Rice Whitefly (*Aleurocybotus occiduus* Maria), a new emerging threat of rice production and its natural control in Chitwan, Nepal

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Abstract

An intensive field study was carried out to identify the problem causing reddish yellowing of the rice plants, access potential natural control of the suspected pests, estimate yield losses and to suggest an immediate, environmentally safe, possible control measures. Whitefly (*Aleurocybotus occiduus* Maria) was outbreak on main season rice in Chitwan valley, which affected a total of 20561 ha (Severly 177.3 ha, medium 2787.6 ha, low 6945.4 ha and mild 10691.7 ha) land, losing 9448 mt rice yield in 2003. Use of monoculture, susceptible varieties (Sabitri) and improper cultural operations, excess use of agrochemicals and unconsciousness on the population build up of pest and natural enemies were the causes of outbreak. A maximum of 1000 Whitefly nymphs /tiller were counted. Parasitoid, *Encarsia* sp was fond most functional natural enemy in the field. However, the population build up of the parasitoid was observed quite late. Rice plants recovered in some extent after heading when the Whiteflies were found naturally controlled. Higher the population of Whitefly proportionally decreased the tillers number/hill, fertile tillers/hill, grain weight/panicle and the grain yield/ha. Rice plants infested with high population of Whitefly (898/tiller) failed to gave rice yield, where medium population (335 / tiller) gave 1287 kg and low population (103 Whitefly/tiller) gave 3456.0 kg (30.8% less than of last year) /ha. Kanchhi Mansuli (4200 kg/ha) and Mansuli (3960 kgs/ha) were comparative tolerant varieties than the Sabitri.

Key words: Natural enemies, parasitoid, natural control, proportionally

Introduction

Rice is one of the oldest cultivated crops on earth that grows at more than 3000m asl in the mountains and at sea level in the deltas of great rivers of Asia. More than 90 percent of the world rice is grown and consumed in Asia (Narayanswamy, 2002), where about 80 percent of the world's people live (Kisimoto and Yamasina, 1987). In Nepal, rice is the main food, which also earned foreign exchange in the eighties. It is grown through out the tarai region followed by mid hills and also in high hills like Jumla valley (CBS, 1999), where rice is growing since time immemorial. The total area under rice is estimated 1506340 ha (58% of total cultivated area) with the estimated annual yield 3640860 mt in Nepal (CBS, 1999).

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However, the national production is not far to meet the per capita requirement of rice, ie. 126.02 kg. Moreover, the total per capita food requirement is calculated 200kg, where the national per capita production is only 190kg in the state (Bista, 2002).

Inner Tarai of central Nepal (Chitwan and Nawalpur area of Nawalparasi) is one of the important rice-growing belts in Nepal. The total rice growing area in Chitwan district alone is 30198 ha with the annual production of 90594 mt rice grain (ADO, 1996). The district is highly suitable for rice cultivation, due to highly fertile humus enriched soil, after the deforestation of dense forest in late 44 years is now available for the rice cultivation. Chitwan is supplying rice to its neighboring hill district including the capital city Kathmandu. Few VDCs of eastern Chitwan and some more patches of western Chitwan are having year round irrigation, where rice is grown twice a year. Sabitri, BG, Mansuli, Anadi, Masino, Radha-4 are the major rice varieties grown in the main rice growing season (Pokhrel, 2002).

Severe outbreaks of plant hoppers (BPH and WBPH) were observed on early rice (Feb/March-June/July) crops in eastern Chitwan in 1996 (2053 BS). A total of 1568 ha rice crop was severely damaged resulting 4262 mt yield loss equivalent to Rs. 29834210 (ADO, 1996; Himalayan Times Sep 30, 1996; Gorkhapatra Daily, 11 Sept, 1996; Pokhrel, 1998). These pests were managed by the ADO office by means of the farmer's field schools in collaboration with National IPM program and FAO (Pokhrel, 2002).

A new rice problem has been arisen in the main season rice during August-September (August-September 2003). The problem was extended in a vast area getting reddish-yellow rice field. Green areas of the leaves were totally become reddish-yellow. The extortionists form DADO offices get confused with Bacterial blight and nutritional deficiencies. However, an extensive field survey carried by us during early September found that the problem was really by the insect pests Whiteflies, *Aleurocybotus occiduus* Maria.

Whiteflies are the poly-phagus, tiny insects of 1-1.5 mm in size. Adults are having two pairs of white wings with prominently longer hind wings. These migratory adult lay up to 120 eggs, which are sub-elliptical in shape, light yellow in color and are laid singly on the under surface of the leaves and succulent stems. Nymph hatch in 3-7 days and go through 4 instars, which are stationary. Pupation ends in 2-8 days. The stationary nymphs are the most harmful stage, which sucks the plant sap from stems and leaves. The total life cycle from egg to adult is 14-120 days (PCIP, 2004).

