Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; Sp 9(4): 454-459
Received: 04-05-2020
Accepted: 06-06-2020

PB Suryavanshi
Assistant Professor
Department of Agrometeorology
DP COA, Dahegaon,
Maharashtra, India

NV Kashid
Officer in-Charge, Agricultural Research Station Farm, Vadgaon Maval, Tal- Maval, Dist- Pune, Maharashtra, India

SS Misal
Research Associate,
CASST-CSAWM, MPKV,
Rahuri, Maharashtra, India

KA Rewale
Assistant Professor, Department of Plant Pathology DP COA, Dahegaon, Maharashtra, India

Corresponding Author:
PB Suryavanshi
Assistant Professor
Department of Agrometeorology
DP COA, Dahegaon,
Maharashtra, India

Effect of weather parameters on pest incidence of summer paddy varieties: Indrayani and Phule Samruddhi

PB Suryavanshi, NV Kashid, SS Misal and KA Rewale

Abstract
The present investigation entitled "Effect of weather parameters on pest incidence of summer paddy varieties" was carried out during summer, 2014 at Agricultural Research Station farm, Vadgaon Maval, Tal- Maval, Dist- Pune. The field experiment was laid out in a split plot design with three replications. There were Eight treatment combinations comprising of two varieties VDN-3-51-18 (Indrayani), VDN-99-29 (Phule Samruddhi as main plot treatments and four fertilizer levels (F1-75% RDF through straight fertilizers, F2-100% RDF through straight fertilizers, F3-125% RDF through straight fertilizers and F4-RDF through Urea DAP form (57:29:00)+50 KgK2O) as sub plot treatments. The gross and net plot size were 2.95 m x 2.95 m and 2.55 m x 2.55 m, respectively. A spacing of 15-25 cm x 15-25 cm was adopted. Pest incidence and pest intensity (%) was lower in VDN-99-29 (Phule Samruddhi) followed VDN-3-51-18 (Indrayani) and higher incidence with IET-13549 (Bhogawati) and RDN-99-1 (Phule Radha). Pest Incidence and pest intensity (%) was more with fertilizer levels of 75% RDF through straight fertilizers and lower with fertilizer through Urea DAP briquette form (57:29:00)+50KgK2O. There was positive correlation between maximum temperature, morning relative humidity, BSS and canopy temperature and incidence of leaf folder, stem borer and brown plant hopper but negative correlation with minimum temperature, evening relative humidity, growing degree day.

Keywords: Summer, fertilizer, weather, pest

Introduction

Rice feeds more people over a longer period of time than any other crop. Rice has been documented in the history books as a source of food and for tradition as well since 2500 B.C. Beginning in China and the surrounding areas, its cultivation spread throughout Sri Lanka and India. It was then passed into Greece and areas of the Mediterranean. Rice spread throughout Southern Europe and to some part of North Africa. From Europe rice was brought to the New World. From Portugal it was brought into Brazil and from Spain to Central and South America. Rice belongs to the genus *Oryza* and family *Poaceae*. It has two cultivated and 22 wild species. The cultivated species are *Oryza sativa* and *Oryza glaberrima*. *Oryza sativa* is grown all over the world while *Oryza glaberrima* has been cultivated in West Africa for the last 3500 years. From an early history in the Asian areas rice has spread and is now grown on all continents except Antarctica. Being able to grow in this wide spectrum of climates is the reason that why rice is one of the most widely eaten foods of the world. About 85% of the rice produced in the world is used for direct human consumption. The UN/FAO forecasts that global food production will need to increase by over 40% by 2030 and 70% by 2050. Yet globally, water is anticipated to become scare and there is increasing competition for land, putting added pressure on agricultural production. In addition, climate change will reduce the reliability of food supply through altered weather patterns and increased pressure from pests and diseases. Rice along with wheat from the bedrock of Indian food security and to meet the country's stated goal of ensuring food for all, farmer will have to produce more rice from lesser land, using less water, energy and other inputs and keeping in harmony with the fragile environment. For obtaining the higher summer paddy production study of crop in relation to weather condition and pest and diseases infestation is very necessary. As 2 ^{0}C increase in air temperature could decreased rice yield by about 0.75 tons ha^{-1} in high yielding area. There is 5% decrease in rice yield for every 1 ^{0}C rise in temperature above 32 ^{0}C. Attack of pest and disease is totally depends on weather condition and host abundance (Khan and Ram Murthy, 2004) have reported that, minimum temperature and rainfall had significant effect on leaf folder population structure in paddy.

