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RESEARCH ARTICLE

EFFECTS OF DIFFERENT WEATHER PARAMETERS ON INSECT PEST INCIDENCE IN PADDY IN SUNDARBAZAR LAMJUNG

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ABSTRACT

The study was conducted during the Kharif season i.e. from 3rd June to 19th Oct of 2019 to observe the effects of different weather factors in seasonal variation of insects in paddy plants. A fixed plot survey was carried out with altogether 39 plots count ($6 \times 6 \text{ m}^2$, total area $1,404 \text{ m}^2$). The analysis disclosed that the Rice gundi bug, Short-horned grasshopper, and Black bug were the most abundant insect pests of rice. Rice gundi bug showed different variations with the cardinal temperatures viz. negative, positive, and negative with T_{max} ($r = -0.319$), T_{min} ($r = 0.188$) and T_{avg} ($r = -0.099$) respectively. All were non-significant correlations. Similar was the case with relative humidity (max., min., avg.), as well as average rainfall. By the same token, the Black bug was significantly positively correlated with maximum temperature with $r = 0.622$ and also was in positive but insignificant correlation with all other parameters. Out of the total insects, 40% dominance was shown by the Short-horned grasshopper followed by the Black bug (19%) and Rice gundi bug (12%). Regular monitoring, using pest management strategy, forecasting of pest occurring situation, early plantation of crop could be the best ways to cope with an incidence of pests under different weather parameters.

KEYWORDS

weather factors, fixed plot survey, short-horned grasshopper, monitoring.

1. INTRODUCTION

Rice, the staple diet of more than half of the world's population, is farmed on more than 145 million hectares in more than 110 nations, accounting for nearly one-fifth of all cereal cropland. Rice is grown as far north as 53° N latitude on the USSR-China border and as far south as 39° S latitude in Central Argentina, making it largely a tropical and subtropical crop grown from sea level to altitudes of 3,000 m (Tripathi and Saxena, 2013). The crop is established either by direct sowing (broadcast or drilled) or by transplanting (Pathak and Khan, 1994). In context to Nepal, the total area is around 1.5 million ha, with average productivity of 3.8 t/ha and paddy rice production of 5.5 million tons in the year 2020 (MOALD, 2078). Rice production is being reduced due to some issues. Insect pests are among them, and they cause significant losses in terms of both quality and quantity (NARC, 1999). Although rice is infested by over 800 insect pests, only a few cause substantial harm and necessitate care. Insect pests cause a 25-30% reduction in rice output in Nepal (Adhikari et.al. 2018). More than 100 insect species attack rice plants, with 20 of them capable of causing economic harm. They infest all areas of the plant at all phases of development, and some even transmit viral illnesses (Pathak and Khan, 1994). The main rice pests in Nepal are brown planthoppers, leaf folders, grasshoppers, rice ear-head bugs, and yellow stem borers (Thapa and Tiwari, 2010).

Factors of the physical environment such as temperature, relative humidity, rainfall, etc have a significant effect on Insects as these factors are responsive to the development, population dynamics, and survival of insects. Insects are cold-blooded so are directly under the control of

temperature for their growth. They are also very sensitive to desiccation and hence to humidity, as they have a large body surface relative to their body volume. Light is not used as an energy source in insects like it is in plants, but it does alter the daily rhythm of behavior and controls the life cycle of insects as a very precise seasonal clock (Kisimoto, R. and V. A. Dyck, 1976).

From daily or even hourly effects on individuals to seasonal patterns of phenology (Visser and both, 2006) population dynamics (Logan et al., 2006) and species distributions, the relationships between ambient temperature and development, survival, and reproduction scale up. Many insects' physiology, and consequently their development, longevity, and oviposition, are affected by relative humidity. Heavy and light precipitation has a significant effect on the insects' population. Under heavy showers, small pests such as aphids, jassids, whiteflies, mites, etc. may be washed away (Pathak H., et al. Climate Change Impact, Adaptation and Mitigation in Agriculture: Methodology for Editors (2012)). Significant damage and yield loss are done by the insect pests and have decreased the national as well as global food production leading sometimes to acute and chronic food scarcity.