Whitefly was formerly not reported as an insect pest of rice. The symptoms observed in the field were most confused with toxicity problems. However, the Whiteflies population in the field could confirm the problem.

Nutrimac (2004) recommended using *Encarsia formosa* @ 3000-10000 n/a or *Eretmocerus eremicus* @ 8000 n/a as for the biological control of Whiteflies. However, PAU (2004) recommended to use synthetic pyrethroids e.g. Triazophous. Acmsabati (2004) recommended Apploud against it.

Methodology

Chitwan valley, east and west Chitwan including Bharatpur municipality were the major areas affected. One of the severely infested fields from Radha–Krishna Tole, Bharatpur-12, was selected to carry the study. Few hills of the rice were uprooted. Small, 3" pieces of rice stem together with the leaf sheaths were taken. The mature nymphs of White flies were counted with a help of a hand lens. 50 mature nymphs were retained in the specimens and rest wear removed with the help of an insect-picking needle. The specimens were replicated in different 5 test tubes, plugging with cotton. The adult of both White flies and the parasitoids emerged were counted separately with a help of the hand lens. The same procedure was repeated for 4 dates at about 1 week interval.

An identical rice field with heterogeneously distributed population of whitefly with in a variety (Sabitri) was selected at Radha-Krishna-tole Bharatpur-12. Adjoining plots were having Mansuli and Kandhi Mansuli varieties, planted during the similar period i.e. July first week. Late and synchronized planting was due to the late water emergence in Ghol area that develops at late July each year.

Based on the visual symptoms, three distinct spot of the Sabitri rice field were selected. One was severely (heavily) infested (Figure 1), another moderate (medium) (Figure 2), and 3rd one with low infestation (Figure 3). However the, plot with Mansuli was having uniformly symptom of moderate (medium) type (Figure 5), and Kanchhi Mansuli was also having uniformly symptom similar to low infested plot of Sabitri (Figure 6). One sq. m. areas were selectively identified (based on visual symptom) from the selected spots. The populations of Whitefly nymphs /tiller were counted at booting stage. Insects were counted by taking a random tiller, from each hill with the help of a hand lens. At the harvesting stage, the active tillers or the panicle numbers from each clump were counted. Rice grains were harvested separately and weighted to find the grain yield /sq m, /ha and /panicle. Collected data were tabulated and analyzed by using the computer soft ware "IRRI-STAT"

Figure 1. Heavily infested field, Bharatpur-12

Figure 2. Moderately infested field, Bharatpur-12

Figure 3. Low infested field, Bharatpur-12

Figure 4. Insects from moderately infested field, Bharatpur-12

Figure 5. Crop from moderately infested Mansuli field, Bharatpur-12

Figure 6. Crop from low infested Kanchi Mansuli field Bharatpur-12

Results and discussions

Extent of severity and site description

Whitefly formerly not reported as a rice pest was the major causes associated. A maximum of 1000 Whitefly nymphs per tiller were counted from the rice field from Chitwan. Numerous, Whitefly adults (uncountable in number) were observed in the rice field while tapping the rice hills. The problems were also observed from the smaller pockets of other hilly districts like Tanahun, Lamjung, Gorkha and Kaski during the same period.

A staff meeting of DADO Chitwan, with the extension worker, held on the mid November 2003 made a detail discussion about the extent severity and yield loss of rice in the year 2003. Based on their visual observation the problems were extended on the 23 VDCs and 2 municipalities covering 20561 ha rice field. The problem was not uniform through out the district. They told that the yield loss was not much as the symptoms observed at tillering to

heading stage. However, the economic yield loss was noticed from 48% (9870 ha) rice area resulting 9418 mt grain loss, which was 15.3% lower than that of the previous year (Table-1). Based on the severity 100% yield loss was accrued from 0.6% (117.3ha) and 50%yield loss from 13.6% (2787.6 ha) and 25% yield loss from 33.8% (6945.4ha) rice field. However, the normal yield was harvested from the rest 52% (10691.7 ha) of rice fields, which were mildly infested from whitefly. The problem was most severely observed in Ratnanagar, Parbatipur and Bharatpur areas (Table-1)

Table 1. Paddy area, yields and yields losses in different service centers, Chitwan, 2003