Material and Methods
Details of the experimental material
Experimental site
The field experiment was conducted during *summer*, 2014 at Agricultural Research Station Farm, Vadgaon Maval, Tal. Maval, Dist. Pune.

Soil
The topography of the experimental field was uniform and leveled. The soil was clay loam in texture with a depth upto60 cm. In order to know the physical and chemical properties of the experimental soil, representative composite samples from 0 to 30 cm depth were taken from randomly selected spots in zig-zag fashion before transplanting with the help of screw auger. These samples were mixed together and air-dried under shade. A representative soil sample was prepared for determining physical and chemical properties of the experimental soil.

Climatic conditions
Maximum temperature (^{0}C): The maximum temperature was recorded with the help of maximum thermometer kept in Single Stevenson's screen from observatory.

Minimum temperature (^{0}C): The minimum temperature was recorded with the help minimum thermometer kept in Single Stevenson's screen from observatory.

Humidity (%): The humidity was recorded with the help of dry bulb and wet bulb thermometer kept i Single Stevenson's screen from observatory.

Bright sunshine (hrs.): Bright sunshine hours were recorded with the help of bright campbell stokes sunshine recorder from observatory.

Canopy temperature (^{0}C): The infrared thermometer was used to measure the canopy temperature remotely.

Theory of operation: It detects minute difference between crop canopy and surrounding air temperature. Telatemp (model AG-42) was used for measurement of canopy temperature and canopy-air temperature differential in this experiment.

Working principle: The energy flux emitted by an object is a function of its absolute temperature. The infrared thermometer senses long wave radiation emitted by the object and converts this value to a temperature scale according to Stefan's Law:

$$E = \varepsilon\sigma T^4$$

Where,
E = Energy flux, Wm^{-2}
ε = Emmissitivity of the body
σ = Stefan Boltzman constant = (5.67×10^8 Wm^{-2} K^{-4}),
T= Absolute Temperature of the body, ^{0}K

Measuring temperature: To take temperature measurement, the instrument is held by grip, which promptly "come to life' as evidenced by the digital display.

Rainfall (mm): Rainfall was recorded with the help of automatic type of rain gauge from observatory.

Table 1: Details of treatment with their symbol

Sr. No.	Treatment Details	Symbol used
A.	**Main Plot treatments :Varieties(V)**	
1	VDN-3-51-18 (Indrayani)	V_1
2	VDN-99-29 (PhuleSamruddhi)	V_2
B.	**Sub Plot treatments:fertilizer levels (F)**	
1	75% RDF through straight fertilizer	F_1
2	100%RDF (100:50:50) through straight fertilizer	F_2
3	125%RDF through straight fertilizer	F_3
4	Fertilizer through Urea DAP briquette form (59:29:00)+50Kg K_2O ha^{-1}	F_4

Table 2: Treatment combinations (08)

1	V_1F_1	5	V_2F_1
2	V_1F_2	6	V_2F_2
3	V_1F_3	7	V_2F_3
4	V_1F_4	8	V_2F_4

Table 3: Preparation of field layout Theplan of layout are given below:

1.	**Name of crop**	:	**Paddy**
2.	Varieties	:	As per treatments
3.	Season	:	*Summer*, 2014
4.	Design	:	Split plot
5.	No. of Replications	:	Three
6.	Treatments	:	Eight
7.	Spacing	:	15-25 cm x 15-25 cm
8.	Plot size	:	Gross: 2.95 m x 2.95 m Net: 2.55 m x 2.55 m
9.	Place of research work	:	A.R.S. farm, Vadgaon Maval, Tal. Maval, Dist. Pune.
10.	Commencement of research work	:	*Summer*, 2014
11.	Transplanting date	:	2/1/2014
12.	Fertilizer	:	100:50:50 NPK kg ha^{-1}

Pest Observation

Leaf folder (*Cnaphalocrocis medinalis*)

Larvae consume the leaf tissue except the epidermis, causing typical white streaks. They create a leaf tube during later stages of feeding.