2. MATERIALS AND METHODS

2.1 Experimental site description

The experiment was conducted in Sundarbazar municipality of Lamjung district of Nepal. The study area lies between the latitude from $28^\circ 7'$ to

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28°10' North, and longitude from 84°24' to 84°28' East with an elevation of 650m from the sea level. The area has a subtropical climate (Bhusal et.al. 2021) with the highest temperature on average in June, at around 31.2°C and January has the lowest average temperature of the year. It is around 7.3°C. The annual mean precipitation is around 2913.8mm. (soil fertility map of Lamjung district 2014).

2.2 Layout of the experimental site

The experiment was conducted during the Kharif season of 2019, at The Institute of Agriculture and Animal Science research farm, located at Sundarbazar Lamjung in Nepal. The rice variety under our study was "Ramadhan" which is an improved variety. Firstly, rice seedling was grown in a nursery on 3rd June 2019 and later it was transplanted to the main field on 14th July 2019 with a spacing of 20*20cm between seedlings and all the agronomical practices viz. irrigation, fertilizer application, and intercultural operations were followed as recommended for rice crop in this area to raise the crop. 6*6 m² plot with altogether 39 plots in total (total area 1,404 m²) was the dimension of the rice field under study. No chemical insecticides and pesticides were applied throughout the crop period to get the natural incidence of the pests on the crop.

2.3 Counting of insects

The pest population was recorded based on a fixed plot survey. The pest was counted from the 3rd of August 2019 after 21 DAT at every seven days' interval up to the harvesting. Paddy hills leaving 3-4 edge rows from each plot were surveyed. With the insect count, maximum and minimum temperature, humidity as well as rainfall were also recorded simultaneously.

2.4 Insects collection Methods

2.4.1 Light trap design

For this experiment, a simple light trap was used. The light trap was placed in the middle of the plot at a height of about 2meters from the ground with an LED bulb of 9 watts. The diode produced white light and it was switched on throughout the night from 6:30 pm to 5am. There was a collection chamber below made up of a net so that it was easier to collect insects.

2.4.2 Sweep net

The next method of collection was by using a sweep net. A standard sweep net of 38cm diameter was used. The sweep net was swayed on the field ten times on every plot. This method was very effective in the collection of insects like grasshoppers, locusts, bugs, flies, beetles, etc.

2.5 Weather parameters recording method

2.5.1 Maximum and Minimum Temperature

Maximum and minimum temperatures were recorded by using the maximum and minimum thermometer. The thermometer was kept in the field for 24 hours and the recording was taken in the morning (7 am) every day throughout the experiment period.

2.5.2 Relative Humidity

Relative Humidity was recorded with the help of a hygrometer available at the Agricultural Research Farm, Lamjung Campus. The hygrometer was also kept in the field for 24 hours and recording was taken every morning at 7 am throughout the research period.

2.5.3 Rainfall

Rainfall was recorded with the help of Standard rain gauge available at the Lab of Lamjung Campus. Rain Gauge was taken to the field and made to stand on its tripod. It consisted of outer and inner cylinders.

The inner one collected rainwater and the rainfall were measured using a standard measuring cylinder. Rain Gauge was on the field throughout the experiment and rainfall recording was also taken every day at 7:15 am.

P.S.: The collected data were compared with the nearer geographical weather station situated at Kunchha, Nepal. The obtained data were somewhat similar.

2.6 Observation and analysis

Statistical analysis was done on the influence of weather parameters viz. maximum temperature(°C), minimum temperature(°C), mean temperature(°C), minimum relative humidity (%), maximum relative humidity (%), mean relative humidity (%), total mean rainfall(mm) were correlated with the different types of insects found in the rice field, were analyzed using SPSS and Excel package. The insect diversity was calculated through Shannon Weiner Diversity Index. The Simple correlation was worked out and a regression equation was developed between the seven weather parameters viz. T max, T min, T av, Max RH, Min RH, Av RH and mean rainfall(mm)

3. RESULTS AND DISCUSSION

3.1 Population dynamics of insect pest of rice

Table 1: calculation of H, Hmax, evenness and effective number of species.