SN	Service center and VDCs/Municipality	Area (ha)	Exp.Yield @3 T/ha (mt)	% Rice area under different level of severity				Grain Yield (mt)	Yield Losses (mt)
				High (75-100% loss)	Medium (25-75% loss)	Low (1-25% loss)	Mild (0% loss)		
1	**Bhandara** (Bhandara and Piple)	2044	6132	0	10	30	60	5437	(695)
2	**Khairahani** (Khairahani, Kathar, Chainpur Birendranagar, and Kumroj)	4258	12774	0	10	30	60	11177	(1597)
3	**Ratnanagar** (Ratnanagar and Bachhauli)	2096	6288	0	20	50	30	4816	(1472)
4	**Kholesimal** (Jutpani, Pithuwa, Padampur)	1700	5100	0	10	30	60	3952	(1148)
5	**Bharatpur** (Bharatpur)	2080	6240	1	14	25	60	3380	(860)
6	**Mangalpur** (Mangalpur)	614	1842	0	25	25	50	1496	(346)
7	**Fulbari** (Fulbari and Gitanagar)	1599	4797	0	15	25	60	4337	(460)
8	**Parbatipur** (Parbatipur and Patihani)	1938	5814	5	20	35	50	4433	(1381)
9	**Gunjanagar** (Gunjanagar, Jagatpur and Sukranagar)	1720	5160	0	10	25	65	4579	(581)
10	**Saradanagar** (Saradanagar and Shivanagar)	1719	5157	0	5	35	60	4577	(580)
11	**Meghauli** (Meghauli and Dibyanagar)	793	2379	0	10	30	60	2081	(298)
12	**Total infested area (ha)**	20561	-	117.3	2787.6	6945.4	10691.7	-	-
	Area %	58%	-	0.6%	13.6%	33.8%	52.1%	-	-
	Yield(mt)	-	61683	(322)	(4483)	(4613)	(000)	52265	(9418)
13	**Hills and Madi (13 VDCs)**	9537 (42%)	28611	-	-	-	100%	28611	-
14	**District Total**	**30198**	**90594**	-	-	-	-	**80876**	**9418**

Source: ADO, Staff discursion, Chitwan, 2003, Note: Figure in parenthesis is the lost grain yield

Monitoring of pest population

Difference on Whitefly populations at different observation spots

The heavily infested, medium infested and low infested plots were selected based on the visual symptoms for Whitefly population counting.

The number of Whitefly (nymphs) per tiller was counted during the panicle initiation stage. The insect populations were found significantly different from high to medium and medium to low infested plots (Table-2 and Figure 7). The average numbers of whitefly from the heavily infested plot were 912.3 and 469.9/tiller, where it was 337.0 and 202.8 from the medium infested and 103.4 and 72.4/tiller from low infested plot (Table-2).

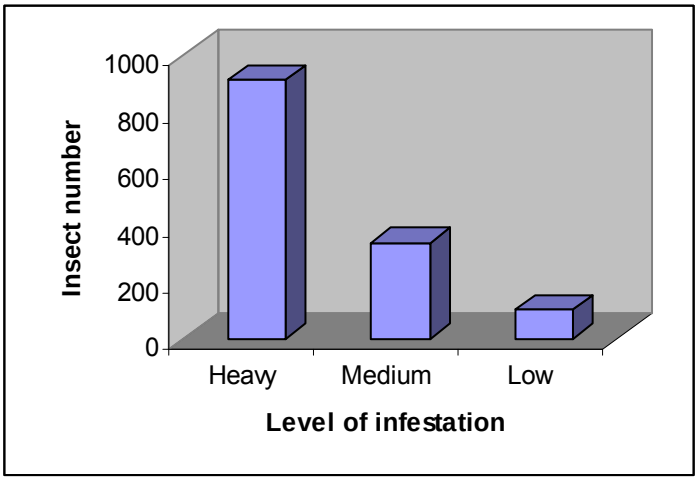

Figure 7. Difference on nymph population in different observation spots, Chitwan

Table 2. Pest population (Number/tiller) at different observation spot, Chitwan

SN	Population level	Whitefly, mean
1	Heavy	912.3 a
2	Medium	337.0 b
3	Low	103.4 c
4	Total	450.9

Coefficient of variation: 12.8%, Means followed by different letters in column are significantly different at 5% level by DMRT

Effect of Whitefly on plant growth and grain yield

Effect of Whitefly on plant height

The plant heights were significantly reduced on the plots (hills) infested with higher number of Whitefly nymphs (Table-3, Figure 9). The average plant height was reduced by 13.9% in

the heavily infested area fallowed by 3.42% in the moderately infested area compared to low infested area. The average plant height of the plants infested with high insect population was 78.0 cm, where it was 87.5 cm with medium insect population and was 90.6 cm for the low infestation (Table-3). The observations were taken during the panicle initiation stage.