Used the following scale on the basis of the percentage of damaged leaves on a 0-9 scale.

Scale for leaf folder:	
0	No damage
1	1-10%
3	11-20%
5	21-35%
7	36-50%
9	51-100%

The observations were recorded a tillering, stem elongation, booting, heading, milk stage and dough stages.

Stem Borers (*Scirpophaga incertulas*)

Scale for stem borer (Dead hearts):	
0	No damage
1	1-10%
3	11-20%
5	21-30%
7	31-60%
9	61% and above
Scale for stem borer (White heads):	
0	No damage
1	1-5%
3	6-10%
5	11-15%
7	16-25%
9	26% and above

The observations for stem borer were recorded at tillering, stem elongation and booting (Dead hearts), and dough stage and grain mature stages (Whiteheads).

Brown plant hopper (*Nilaparvata lugens*)

Partial to pronounced yellowing of plant with increased severity of stunting. Extreme signs are wilting to death of plants. Infested areas in the field may be patchy.
The observations were recorded at tillering, stem elongation, booting, heading, milk stage, dough stage and mature grain stages.

Scale for brown plant hopper:

0	No damage
1	Very slight damage
3	First and 2nd leaves of most plants partially yellowing
5	Pronounced yellowing and stunting or about 10 to 25% of the plants wilting or dead and remaining plants severely stunted or dying
7	More than half of the plants
9	All plants dead

Result and Discussion

Correlation between weather parameters and incidence of pests

Correlation analysis of weather parameters and incidence of pests on paddy is given as follows:

On variety Indrayani (V_1)

a) Incidence of Leaf folder

Correlation of incidence of leaf folder with weather parameters at different varieties is presented in Table 4.
Correlation of incidence of leaf folder with weather parameters at 30 DAT revealed significant positive correlation with maximum temperature (r = 0.831**), RH-I(r = 0.674*) and BSS (r = 0.819**) indicating increase in canopy temperature (r = 0.872**), maximum temperature and BSS increased infestation of leaf folder. Significant negative correlation with minimum temperature(r = -0.632*), RH-II (r = -0.344), GDD (r = -0.859**) and indicated increase in RH-II, and GDD decrease infestation of leaf folder.
Correlation of incidence of leaf folder with weather parameters at 45 DAT revealed significant negative correlation with maximum temperature (r = 0.932**), RH-I(r = 0.780*) and BSS (r = 0.886**) indicating increase in canopy temperature (r = 0.671*), maximum temperature and BSS increased infestation of leaf folder. Significant negative correlation with minimum temperature(r = -0.324), RH-II (r = -0.246), GDD (r = -0.531*) and indicated increase in Tmin, RH-II, and GDD decrease infestation of leaf folder. Correlation of incidence of leaf folder with weather parameters at 75 DAT revealed significant positive correlation with maximum temperature (r = 0.818**), RH-I(r = 0.426) and BSS (r = 0.698*) indicating increase in canopy temperature (r = 0.423), maximum temperature and BSS increased infestation of leaf folder. Significant negative correlation with minimum temperature(r = -0.839**), RH-II (r = -0.452), GDD (r = -0.715*) and indicated increase in Tmin, RH-II, and GDD decrease infestation of leaf folder.
Correlation of incidence of leaf folder with weather parameters at 90 DAT revealed significant positive correlation with maximum temperature (r = 0.764*), RH-I(r = 0.528*) and BSS (r = 0.525*) indicated increase in canopy temperature (r = 0.734**), maximum temperature and BSS increased infestation of leaf folder. Significant negative correlation with minimum temperature(r = -0.525*), RH-II (r = -0.899**), GDD (r = -0.641*) and indicated increase in Tmin, RH-II, and GDD decrease infestation of leaf folder.
Correlation of incidence of leaf folder with weather parameters at harvest revealed significant positive correlation with maximum temperature (r = 0.674*), RH-I(r = 0.261) and BSS (r = 0.432) indicated increase maximum temperature and BSS increased infestation of leaf folder. Significant negative correlation with minimum temperature (r = -0.774*), RH-II (r = -0.948**), GDD (r = -0.863**) and in canopy temperature (r = 0.674*), indicated increase in Tmin, RH-II, canopy temperature and GDD decrease infestation of leaf folder.

