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Abundance of insect pests population in rice field ecosystem under changing climatic conditions of Eastern Uttar Pradesh

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Abstract
The present study was undertaken to investigate the abundance of insect pest species associated with rice field ecosystem under changing climatic conditions of Eastern Uttar Pradesh of India. The surveillance was conducted in 03 administrative divisions namely, Gorakhpur, Basti and Azamgarh for two consecutive years, 2014 and 2015 in rainy season (Kharif). The surveillance for abundance of insect pest population in rice field was conducted as per methodology of agro ecosystem analysis (AESA) modified as accessibility. There were 38 insect pest species observed under 03 rice growth stages of seedling, transplanting and flowering. Among 12 major insect pest species of rice observed significant damage above 10% infestation, there were confined 7 insect pest species as very serious (10- 15% infestation) and 5 insect pest species as most serious (> 15% infestation). Of the total observed population of major insect pests under damaging groups in all growth stages of rice under temperature maximum, temperature minimum, relative humidity, and rainfall, the correlation coefficients were - 0.732, - 0.715, - 0.635, and 0.868 for stem borers; 0.989, 0.992, 0.999, and - 0.929 for leaf feeders; -0.326, -0.302, -0.198, and 0.533 for sap feeders; 0.244, 0.219, 0.113, and - 0.459 for root feeders; and 0.509, -0.170, -0.274, and - 0.299 for total population of all damaging groups respectively. The abundance of major insect pests under damaging groups was inference non-significant correlation with particular weather parameters in all growth stages of rice, except relative humidity was inference significant with insect pest population of leaf feeders damaging group. The population of stem borers and leaf feeders was highly correlated with rainfall, but the stem borers were correlated positively and leaf feeders were correlated negatively. The total population of major insect pests of rice were abundant descendingly with transplanting, flowering, and seedling growth stages of rice respectively.

Keywords: Abundance, insect pests, rice ecosystem, weather parameters, eastern Uttar Pradesh, India

Introduction
Rice is one of the most important staple foods of the world (70% of the population) as well as India (65% of the population). About 90% of the world's rice is produced and consumed in the Asian region and most staple food of South East Asia. More than 110 countries grow rice on one fifth of the world food grain crop area. The rice fragrance spreads to the entire world. It provides livelihood and food security to the about, 56% of the world population (7.46 billion) as well as 65% of the India population (1.32 billion). Rice is cultivated in India since Indus valley civilization and worshipped for wealth prosperity. More than 60% of India population living in rural areas, where agriculture is the major concerns of rural economy, that is the backbone of Indian economy. Despite these above proud credentials, Uttar Pradesh is not appearing leading position. The main cause of low productivity of rice is ill cultivation practices and crop losses. The crop losses share about 32.1% losses by plant ailments (pests, diseases & weeds) and among them, about 10.8% losses caused by pests globally and India have been reported about 17.5% losses caused by insect pests. Historically, insect pest outbreaks have been causing extensive losses in rice crop production ranging from 60 to 95% over the world and 21 to 51% over the India respectively. (Pathak and Khan, 1994; Maclean *et al*., 2002; Oerke, 2006; Dhaliwal *et al*., 2015; Heinrichs and Muniappan, 2017; Sharma *et al*., 2017; DAC&FW, 2018; Pathak *et al*., 2018; FAOSTAT, 2019) [20, 15, 17, 10, 13, 24, 6, 19, 11].
About 800 insect pest species associated with rice crop over world. Among them about 250 insect pest species associated with rice crop in India and about 20 of them are major economic significance. The insect pests of rice infest all parts of the plant at all growth stages and transmit few viral diseases of rice. In India national level, stem borers accounted for 30% yield loss, while plant hoppers (20%), gall midge (15%), leaf folders (10%), and other insect pests (25%) respectively. Rice is grown under wide range of climatic conditions.

