on natural chilli cultivation systems because the habitats of wild (naturally) gives shelter to the natural enemies

of plant pests, including predators such as spiders, lizard, garden-lizards, dragonflies, frogs, weaver ants, fire ants, black ants, birds 'Bantik', crow. snakes, and parasitoids. In particular habitats consisting of annual and perennial vegetation can serve as a source of pollen and nectar for insect parasitoids. Long life and fertility parasitoids was significantly increased when nectar is available.

A high diversity of plant species in a garden also tend to prevent viral infection in plants - 89% of viruses are transmitted by insect herbivores. The higher plant species diversity can reduce abundance of viral vectors [30]. *M. persicae and A. dispersus* that attack some chili trees in natural garden do not bring chili pathogenic viruses because these pests be move from other plant species in the vicinity that do not contain the virus. Various plant species in a chili garden are served as a barrier in dispersal of insect pests and pathogens, and may be met by natural enemies such as spiders are found in many plants and herbs chili around .

IV. CONCLUSION

From these results, several major conclusions as follows: (1) a population of *M. persicae* and *A. dispersus* on natural farming system disappear after one month they infest peppers, contrary to the monoculture of their population continues to increase, and (2) severity of CLCC on natural farming system zero percent, while the monoculture system 100 percent. CLCC severity at zero percent in natural agricultural systems may be due to the population *of M. persicae* and *A. dispersus* not from chili infected with the virus, the source concentration is low and natural enemies that already exist in the experimental garden.

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APPENDIX 3.1
POPULATION DYNAMICS OF *M. persicae* ON MONOCULTURE CHILI CULTIVATION FROM APRIL TO JULY 2013

Chili Trees To:	Population *M. persicae* on the Moon:			
	April	May	June	July
1	0	0	0	5
2	0	0	1	8
3	0	0	1	7
4	0	3	11	28
5	2	10	21	30
6	0	5	12	25
7	0	0	0	4
8	0	0	0	2
9	0	0	1	7
10	0	0	0	1
11	0	0	0	6
12	0	0	0	4
13	0	0	0	1
14	3	0	17	33
15	0	0	6	12
16	0	0	0	3
17	0	0	0	3
18	0	0	0	7
19	0	0	0	4
20	0	0	0	22
21	0	7	22	63
22	0	0	4	18
23	0	0	10	21
24	0	0	1	11
25	0	5	12	29
26	0	0	3	17
27	0	0	0	7
28	0	0	0	6
29	0	0	0	11
30	0	0	4	13
31	0	0	0	16
32	0	0	7	30
33	0	0	0	11
34	0	0	0	9
35	0	0	3	17
36	0	0	2	14

37	0	0	0	3
38	0	0	0	7
39	0	0	4	17
Continued				
40	0	0	0	3
41	0	0	0	3
42	0	0	0	2
43	0	0	0	9
44	0	2	11	30
45	0	0	3	14
46	0	0	0	12
47	0	0	2	19
48	0	0	0	7
49	0	4	5	18
50	0	0	0	8
51	0	0	0	3
52	0	0	0	3
53	0	0	0	6
54	0	7	20	48
55	0	0	0	16
56	0	0	11	33
57	0	0	0	7
58	0	0	4	16
59	0	0	0	4
60	0	0	2	15
61	0	0	0	3
62	0	0	0	4
63	0	0	0	7
64	0	0	3	13
65	0	0	0	2
66	0	0	0	16
67	0	0	2	19
68	0	0	0	5
69	0	3	10	30
70	0	0	0	4
71	0	0	0	7
72	0	0	0	11
73	0	0	0	6
74	0	0	0	9
75	0	2	0	22
76	0	0	7	11
77	0	0	0	8
78	0	0	1	3
79	0	0	0	3
80	0	0	0	6

APPENDIX 3.2
POPULATION DYNAMICS OF *A. dispersus* ON MONOCULTURE CHILI CULTIVATION FROM APRIL TO AUGUST 2013

Chilli Tree to:	Population Densities of A. *dispersus*(Nymphs + Adults) on:				
	April	May	June	July	August
8	3	7	11	15	20
16			5	9	13
22	5	8	12	20	29
32				3	9
50					4
65				2	10
78			7	15	27