Thus, Shannon Weiner diversity index(H)= 1.74717 ("-" sign neglected)
H_{max}=2.302

Evenness of species=0.758("-" sign neglected) effective no of species=5.740

=~6

S/No.	NAME OF INSECT SPECIES	NO. OF INDIVIDUALS	PROPORTION (Pi)	lnPi	Pi*lnPi
1	Short-horned grasshopper	162	0.399	-0.918	-0.366
2	Black bug	75	0.184	-1.688	-0.311
3	Rice gundhi bug	50	0.123	-2.094	-0.257
4	Brown plant hopper	47	0.115	-2.156	-0.249
5	Rice hispa	35	0.086	-2.451	-0.211
6	Locust	12	0.029	-3.521	-0.104
7	Long-horned grasshopper	10	0.024	-3.703	-0.091
8	Field cricket	8	0.019	-3.926	-0.077
9	Click beetle	6	0.014	-4.214	-0.062
10	Yellow stem borer	1	0.002	-6.006	-0.014

Figure 1: Incidence of short-horned grasshopper, black bug, rice gundhi bug, brown planthopper, rice hispa, and locust in different growth stages of rice, 2019.

In the above diagram,

3-Aug to 31-Aug= vegetative stage,

7-sep to 28-sep= reproductive stage and 5-oct to 19-oct= ripening stage

Figure 3: Major insect pest distribution in Kharif season of rice, 2019.

The results in the above tables and diagrams clearly showed that from 10-Aug to the 24-Aug pest incidence gradually increased. That was the time of tillering in rice. The highest incidence was found in the third week of August and gradually the incidence of pest decreased to the ripening stage. During the early vegetative stage, the population of the Black bug was highest. During the late vegetative stage and in the reproductive stage incidence and damage of short-horned grasshopper was found to be highest which supports the findings of Regmi et. al. (2017) and during the ripening stage, the incidence of the short horned grasshopper was found to be significantly high.

Black bug incidence was very common. It was seen almost in all the stages of the rice plant. Rice gundhi bug was seen in the first week of August but was absent in the second and third week of August itself, but again from the late vegetative stage till the ripening stage, it was seen. Gundhi bug seemed to attack the crop mostly during the milking to grain filling stage of the crop and causes greater loss by producing chaffy grains. It supports the findings of Sulagitti et.al.(2017). The highest incidence of rice gundhi bug was seen in the first week of September. Brown plant hopper was seen from the early vegetative stage i.e. 3-Aug to 21-Sep; which was a week

earlier to completion of the reproductive stage. Its highest incidence was seen in the first week of September. Brown plant Hopper's incidence was in status quo with the findings of Firake et.al.(2010, Uttarakhand) except that its highest incidence was seen on the first week of September not on the third week of September. Rice hispa was seen from the early vegetative stage to the early reproductive stage. During tillering its incidence was common. Its population was highest on second week of August in contrast to the findings of (Sharma et.al.,2018) who reported that adults started appearing with the early monsoon showers during June under mid-hill conditions of Himachal Pradesh. Similarly, Locusts were seen during the early tillering stages in a very few numbers for a very short period. During our research, we found out that the major pests that affected the paddy field were short-horned grasshopper, black bug, and rice gundhi bug. Other pests that were considered to be major like rice stem borer, green leaf hopper, rice leaf folder, armyworm e.t.c. weren't seen in the field during our research. Black bug infestation was seen almost throughout the research period. The majority of insects were seen during the late vegetative stage of rice i.e. tillering stage. Gundhi bug infested from late vegetative to ripening stage.

3.2 Relationship of insect pests with different weather parameters

Table 2: Correlation of insect population with different weather factors:

Insects	Shorthorned grasshopper	Black bug	Rice gundhi bug	Brown plant hopper	Rice hispa	Locust
Weather factors(X)	Correlation Coefficient (r)	(r)	(r)	(r)	(r)	(r)
Max. Temp.	-0.231(NS)	0.622*	-0.319 (NS)	0.138 (NS)	0.374(NS)	-0.056 (NS)
Min. Temp.	0.237(NS)	0.240(NS)	0.188(NS)	0.585*	0.503(NS)	0.320 (NS)
Av. Temp.	-0.015(NS)	0.536(NS)	-0.099 (NS)	0.419 (NS)	0.525(NS)	0.144 (NS)
Max. R.H.	0.091(NS)	0.199(NS)	-0.125 (NS)	0.015 (NS)	0.162(NS)	0.360 (NS)
Min. R.H.	-0.041(NS)	0.112(NS)	-0.112 (NS)	0.125 (NS)	-0.023(NS)	0.240 (NS)
Av. R.H.	0.042(NS)	0.183(NS)	-0.133 (NS)	0.066 (NS)	0.098(NS)	0.34 (NS)
Av. Rainfall(mm)	-0.019(NS)	0.490(NS)	-0.297 (NS)	0.471 (NS)	0.385(NS)	0.077 (NS)

*= Significant at 5% level, NS= Non-Significant

Figure 2: Weather factors and insect pest incidence.