b) Incidence of brown plant hopper

Correlation of incidence of brown plant hopper with weather parameters at different varieties is presented in Table 4.
Correlation of incidence of brown plant hopper with weather parameters at 30 DAT showed significant positive correlation with maximum temperature (r = 0.831**), RH-I (r = 0.482) and BSS (r = 0.236), canopy temperature (r = 0.437) indicated increase in maximum temperature, BSS and canopy temperature increased in infestation of brown plant hopper . On the other hand significant negative correlation was observed with minimum temperature (r = -0.583*), RH-II (r = -0.759*), and GDD(r = -0.912**) indicated increase in these meteorological element decreased infestation of brown plant hopper.
Correlation of incidence of brown plant hopper with weather parameters at 45 DAT revealed significant positive correlation with T max (r = 0.846**) RH-I (r = 0.721*), BSS (r = 0.462) and canopy temperature (r = 0.551*) indicated increased maximum temperature and BSS increases in

infestation of stem borer and significant negative correlation with T min (r = -0.943**), RH-II (r = -0.283) and GDD (r = -0.748*) and indicated increase in T min, RH-II and GDD decreased infestation of brown plant hopper.
Correlation of incidence of brown plant hopper with weather parameters at 60 DAT revealed significant positive correlation with T max (r = 0.742*), RH-I (r = 0.562*), BSS (r = 0.324) and canopy temperature (r = 0.746*) indicated increased maximum temperature and BSS increases in infestation of stem borer and significant negative correlation with T min (r = -0.445), RH-II (r = -0.457) and GDD (r = -0.776*) and indicated increase in T min, RH-II and GDD decreased infestation of brown plant hopper.
Correlation of incidence of brown plant hopper with weather parameters at 75 DAT revealed significant positive correlation with T max (r = 0.949**) RH-I (r = 0.424), BSS (r = 0.554*) and canopy temperature (r = 0.455) indicated increased maximum temperature and BSS increases in infestation of stem borer and significant negative correlation with Tmin (r = -0.311), RH-II (r = -0.388) and GDD (r = -0.899**) and indicated increase in T min, RH-II and GDD decreased infestation of brown plant hopper.
Correlation of incidence of brown plant hopper with weather parameters at 90 DAT revealed significant positive correlation with T max (r = 0.714*), RH-I (r = 0.628*), BSS (r = 0.143) and canopy temperature (r = 0.723*) indicated increased maximum temperature and BSS increases in infestation of stem borer and significant negative correlation with T min (r = -0.666*), RH-II (r = -0.886**) and GDD (r = -0.798*) and indicated increase in T min, RH-II and GDD decreased infestation of brown plant hopper.

Table 4: Correlation between weather parameters and pests of paddy on variety Indrayani

Particular	Leaf folder						Brown plant hopper					
Climatic factor	**30DAT**	**45DAT**	**60DAT**	**75DAT**	**90DAT**	**At harvest**	**30DAT**	**45DAT**	**60DAT**	**75DAT**	**90DAT**	**At harvest**
T max	0.831**	0.932**	0.742*	0.818**	0.764*	0.674*	0.831**	0.846**	0.742*	0.949**	0.714*	0.836**
Tmin	-0.632*	-0.324	-0.477	-0.839**	-0.595*	-0.774*	-0.583*	-0.943**	-0.445	-0.311	-0.666*	-0.539*
RH-I	0.674*	0.780*	0.123	0.426	0.528*	0.261	0.482	0.721*	0.562*	0.424	0.628*	0.514*
RH-II	-0.344	-0.246	-0.776*	-0.452	-0.899**	-0.948**	-0.759*	-0.283	-0.457	-0.388	-0.886**	-0.434
BSS	0.819**	0.886**	0972**	0698**	0.525**	0.432	0.236	0.462	0.324	0.554**	0.143	0.852**
Canopy temp	0.872**	0.671*	0.596*	0.423	0.734*	0.674*	0.437	0.551*	0.746*	0.455	0.723*	0.636*
GDD	-0.859**	-0.531*	-0.599*	-0.715*	-0.641*	-0.863**	-0.912**	-0.748*	-0.776*	0.899**	-0.798*	-0.916**