The warm humid environment is congenial for rice production and conductive to the survival and proliferation of insect pest biodiversity. Environment is the key factor of insect pest population dynamics. The weather factors have always been found to be important for insect pests survival, growth, development, fecundity and reproduction. (Pathak and Khan, 1994; Shepard, Barrion and Litsinger, 1995; Matteson, 2000; David and Ananthakrishnan, 2004; Bentur, 2011; Prakash *et al*., 2014; Singh *et al.*, 2016; Heinrichs and Muniappan, 2017; Krishnaiah and Varma, 2018) [20, 25, 16, 8, 2, 22, 26, 13, 14].

Chakraborty and Deb (2012) [4], studied the incidence of rice hispa influenced by agroclimatic conditions for monsoon rice. Parasappa *et al.* (2017) [18] has been found that, the yellow stem borer caused dead hearts during vegetative stage and white ears at harvest. Sulagitti *et al*. (2017) [27] has been observed the incidence of yellow stem borer and leaf folder were highest at vegetative phase and showed a positive significant correlation with evening and average humidity. Bisen *et al*. (2019) [3] has been reported that, the population of army worm were observed increase after drought followed by heavy rains.

Materials and Methods

The present study was undertaken to investigate the abundance of insect pest species associated with rice field ecosystem under changing climatic conditions of Eastern Uttar Pradesh of India for two consecutive years (2014 and 2015). The observation was undertaken in all 10 districts of 03 administrative divisions of Eastern Uttar Pradesh *i.e*., Gorakhpur (Gorakhpur, Deoria, Kushinagar, and Maharajganj), Basti (Basti, Santkabirnagar, and Siddharthnagar) and Azamgarh (Azamgarh, Mau, and Ballia). It lies between 27^0 40' N latitude and 80^0 00' E longitude of geographical coordinates and altitude at about 240 meters. The samples were taken randomly for concerned districts of all 03 divisions for each growth stage of rice under 03 growth stages *i.e.*, seedling, transplanting, and flowering for consecutively two years. There was each field selected at each division per growing stages for each year. The duration of rice crops started from pre week of August to mid-week of November for about 110 days. The seedling stage started when the seeds were seeded to germinate in the nursery. The transplanting stage began with the transplantation in the field to completed tillering, panicle formation and booting phase for about 50 days before flowering stage just before harvesting and lasted for about 30 days. Samples were taken 03 times at interval of 20 days after sowing (20 DAS) for seedling stage, 30 days after transplanting (30 DAT) for transplanting stage and 60 DAT for flowering stage respectively. Each plot was selected 5 spots (4 in the corner at least 60 cm inside the border and one in the centre) to collect samples at $0.25m^2$ /spot for seedling stage and at 01 hill/spot for transplanting and flowering stage to observe abundance of insect pests and their infestation. There were also at each plot, 05 net sweeps made randomly at every 05 steps to observe abundance of insect pests for all 03 growth stages of rice. The timing of sampling was 9.30 A.M. to 12.30 P.M. respectively. Each observation was recorded abundance of insect pest species concerned to screen major insect pest species for significant damage above 10% infestation and recognize among them most serious insect pests of rice from previous reports. The observation was also calculated correlation with meteorological factors at different rice growth stages.

The meteorological recording was coordinates with Gorakhpur (India) meteorological station concerning Tutiempo (2019) [29] and Timeanddate (2019) [28] web portal regarding maximum and minimum temperature, relative humidity, and rainfall of months, *i.e.*, August, September, October, and December for years, 2014 and 2015 respectively. Surveillance was conducted as per methodology of agroecosystem analysis (AESA) (Pontius *et al*., 2002) [21] modified as accessibility. Taxonomic identification was verified with texts of reference, *i.e*., Dale (1994) [7], Barrion and Litsinger (1994) [1], Pathak and Khan (1994) [20], David and Ananthakrishnan (2004) [8]; Rice knowledge management portal (RKMP); and Subject experts respectively.