In figure 2:

3-Aug to 31-Aug= vegetative stage,

7-sep to 28-sep= reproductive stage and

5-oct to 19-oct= ripening stage.

3.2.1 Cardinal temperature and insects

An increase in maximum temperature and the average temperature was seen to have a negative correlation in the incidence of short-horned grasshopper ($r_{\text{max}}=-0.231$, $r_{\text{av}}=-0.015$) while the minimum temperature had a positive insignificant correlation with its appearance ($r=0.237$). On contrary to the present findings Muchhala (2014) reported a correlation between various weather parameters and grasshopper catches were found to be non-significant, except sunshine, which exhibited a significant

positive effect on hopper catches. But our experiment supported the findings of Mishra et.al.(2019), which clearly stated that the correlation coefficients between *T. subulata* and minimum temperature exhibited a positive effect but statistically found non-significant. In the case of black bug, its population was significantly positively correlated with maximum temperature with $r=0.622$ and also was in positive correlation with minimum as well as average temperature with $r = 0.240$ and 0.536 respectively. Maximum temperature and the average temperature had an insignificant negative correlation with an r value of -0.319 and -0.099 respectively in gundhi bug but had a positive correlation with minimum temperature with an r value of 0.188 . In contrast, to present findings, Bhatnagar and Saxena (1999) found a positive correlation between maximum temperature and sunshine for the incidence of rice gundhi bug. They also found a significant negative correlation of the minimum temperature of *L. acuta* at Jagdalpur, India. But our findings were in status quo with the findings of Sharma et. al. (2004) who reported that but maximum temperature played a negative role in population buildup of rice gundhi bug with negative r value i.e. -0.132 .

With maximum and average temperature brown plant hopper had a positive insignificant correlation with r value of 0.138 and 0.419 respectively but with the minimum temperature, it showed a significant positive correlation with an r value of 0.585 . Our findings support the findings of Sulagitti et. al. (2017) who reported that the correlation analysis of *N. lugens* revealed a positive non-significant correlation of pest population with temperature ($r = 0.295$). With all the cardinal temperatures rice hispa was positively insignificantly correlated with r values $r_{\text{max}}=0.374$, $r_{\text{min}}=0.503$, and $r_{\text{av}}=0.525$. Our findings supported the findings of K.C. et. al.(2018) for maximum temperature($r=0.155$) but it was in contrast with the correlation values of minimum and average temperature where $r_{\text{min}}=-0.638$ and $r_{\text{av}}=-0.300$ in their findings. Chakraborty and Dev (2012) also reported that maximum temperature is conducive to rice hispa population growth and multiplication. Locust was negatively correlated with maximum temperature with an r value of -0.056 but it was positively correlated with minimum and average

temperature with r values of 0.320 and 0.144 respectively. In a case study by Yu et.al. 2009, a significant correlation with spring-summer warm and dry years were obtained, and also, analyzing the data of past 1000 years, correlations between the annual temperature variance and locust index showed significant positive correlations (95% CI and B test with $p < 0.05$) in the northern region. Apart from the correlation of maximum temperature, other temperature parameters of our research are in status quo with the findings of Yu et.al (2009).

3.2.2 Relative humidity and insects

Maximum and average relative humidity had a positive insignificant correlation in the case of short-horned grasshopper with an r value of 0.091 and 0.042 respectively whereas with the minimum humidity it had a negative correlation ($r = -0.041$). A study carried out by Mishra et.al. (2019) showed that morning relative humidity and evening relative humidity showed negative effects but statistically found non-significant in contrast to our findings. All the maximum, minimum, and average relative humidity had a positive insignificant correlation with black bug incidence with r value of 0.199, 0.112 and 0.183 respectively. Likewise, maximum, minimum, and average relative humidity had a negative insignificant correlation with rice gundhi bug incidence with r value of -0.125, -0.112, and -0.133 respectively. Bhatnagar and Saxena (1999) found a significant negative correlation with evening relative humidity. These findings were similar to our research except that we found an insignificant correlation. In a similar scenario, maximum, minimum, and average relative humidity had a positive insignificant correlation with brown planthopper incidence with r value of 0.015, 0.125 and 0.066 respectively. Sulagitti, et. al. (2017) also reported similar findings i.e. The correlation analysis of *N. lugens* revealed a positive non-significant correlation of pest population with relative humidity ($r = 0.543$). Maximum and average relative humidity had a positive insignificant correlation in the case of rice hispa with r value of 0.162 and 0.098 respectively whereas with the minimum temperature it had a negative correlation ($r = -0.023$). Chakraborty and Dev (2012) also reported that maximum humidity was conducive to rice hispa population growth and multiplication. A significantly negative relation between minimum R.H. and the rice hispa population was reported but our study showed a negative but insignificant correlation between R.H.min and rice hispa. All the maximum, minimum, and average relative humidity had a positive insignificant correlation with Locust incidence with r values of 0.360, 0.240 and 0.348 respectively.