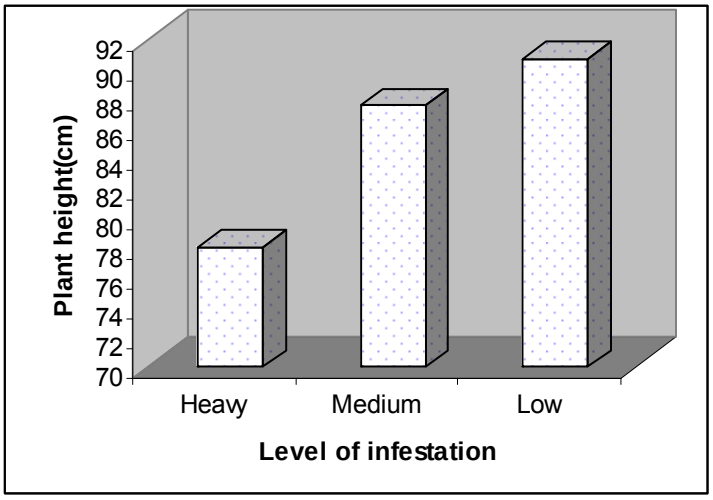

Figure 8. Difference on plant height (cm) in relation to pest population. Chitwan

Table 3. Difference on plant height (cm) with different level of pest population. Chitwan

SN	Insect population	Mean (cm)
1	Heavy	78.0 a
2	Medium	87.5 b
3	Low	90.6 c
4	Total	85.4

Coefficient of variation: 4.2%, Means followed by different letters in column are significantly different at 5% level by DMRT

Effect of Whitefly on tiller numbers

The tiller numbers were significantly higher with low infestation (Table-4). The average plant tillers/hill was reduced by 50.9% in the heavily infested spot fallowed by 22.55% in the moderately infested area compared to low infested spot. Average tillers/hill were found 27.5 in low infestation, 21.3 for medium and only 13.5/hill for high infestation plots during panicle initiation period (Table-4, Figure 10).

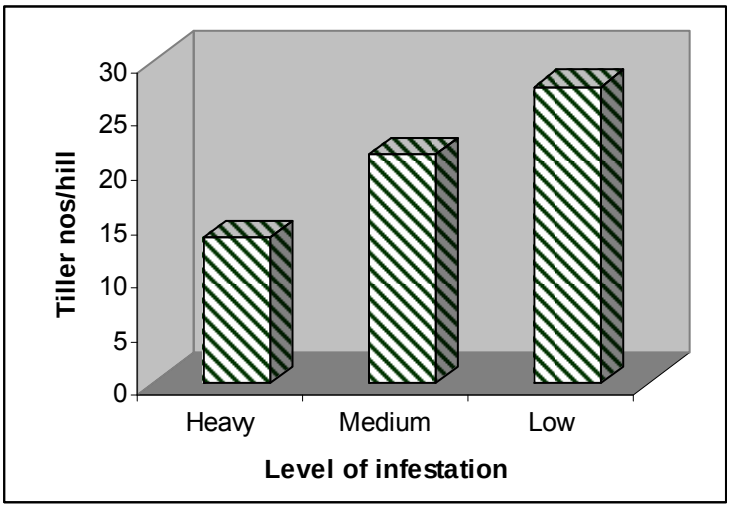

Figure 9. Effect of Whitefly infestation on tiller number. Chitwan.

Table 4. Effect of Whitefly infestation on tiller number. Chitwan

SN	Insect population	Mean
1	Heavy	13.5 a
2	Medium	21.2 b
3	Low	27.5 c
	Total	20.80

Coefficient of variation: 9.1%, Means followed by different letters in column are significantly different at 5% level by DMRT

Effect of Whitefly on panicle numbers

The panicle number/hills were significantly reduced with higher number of insect infestation (Table-5 and Figure 10). The average panicles/hill was reduced by 91.1% in the heavily infested spot fallowed by 40.0% in the moderately infested area compared to low infested spot. Only 10% of the tillers were able to produce the ears in the spot heavily infested by these insects where, it was 51.2% in moderately infested and 65.5% in lower infested spots respectively. The average panicles per hill were only 1.6 on highly infested plot, where it was 10.8 and 18.0/hill for medium and low infestation plots respectively (Table-5).