Results and Discussion

There were 38 insect pest species belonging to 4 damaging groups (stem borers, leaf hoppers, sap feeders and root feeders) under 3 rice growth stages (seedling, transplanting and flowering) observed for sum of both the years 2014 and 2015 respectively. There were 12 insect pest species confined major insect pests of rice above 10% Infestation. The stem borers comprise 2 species, the leaf feeders comprise 4 species, the sap feeders comprise 5 species and the root feeders comprise 1 species for major insect pests of rice respectively. The major insect pests of rice were confined, 7 insect pest species as very serious (10- 15% infestation) and 5 insect pest species as most serious (> 15% infestation). The all 12 major insect pests of rice under insect pest complex for sum of both the years 2014 and 2015 were confined namely, very serious- 1.Rice cutworm (*Spodoptera mauritia* Boisduval), 2.Common termite (*Odontotermes obesus* Rambur), 3.Rice grasshopper (*Hieroglyphus banian* Fabricius), 4.Striped stemborer (*Chilo suppressalis* Walker), 5.Plain green leafhopper (*Nephotettix virescens* Distant), 6.Spotted green leafhopper (*Nephotettix nigropictus* Stal), 7.Whitebacked planthopper (*Sogatella furcifera* Horvath); and most serious- 6.Rice hispa (*Dicladispa armigera* Oliver), 7.Rice earheadbug (*Leptocorisa acuta* Thunberg); 9.Yellow stemborer (*Scirpophaga incertulas* Walker), 11.Brown planthopper (*Nilaparvata lugens* Stal), 12.Common rice leaffolder (*Cnaphalocrocis medinalis* Guenee) respectively. The present study was revealed that, the population of sap feeders and leaf feeders were dominated and the population of sap feeders were tended towards transplanting stage of rice. Under most serious infestation of insect pests, the yellow stemborer was caused dead hearts and white ear formation, common rice leaffolder was caused folded leaves and drying of leaves, brown planthopper was caused hopper burn in circular patch area, rice hispa was caused defoliation and stunting of plants, and rice earheadbug was caused chaffy grains and panicles de-initiation respectively (Table-1a, 1b & 2 and Figure-1).

The population of major insect pests of rice were observed influence by weather parameters in all growth stages of rice under temperature maximum, temperature minimum, relative humidity, and rainfall for sum of both the years 2014 and 2015 under damaging groups of stem borers, leaf hoppers, sap feeders and root feeders respectively. The observation was calculated correlation with particular weather parameters at different growth stages rice of seedling, transplanting and flowering. Of the total observed population of major insect pests under damaging groups in all growth stages of rice under temperature maximum, temperature minimum, relative humidity, and rainfall, the correlation coefficients were - 0.732, - 0.715, - 0.635, and 0.868 for stem borers; 0.989, 0.992, 0.999, and - 0.929 for leaf feeders; -0.326, -0.302, - 0.198, and 0.533 for sap feeders; 0.244, 0.219, 0.113, and - 0.459 for root feeders; and 0.509, -0.170, -0.274, and - 0.299

for total population of all damaging groups respectively. The abundance of major insect pests under damaging groups was inference non-significant correlation with particular weather parameters in all growth stages of rice, except relative humidity was inference significant with insect pest population of leaf feeders damaging group. The population of stem borers and leaf feeders was highly correlated with rainfall, but the stem borers were correlated positively and leaf feeders were correlated negatively. The total population of damaging groups showed moderately positive correlation with temperature maximum, but highly negative correlation with temperature minimum, relative humidity and rainfall. The damaging groups of major insect pests population were highly decreased with highly increasing temperature maximum, temperature minimum, and relative humidity and decreasing rainfall in seedling stage; highly increased with moderately decreasing temperature maximum, temperature minimum, and relative humidity and increasing rainfall in transplanting stage; and moderately decreased with highly decreasing temperature maximum, temperature minimum, and relative humidity and increasing rainfall in flowering stage for damaging groups of stem borers, leaf hoppers, sap feeders and root feeders. The population of root feeders and leaf feeders were highly decreased with influence of weather parameters under transplanting stage and flowering stage. The total population of major insect pests of rice were abundant descendingly with transplanting, flowering, and seedling growth stages of rice respectively (Table-3 and Figure-2). These results are in agreement with Pathak and Khan (1994) [20], Shepard, Barrion and Litsinger (1995) [25], Chakraborty and Deb (2012) [4], Prakash *et al.* (2014) [22], Gangwar *et al.* (2015) [12], Saini *et al*. (2015) [23], Singh *et al.* (2016) [26], Krishnaiah and Varma (2018) [14], Bisen *et al.* (2019) [3], and Deshwal *et al*. (2019) [9] respectively.