3.2.3 Average rainfall and insects

From Table 2, we found out that short-horned grasshopper and rice gundhi bug had a negative insignificant correlation with an r value of -0.019 and -0.297 respectively. This is contrary to the findings of Sharma, et. al (2004). Who reported that rainfall had a positive contribution on population build-up of rice gundhi bug through negligible indirect contributions of maximum temperature. Our findings were in status quo with the findings of Mishra et.al. (2019) who reported that rainfall had a negative insignificant effect on the incidence of short-horned grasshopper. Brown planthopper had positive insignificant relation with average rainfall with $r = 0.471$. Our research supported the findings of Sulagitti, et. al. (2017) who reported that *N. lugens* revealed a positive non-significant correlation of pest population with rainfall ($r = 0.292$). In the case of rice hispa, rainfall showed a positive insignificant relationship where $r = 0.385$. Our report supported the findings of Chakraborty and Dev (2012) who reported that drizzling rainfall had a positive effect on the pest structure with r values 0.329, 0.345, 0.267, and 0.415 for years 2005, 2006, 2007, and 2008 respectively. In the case of locust, we obtained a positive insignificant correlation i.e.

$r = 0.077$. A case study by Yu, et.al. 2009, had found that in the northern region, the results of each site correlation between locust index and monthly temperatures showed higher frequencies of significant positive correlations. Ant and the black bug had insignificant positive correlations with r values 0.293 and 0.490 respectively.

4. CONCLUSION

Among the various pest in our study short-horned grasshopper, rice gundhi bug, and black bug were seen to be more prominent. Grasshopper was seen throughout the research period; rice gundhi bug infestation was seen from vegetative stage to ripening stage and black bug infestation was also seen from vegetative stage to ripening stage. All of them had different

correlations with the weather factors taken into consideration during the research period carried out on a variety of "Ramadhan" from August to October during the Kharif season of rice, 2019 at Lamjung Campus. At the time of the vegetative stage specifically tillering, the insect and pest incidence was relatively high. From this, we can infer that crop growth stages as well as weather factors are the reason behind different insect pest incidence and also conclude that short-horned grasshopper, rice gundhi bug, and black bug are the major pests of the western mid-hill of Lamjung.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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APPENDICES

Appendix 1: Weather data during the entire research period from 3rd August to 19th October, 2019.

Standard Days	Date	Temperature(°C)			Relative Humidity (%)			Rainfall(mm)
		Max. Temp.	Min. Temp.	Av. Temp.	Max. Hum.	Min. Hum.	Av. Hum.	
21 DAT	3-Aug	34	20	27	90	80	85	79.8957
28 DAT	10-Aug	30	23	26.5	90	73	81.5	41.0157
35 DAT	17-Aug	28	23	25.5	90	75	82.5	51.4256
42 DAT	24-Aug	34	23	28.5	81	68	74.5	100.6294
49 DAT	31-Aug	29	24	26.5	90	72	81	0.00
56 DAT	7-Sep	29	23	26	77	71	74	81.5831
63 DAT	14-Sep	28	23	25.5	89	75	82	87.8503
71 DAT	21-Sep	28	19	23.5	92	73	82.5	0.00
78 DAT	28-Sep	25	20	22.5	85	75	80	0.00
85 DAT	5-Oct	31	23	27	85	64	74.5	0.00
92 DAT	12-Oct	27	18	22.5	78	70	74	0.00
99 DAT	19-Oct	27	17	22	72	67	69.5	42.1716