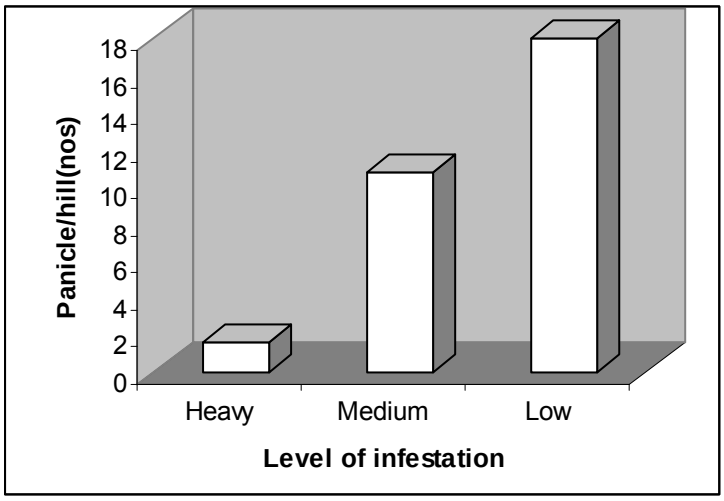

Figure 10. Effect of Whitefly on panicle number/hill, Bharatpur-12, Chitwan

Table 5. Effect of Whitefly on panicle number/hill, Bharatpur-12 Chitwan

SN	Insect population	Mean
1	Heavy	1.6 a
2	Medium	10.8 b
3	Low	18.0 c
	Total	10.1

Coefficient of variation: 14.5%, Means followed by different letters in column are significantly different at 5% level by DMRT

Effect of Whitefly on grain yield /panicle

Very few grains were developed on the panicle from the plants infested from high insect population. The average grain yield /panicle were reduced by 72.92% in the heavily infested spot fallowed by 45.83% in the moderately infested area compared to low infested spot. There was only 0.65 grams grains produced per panicle from the highly infested plot, where it was 1.3 grams and 2.4 grams from medium and low infested Sabitri plots respectively (Table-6 and Figure 11)

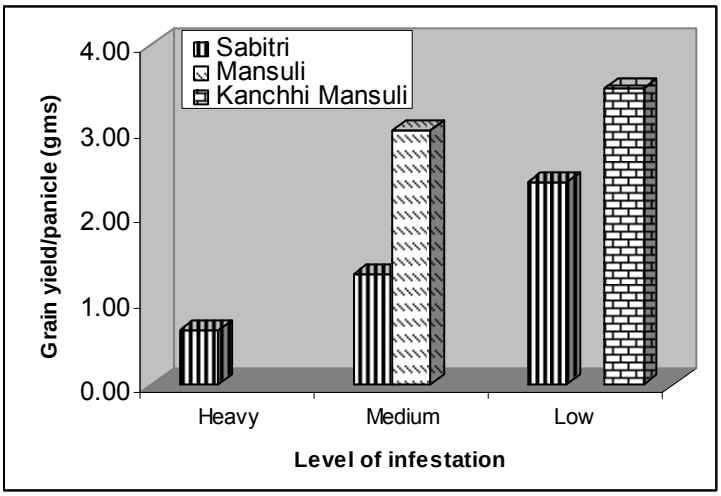

Figure 11. Effect of Whitefly on grain yield/panicle (gms), Bharatpur-12, Chitwan

Table 6. Effect of Whitefly on grain yield/panicle (gms), Bharatpur-12 Chitwan

S.N	Plot	Variety	Grain wt/panicle (gms)
1	Heavy infestation	Sabitri	0.65 gms
2	Medium infestation	Sabitri	1.3 gms
		Mansuli	3.0 gms
3	Low infestation	Sabitri	2.4 gms
		Kanchhi mansuli	3.5 gms

Average insects on other varieties: Mansuli- 315, Kanchhi mansuli- negligible.

Effect of Whitefly on rice yield

The grain yield was negligible (84.5 kgs/ha) from the heavy infested plot. However, a significant higher grain yields were harvested from medium (1287 kgs/ha) and lower (3456kgs/ha) number of whitefly infested Sabitri plots (Table-7 and Figure 13). The average grain yield was reduced by 97.50% in the heavily infested spot fallowed by 62.76% in the moderately infested area compared to low infested spot. It shows that the timely management of these insects could substantially increase the yield. This figure indicated that a total of 9418 mt grain yield has been decreased by these insects, only in Chitwan district in the year 2003 (Table-1).