* significant at 5% levels
* significant at 1% levels

On variety Phule Samruddhi

a) Incidence of leaf folder

Correlation of incidence of leaf folder with weather parameters at different varieties is presented in Table 5.
Correlation of incidence of leaf folder with weather parameters at 30 DAT revealed significant positive correlation with T max (r = 0.984**), RH-I (r = 0.654*), BSS (r = 0.972**) and canopy temperature e (r = 0.582*) and indicated increase in T max and BSS increased infestation of leaf folder. On the other hand significant negative correlation was noticed with, T min (r = -0.534*), RH-II (r = -0.639*), GDD(r = -0.666*) and indicated increase in these parameters resulted in decreased infestation of leaf folder.
Correlation of incidence of leaf folder with weather parameters at 45 DAT revealed significant positive correlation with T max (r = 0.864**),RH-I (r =0.716*), BSS (r = 0.846**) and canopy temperature (r = 0.834**) and indicated increase in T max and BSS increased infestation of leaf folder. On the other hand significant negative correlation was noticed with, T min (r = -0.857**), RH-II (r = -0.528*), GDD (r = -0.837**) and indicated increase in these parameters resulted in decreased infestation of leaf folder.
Correlation of incidence of leaf folder with weather parameters at 60 DAT revealed significant positive correlation with T max (r = 0.909**), RH-I (r = 0.412), BSS (r = 0.984**) and canopy temperature (r = 0.728*) and indicated increase in T max and BSS increased infestation of leaf folder. On the other hand significant negative correlation was noticed with, T min (r = -0.534*), RH-II (r = -0.233), GDD(r = -0.493) and indicated increase in these parameters resulted in decreased infestation of leaf folder.
Correlation of incidence of leaf folder with weather parameters at 75 DAT revealed significant positive correlation with T max (r = 0.752*), RH-I (r = 0.623*), BSS (r = 0.762*) and canopy temperature (r = 0.862**) and indicated increase in T max and BSS increased infestation of leaf folder. On the other hand significant negative correlation was noticed with, T min (r = -0.725*), RH-II (r = -0.456), GDD (r = -0.785*) and indicated increase in these parameters resulted in decreased infestation of leaf folder.
Correlation of incidence of leaf folder with weather parameters at 90 DAT revealed significant positive correlation with T max (r =0.894**), RH-I (r = 0.484), BSS (r = 0.836**) and canopy temperature (r = 0.482) and indicated increase in T max and BSS increased infestation of leaf folder. On the other hand significant negative correlation was noticed with, T min (r = -0.662*), RH-II (r = -0.886**), GDD (r = -0.858**) and indicated increase in these parameters resulted in decreased infestation of leaf folder.
Correlation of incidence of leaf folder with weather parameters at harvest revealed significant positive correlation with T max (r=0.861**), RH-I (r = 0.669*), BSS (r = 0.443) and canopy temperature (r=0.591*) and indicated increase in T max and BSS increased infestation of leaf folder. On the other hand significant negative correlation was noticed with, T min (r = -0.388), RH-II (r = -0.651*), GDD(r = -0.533*) and indicated increase in these parameters resulted in decreased infestation of leaf folder.

b) Incidence of brown plant hopper

Correlation of incidence of brown plant hopper with weather parameters at different varieties is presented in Table 5.
Correlation analysis of incidence of brown plant hopper with weather parameters at 30 DAT revealed significant positive correlation with T max (r = 0.651*), RH-I (r = 0.789*),BSS (r = 0.643*) and canopy temperature (r = 0.193) indicated increase in T max and RH-I increased infestation of brown plant hopper and significant negative correlation with Tmin (r = -0.488), RH-II (r = -0.851**),GDD (r = -0.843**) and indicated increase in Tmin, RH-II, and canopy temperature decreased infestation of brown plant hopper.

Correlation of incidence of brown plant hopper with weather parameters at 45 DAT revealed significant positive correlation with T max (r = 0.948**), and RH-I (r = 0.716*), BSS (r = 0.736*) and canopy temperature (r = 0.634*) indicated increase in T max and RH-I increased infestation of brown plant hopper and significant negative correlation with Tmin (r = -0.984*), RH-II (r = -0.428), GDD (r = -0.437) and indicated increase in Tmin, RH-II, and canopy temperature decreased infestation of brown plant hopper.