Table 1a: Major Insect Pests of Rice Confined above 10% Infestation (Sum of 2014 & 15)

Damaging Groups	Major Insect Pest Species		
	Common Name	Scientific Name	Order: Family
1. Stem borers	1. Yellow stemborer	*Scirpophaga incertulas*	Lepidoptera: Pyralidae
	2. Striped stemborer	*Chilo suppressalis*	Lepidoptera: Pyralidae
2. Leaf feeders	1. Common rice leaffolder	*Cnaphalocrocis medinalis*	Lepidoptera: Pyralidae
	2. Rice cutworm	*Spodoptera mauritia*	Lepidoptera: Noctuidae
	3. Rice grasshopper	*Hieroglyphus banian*	Orthoptera: Acrididae
	4. Rice hispa	*Dicladispa armigera*	Coleoptera: Chrysomelidae
3. Sap feeders	1. Brown planthopper	*Nilaparvata lugens*	Hemiptera: Delphacidae
	2. Whitebacked planthopper	*Sogatella furcifera*	Hemiptera: Delphacidae
	3. Plain green leafhopper	*Nephotettix virescens*	Hemiptera: Cicadellidae
	4. Spotted green leafhopper	*Nephotettix nigropictus*	Hemiptera: Cicadellidae
	5. Rice earheadbug	*Leptocorisa acuta*	Hemiptera: Coreidae
4. Root feeders	1. Common termite	*Odontotermes obesus*	Isoptera: Termitidae
Total	12		

Table 1b: Major Insect Pests of Rice under Very Serious and Most Serious (Sum of 2014 & 15)

Damaging Status	
Very Serious (10 - 15% Infestation)	**Most Serious (> 15% Infestation)**
1. Rice cutworm (*Spodoptera mauritia*)	1. Rice hispa (*Dicladispa armigera*)
2. Common termite (*Odontotermes obesus*)	2. Rice earheadbug (*Leptocorisa acuta*)
3. Rice grasshopper (*Hieroglyphus banian*)	3. Yellow stemborer (*Scirpophaga incertulas*)
4. Striped stem borer (*Chilo suppressalis*)	4. Brown planthopper (*Nilaparvata lugens*)
5. Plain green leafhopper (*Nephotettix virescens*)	5. Common rice leaffolder (*Cnaphalocrocis medinalis*)
6. Spotted green leafhopper (*Nephotettix nigropictus*)	—
7. White backed planthopper (*Sogatella furcifera*)	—

Table 2: Insect Pests Population for Damaging Groups & Growth Stages (Sum of 2014 & 15)

Observation Years	Damaging Groups	Growth Stages of Rice							
		Number				Percentage			
		Seedling	Transplanting	Flowering	Total	Seedling	Transplanting	Flowering	Total
2014	Stem borers	85	183	224	492	1.88	4.05	4.96	10.89
	Leaf feeders	1534	123	27	1684	33.97	2.72	0.59	37.29
	Sap feeders	624	1018	655	2297	13.82	22.54	14.50	50.87
	Root feeders	22	4	16	42	0.48	0.08	0.35	0.93
	Total	2265	1328	922	4515	50.16	29.41	20.42	100
2015	Stem borers	83	201	109	393	1.97	4.45	2.41	9.32
	Leaf feeders	1563	175	20	1758	37.10	3.87	0.44	41.72
	Sap feeders	574	1024	432	2030	12.71	22.68	9.56	48.18
	Root feeders	21	6	5	32	0.46	0.13	0.11	0.75
	Total	2241	1406	566	4213	53.19	33.37	13.43	100
2014 and 2015	Stem borers	168	384	333	885	1.92	4.40	3.81	10.13
	Leaf feeders	3097	298	47	3442	35.48	3.41	0.53	39.43
	Sap feeders	1198	2042	1087	4327	13.72	23.39	12.45	49.57
	Root feeders	43	10	21	74	0.49	0.11	0.24	0.84
	Total	4506	2734	1488	8728	51.62	31.32	17.04	100