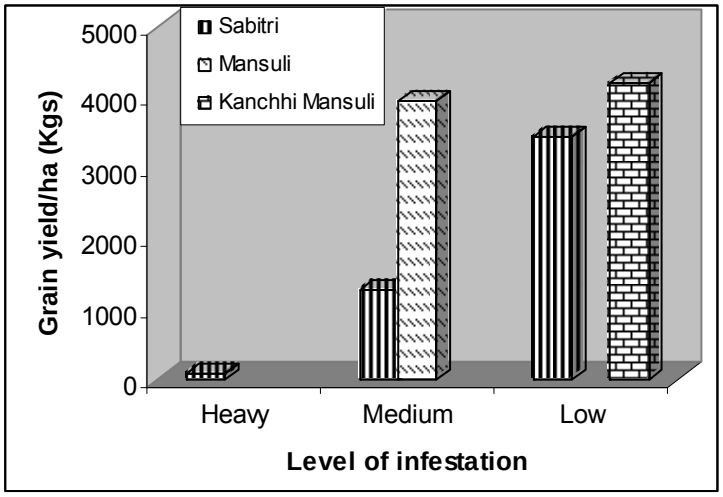

Figure 12. Effect of whitefly infestation on Rice grain yield (kgs/ha), Chitwan,

Table 7. Effect of whitefly infestation on Rice grain yield (kgs/ha)

S.N	Plot	Variety	Grain weightkg/ha
1	Heavy infestation	Sabitri	84.5
2	Medium infestation	Sabitri	1287.0
		Mansuli	3960.0
3	Low infestation	Sabitri	3456.0
		Kanchhi mansuli	4200.0

Varietals performance

Varietals performance on grain yield /panicle

Equal insect infested plots of Sabitri and Mansuli variety gave different grain yield /panicle. Medium infested Mansuli variety produced bigger panicle (3 gms/panicle) than the Sabitri. (1.3 gms/panicle). However, Kanchhi mansuli plot infested with lower number of insect provided 3.5 gms grain/panicle where, equally infested Sabitri produced only 2.4 gms/panicle (Table-6). It seems that Kanchhi mansuli and Mansuli showed greater resistance to these insects than the Sabitri variety.

Varietal performance on grain yield losses

Among the variety observed, Knachhi mansuli seems better tolerance against Whitefly and produced higher (4200 kg/ha) grain yield. Where, equally infested Sabitri gave only 3456 kgs grains/ha. Medium infested Mansuli variety was able to produce 3960 kgs grains/ha, which was higher than that of medium and even low insect infestation on Sabitri variety (Table-7).

Causes of Whitefly out break

Mono cropping

Hence farmers were not adopting the crop rotation system, thus provided continuity to pest population build up.

Rice varieties used

Sabitri was only a widely adopted variety used by the farmers. The variety was highly vulnerable to Whitefly attack.

High dose fertilizer and manure application

Average use of FYM was 30-cart load, in addition to 75 kg urea top dressing/ha. Thus the high dose of fertilizer and manure application in the hilly fertile soil with continuous irrigation has provided the luxury growth, building thick rice canopy, giving suitable condition for breeding the Whiteflies.

Improper cultural operation

Continuous irrigation favored to sucking insect's outbreak. Weeding was not adopted, building favorable situation to insect population build up. Rice planting period was not synchronized and provided longer crop season, farmer practiced dense planting of rice with higher number of seeding (10-15) per hill, giving thick rice canopy favorable to Whitefly population build up. Higher the plant population the higher insect populations were found

Favorable climatic condition

Earlier attack was noticed in August 2003. Rapid build up of population was occurred in August-September. The air temperature during the period seems most favorable (25-35^0 C) for the population growth. Other climate condition e.g. rainfall and relative humidity was also found favorable for this insect.

Lack of awareness

Formerly Whiteflies were not counted the rice pest in Nepal. Both the extension worker and farmers were not aware about its attack. They noticed the attack of this insect only at the withering stage just on the panicle initiation, which was delayed to full save the crop.

Improper use of insecticide

Farmers were using many kind of pesticide against regularly occurring pest and disease of rice. When the earlier outbreak of whitefly was noticed they used different insecticides rapidity 1-3 times. High dose at higher frequency of un-selective insecticide spray has damage the rice eco-system. All the natural enemies were destroyed, favoring quick outbreak of the pests.

The cause was not the nutritional one

Confused symptoms to major nutritional deficiency especially of K were not the nutritional one. Both the soil plant samples collected from Radha Krishna Tole Bhuratpur-12 were analyzed from the Regional soil laboratory Khairanitar. The site, where from samples were collected, was a low lying area allowing natural flow of rainwater during rain season, however not a swampy one. At the time of sampling the field was dry.

The boot leaf of the green affected plant was sampled for analysis. Only few tillers in the affected plant were green while sampling. White flies were heavily affected the field. Although the boot leaf was green while collection sample most of other leaves were almost dry. The nitrogen (2.9%), phosphorus (0.31%) and potassium (1.78%) content of the infested plants were with in the normal rank (Table-8).