Correlation of incidence of brown plant hopper with weather parameters at 60 DAT revealed significant positive correlation with T max (r = 0.891**), and RH-I (r = 0.821**), BSS (r = 0.434) and canopy temperature (r = 0.533*) indicated increase in T max and RH-I increased infestation of brown plant hopper and significant negative correlation with Tmin (r = -0.534*), RH-II (r = -0.223),GDD (r = -0.529*) and indicated increase in Tmin, RH-II, and canopy temperature decreased infestation of brown plant hopper.

Correlation of incidence of brown plant hopper with weather parameters at 75 DAT revealed significant positive correlation with T max (r = 0.552*), RH-I (r = 0.628*),BSS (r = 0.692*) and canopy temperature (r = 0.742*) indicated increase in T max and RH-I increased infestation of brown plant hopper and significant negative correlation with Tmin (r = -0.614*), RH-II (r = -0.861**),GDD (r = -0.518*) and indicated increase in Tmin, RH-II, and canopy temperature decreased infestation of brown plant hopper.

Correlation of incidence of brown plant hopper with weather parameters at 90 DAT revealed significant positive correlation with T max (r = 0.661*), RH-I (r = 0.388),BSS (r = 0.757*) and canopy temperature (r = 0.438) indicated increase in T max and RH-I increased infestation of brown plant hopper and significant negative correlation with Tmin (r = -0.134), RH-II (r = -0.851**),GDD (r = -0.828**) and indicated increase in Tmin, RH-II, and canopy temperature decreased infestation of brown plant hopper.

Correlation of incidence of brown plant hopper with weather parameters at harvest revealed significant positive correlation with T max (r = 0.781*), RH-I (r = 0.789*),BSS (r = 0.933**) and canopy temperature (r = -0.863**) indicated increase in T max and RH-I increased infestation of brown plant hopper and significant negative correlation with Tmin (r = -0.388), RH-II (r = -0.751*),GDD (r = -0.233) and indicated increase in Tmin, RH-II, and canopy temperature decreased infestation of brown plant hopper.

Table 5: Correlation between weather parameters and pests of paddy on variety VDN-99-29 (PhuleSamruddhi)

Particular	**Leaf folder**						**Brown plant hopper**					
Weather Prameters	**30DAT**	**45DAT**	**60DAT**	**75DAT**	**90DAT**	**At harvest**	**30DAT**	**45DAT**	**60DAT**	**75DAT**	**90DAT**	**At harvest**
Tmax	0.984**	0.864**	0.909**	0.752*	0.894**	0.861**	0.651*	0.948**	0.891**	0.552*	0.661*	0.781*
Tmin	-0.534*	-0.857**	-0.534*	-0.725*	-0.662*	-0.388	-0.488	-0.984**	-0.534*	-0.614*	-0.134	-0.388
RH-I	0.654*	0.716*	0.412	0.623*	0.484	0.669*	0.789*	0.716*	0.821**	0.628*	0.388*	0.789*
RH-II	-0.639*	-0.528*	-0.233	-0.456	-0.886**	-0.651*	-851**	-0.428	-0.223	0.861**	-0.851**	-0.751*
BSS	0.972**	0.846**	0.984**	0.762*	0.836**	0.433	0.643*	0.736*	0.434	0.692*	0.757*	0.933**
Canopy temp.	0.582*	0.834**	0.728	0.862**	0.482	0.591*	0.193	0.634*	0.533*	0.742*	0.438	0.863**
GDD	-0.666*	-0.837*	-0.493	-0.785*	-0.858**	-0.533*	-0.843**	-0.437*	-0.529*	-0.518*	-0.828**	-0.233

* Significant at 5% levels
* Significant at 1% levels

Conclusions

Pest incidence and pest intensity (%) was lower in VDN-99-29 (Phule Samruddhi) followed VDN-3-51-18 (Indrayani) Pest Incidence and pest intensity (%) was more with fertilizer levels of 75% RDF through straight fertilizers and lower with fertilizer through Urea DAP briquette form (57:29:00)+50KgK_2O. There was positive correlation between maximum temperature, morning relative humidity, BSS and canopy temperature and incidence of leaf folder, stem borer and brown plant hopper but negative correlation with minimum temperature, evening relative humidity, growing degree day.