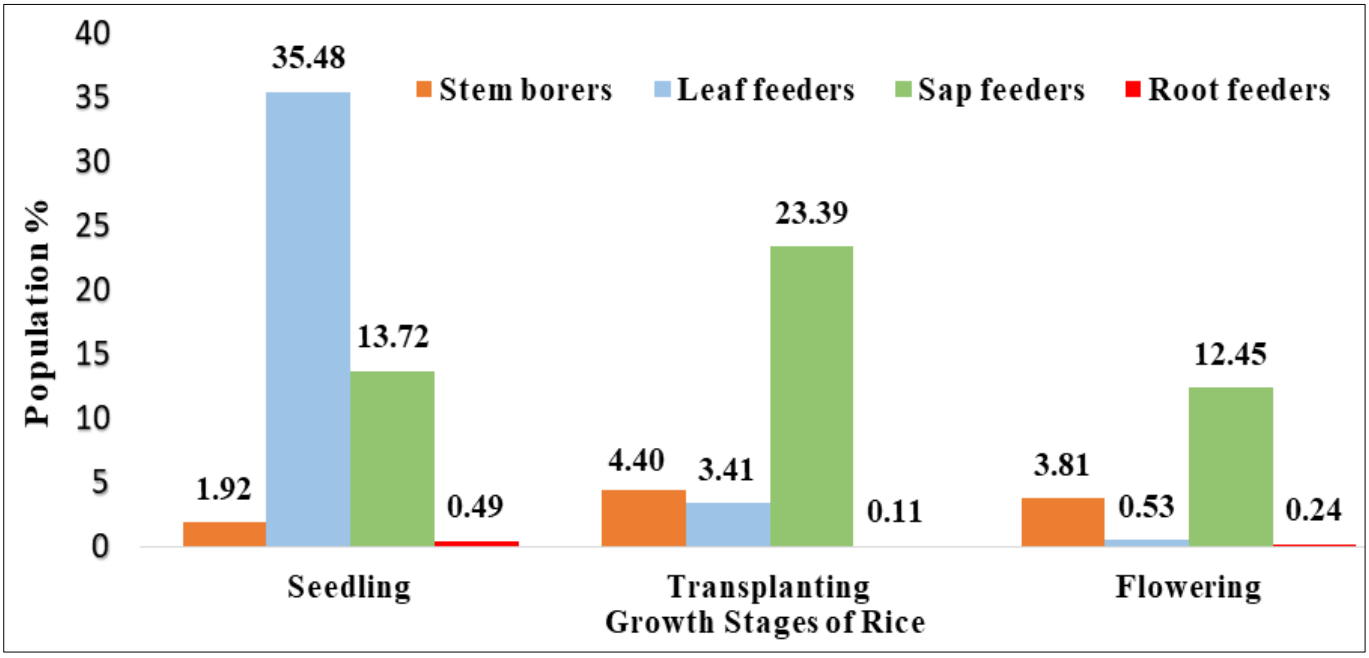

Fig 1: Insect Pests Population for Damaging Groups & Growth Stages (Sum of 2014 & 15)

Table 3: Population of Major Insect Pests of Rice under Weather Parameters (Sum of 2014 & 15)

Influence of Major Insect Pests Population under Weather Parameters								
Damaging Groups of Major Insect Pests of Rice	Growth Stages of Rice			Weather Parameters				
	Seedling	Transplanting	Flowering	Correlation Coefficients				
	34.10	32.40	30.10	Observations	Temperature Maximum (°C)			
	25.20	21.60	16.25			Temperature Minimum (°C)		
	78.70	75.85	69.40				Relative Humidity (%)	
	1000.60	1007.70	1011.95					Rainfall(mm)
Stem borers	110	258	236	Population	-0.732	-0.715	-0.635	0.868
Leaf feeders	138	102	15		0.989	0.992	0.999	-0.929
Sap feeders	0	1576	645		-0.326	-0.302	-0.198	0.533
Root feeders	5	2	4		0.244	0.219	0.113	- 0.459
Total	253	1938	900		0.509	-0.170	-0.274	-0.299