Table 8. Plant analysis report of the infested plants, Bharatpur-12

S. No	Lab No.	Nitrogen (N) %	Status	Phosphorus (P) %	Status	Potassium (K) %	Status	Remarks
1	8	2.9 (2.9-4.2)	Normal	0.31 (0.2-0.4)	Normal	1.78 (1.4-2.0)	Normal	

* Value inside parenthesis indicates the normal range. Source: RSTL, Khairanitar

Moreover, the soil P^H (5.7), OM (5.4%), Nitrogen (0.23%), Phosphorous (271 kg/ha), of the soil were found with in the normal /higher ranks. However, the Potassium (199kg/ha) content was found medium and zinc (DTPA) (0.78PPM) was found low which was similar to normal field (Table-9).

Table 9. Soil analysis report of the infested rice field, Bharatpur-12

SN	Lab No.	pH	OM %	Nitrogen (N) %	Status	Phosphorus (P_2O_5) kg/ha	Status	Potassium (K_2O) kg/ha	Status	Zn* (DTPA) ppm	Status
1	6	5.7	5.4	0.23	High	271	High	199	Medium	0.78	Low

Source: RSL, Khairanitar. * Cricital level for deficiency <0.8 ppm, Note: The sample was collect from Bharatpur Municipality-12, Pokhareli Tole. Both plant and soil sample were collected for analysis.

The soil was good enough to supply the entire plant nutrient except for Zn, which was at marginal level. The N, P and K in plant sample were also normal indicating no hindrance in the availability of plant nutrient from soil. Therefore, soil fertility does not seem to have any role in the yellowing and collapse of the rice plant (RSL, Khairanitar, 2003)

Causes of the problem was really due to Whitefly

Rapid reddish yellowing of the rice field was mainly due to the sucking of the rice saps by the rapidly multiplied population of Whiteflies in the field. The minute adult whiteflies were massively found resting on the foliage, difficult to observe at rest. However, just on tapping the hills, hundreds of them were observed flying. Hundreds of nymphs were observed

mainly on leaf sheaths and few on dorsal side of leaf blades. Morphology of the Whitefly includes greenish, minute adults, whitish color on flying and greenish minute scale like structure of the nymphs and pupae. The sucking apparatus, stylet in case of nymph was retained at the ventro–anterior region projecting backward. Minute setae were seen around the ventro-plural regions. Three yellowish pigments were observed dorsally under a microscope. Sucking upon the rice plants resulted reddening of the plants following by field reddish yellow. Finally, the field was observed drying. Problem was extended in a wider area with in a month. However, the plants were slightly recovered at the end of September, permitting the flag or additional another one fresh leaf.

Potentially of natural control

The rate of adult emergence out of 50 nymphs was 86% during the second week of September, which was gradually decreased to 34% after one month. The populations at different weekly observations were significantly different and were significantly decreasing till the begening of October (Table-10). The cause of the population decreased was due to higher rate of parasitism (Figure 8).

Parasitism rate

Parasitism from the *Encarsia* sp (Hymenoptera) was started from the mid September. The rate of parasitism was significantly increasing up to mid October. Initially the rate was found 11.6% and was increased up to 63.6% after 4 weeks. Afterward, the Whitefly was totally disappeared from the rice field (Table-10 and Figure 8).

Table 10. Whitefly or parasitoid emergence rate

SN	Date	Mean emergence	
		Whitefly	Parasitoid
1	2060/6/9-13	86.0 (68.3129) a	11.6 (19.5451) d
2	2060/6/14-19	54.0 (47.3046) b	43.6 (41.3014) c
3	2060/6/14-24	41.6 (40.1362) c	55.2 (48.0062) b
4	2060/6/25-30	33.6 (35.3985) d	63.6 (52.9203) a
	Total	53.8 (47.7881)	43.50 (40.4433)

Coefficient of variation: 9.0% Coefficient of variation: 13.1%, Means followed by different letters in column are significantly different at 5% level by DMRT, Figure in parenthesis are the arc sign transferred values

Potentiality of the natural control

During mid September the pupal parasitism was finding 11.6%. However, the parasitism rate was increased up to 63.6% during mid October. The recovery of rice plant was observed during mid October, when the parasitism rate was increased and the air temperature and humidity were remarkably decreased. The Whitefly population was highly dependent to parasitoid population (Figure 13).

The observed parasitoid was hymenoptera *Encarsia* sp . Correlation between Whitefly and parasitoid was found highly and negatively correlated (-0.99654). The plants were started recovering from the end of September when the Whitefly population was significantly decreased. The recovery action has permitted to have the flag or more another one fresh, green leaf in case of medium infested plots. A beam of hope to have at least minimum yield could have been expected.