References

1. Abe I, Ono K, Toriyama K, Wada J. Ecological studies on the establishment of regionality in early planting culture and great harvest of rice plant (translated title, English summary). Part I. Relation between the regionality of climate and growth of rice plant in Aomori Prefecture, Nogyo Kosho Agricultural Meteorology Journal. I960; l6:99-105.
2. Chiu TF, Lina S, Hsu SC. Studies on nutrient absorption of rice plants in Taiwan. II, Nutrient absorption by Japonica and indica varieties of rice in relation to temperature. Taiwan Agricultural Research Journal. 196I; 10(1):7-20.
3. Dyck VA, Misra BC, Alam S, Chen CN, Hsieh CY, Rejesus RS. Ecology of the brown plant hopper in the tropics. Los Baños (Philippines): International Rice Research. Institute, 1997, 61-98.
4. Fujiwara A, Ishida H. Nutrio-physiological studies on low temperature damaged rice plants. 3. Effects of soil and air temperature or day and night temperature treatment on growth and nutrioht uptake of rice plants at the highest tillering stage. Soil Science and Plant Nutrition. 1963; 9(6):38.
5. Heong KL, Song YH, Pimsamarn S, Zhang R, Bae SD. Global Warming and Rice Arthropod Communities In: Climate Change and Rice. (Eds. Peng, S., Ingram, K.T., Neue, H.U. and Ziska, L.H.), Springer publications, Berlin: 1995, 327-335
6. Kushwaha KS, Sharma SK. Relationship of date of transplanting, spacing and levels of nitrogen on incidence of rice leaf folder. Indian journal of Entomology. 1983; 43(3):338-339.
7. Matsushima S, Tsunoda K. Analysis of developmental factors determining yield and application to yield prediction and culture improvement of lowland rice. XLIX. Effects of irrigation water temperature and its daily range in different stages upon the growth, grain yield, and constitutional factors in rice plants. Crop Science Society of Japan Proceedings. 1959; 27:357-358.
8. Munakata K. Effects of temperature and light on the reproductive growth and ripening of rice. In: Proc Symp.-sium on Rice and Climate. IRRI, Los Banos. 1976, 187-210.

9. Muhamad R, Chung GT. The relationship between population fluctuations of Helopeltis theivora Waterhouse, availability of cocoa pods and rainfall pattern. Journal Tropical Agricultural Science. 1993; 16(5):81-86
10. Nishiyama I. Effect of temperature on the vegetative growth of rice plants. In: Proc Symp. on Rice and Climate. IRRI Los Banos, 1976, 159-185.
11. Nair KPV, Mammen KV, Pillai KB, Nair SS. Influence of climatic factors on population of the brown plant hopper in Kuttanand. Agricultural Research Journal, Kerala. 1980; 18(1):55-60.
12. Nuttonson MY. Rice culture and rice-climate relationship with special reference to the United States rice areas and their latitudinal and thermal analogues in other countries, Washington, D.C., American Institute of Crop Ecology, I965.
13. Reddy MS, Rao PK, Rao BHK, Rao GN. Preliminary studies on the seasonal prevalence of certain Homoptera occurring on rice at Hyderabad. Indian Journal of Entomology. 1983; 45(1):20-28.
14. Satoh Y. Relations between constituents of rice yields and meteorological factors. Agricultural Meteorology Journal Japan. 1964; 19(3):85-88.
15. Suzuki S, Moroyu H. Effect of high-night temperature treatment on the growth of rice plant with special reference to its nutritional condition. Japan Chugoku Agricultural Experiment Station, Bulletin A, 1962; 8:269-290.
16. Yamakawa Y. Observations on air, water, and soil temperatures in paddy field and carbon black powder test as a method of lowering the field temperatures in Malaya (translated title, English summary). Journal of Agrometerology. I960; l6:106-110.
17. Yoshida S, Parao. Tropical climate and its influence on rice. IRRI Research, 1978; 20:7.