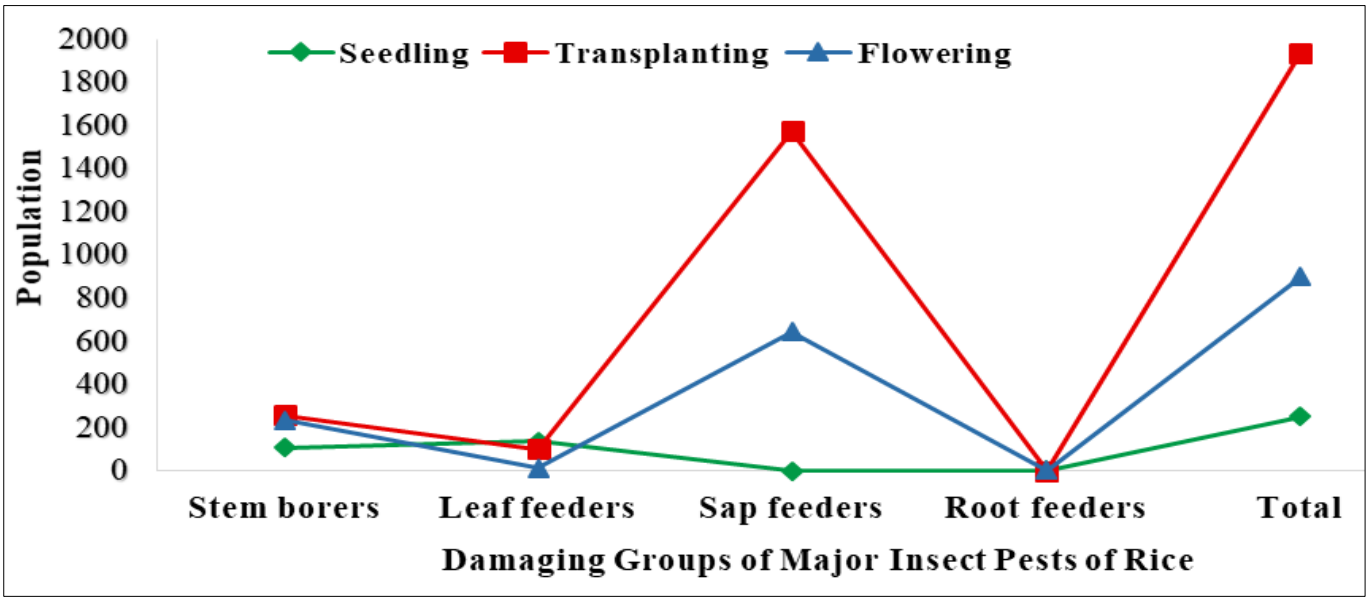

Fig 2: Population of Major Insect Pests of Rice under Weather Parameters (Sum of 2014 & 15)

Conclusion

There were 38 insect pest species belonging to 4 damaging groups (stem borers, leaf hoppers, sap feeders and root feeders) under 3 rice growth stages (seedling, transplanting and flowering) observed for sum of both the years 2014 and 2015. There were 12 insect pest species confined major insect pests of rice above 10% Infestation. The major insect pests of rice were confined, 7 insect pest species as very serious (10-15% infestation) and 5 insect pest species as most serious (> 15% infestation). The population of major insect pests of rice were observed influence by weather parameters in all growth stages of rice under temperature maximum, temperature

minimum, relative humidity, and rainfall for sum of both the years 2014 and 2015 under damaging groups of stem borers, leaf hoppers, sap feeders and root feeders respectively. The population of sap feeders and leaf feeders were dominated and the population of sap feeders were tended towards transplanting stage of rice. The abundance of major insect pests under damaging groups was inference non-significant correlation with particular weather parameters in all growth stages of rice, except relative humidity was inference significant with insect pest population of leaf feeders damaging group. The population of stem borers and leaf feeders was highly correlated with rainfall, but the stem borers were correlated positively and leaf feeders were correlated negatively. The population of root feeders and leaf feeders were highly decreased with influence of weather parameters under transplanting stage and flowering stage. The total population of major insect pests of rice were abundant descendingly with transplanting, flowering, and seedling growth stages of rice respectively.

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