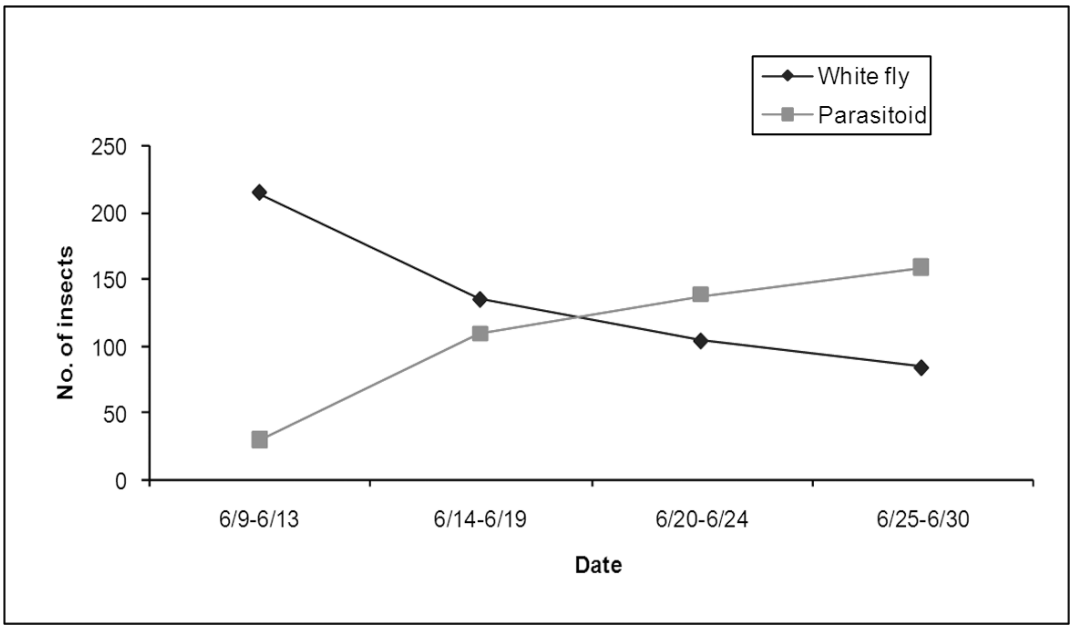

Figure 13. Relationship between Whitefly and parasitoid population, Chitwan

Conclusion and recommendation

The Whitefly, *Aleurocybotus occiduus* Maria Aleyrodidae, Homoptera outbreak was occurred on main season rice in Chitwan valley in 2003, which affected a total of 20561 ha (severely 177.3 ha, medium 2787.6 ha, low 6945.4 ha and mild 10691.7 ha) land, losing 9448 mt rice yield in 2003. Formerly Whitefly was not considered a pest of rice where, now, appeared the number one threat on rice production in inner terai of central Nepal. Improper cultural practices e.g. use of susceptible varieties, rice mono-cropping with susceptible varieties (Sabitri), excess use of agrochemicals, continuous irrigation and unconsciousness on the population build up of pest and natural enemies were the causes of out break. Regular pest and natural enemies monitoring system has been lacking in Nepal. Advanced computer based modules, remote sensing, and other sophisticated pest forecasting technique in Nepal are not available. However, survey patrol could be the best monitoring technique for earlier detection and pest forecasting, which is also not in practice, which resulted the outbreaks of this pest.

A maximum of 1000 Whitefly nymphs /tiller were counted during booting stage in September. Average population distribution in the infested field was ranged from 103.4 to 912.3 /tiller. Various effects of this epizootic on plant growth and yield parameters have been observed. The tiller number/hill was reduced by 50.9%, fertile tillers/hill by 91.1%, plant height by 13.9%, grain yield/panicle by 72.92% and grain production /ha by 97.5%, by the infestation of these insects. However, the potentiality of natural control has been found encouraging. The parasitism rate of *Encarsia* sp was highly and negatively correlated to Whitefly emergence. The rate of parasitism from 11.6% in September was increased to 63.6% with in a month. Mansuli and Kanchhi mansuli shows higher tolerance compare to Sabitri. An integrated insect pest management system is suggested through farmer's field school. The natural enemies existed in the rice field should be conserved and promoted for which misuse and over use of pesticide should be discouraged. Regular monitoring of pest and natural enemies is recommended. Cultural control of these pests is possible by using resistant varieties; synchronize planting, provision of enough spacing, crop rotation, proper sanitation and optimizing the agro chemicals. Use of systemic insecticide as a last resort, when the ETL is reached and there are no natural enemies is recommended. However, adoptive research on various aspects of control mechanisms is most essential. Development of resistant varieties incorporating the resistant genes is suggested for the breeders.

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Annex 1. ANOVA for the different level of pest population, Chitwan

Source of variation	DF	Whitefly population		
		SS	MS	F
Treatment	2	27772725.250	1386362.625	548.260**
Error	21	53101.375	8.092	
Total	23	2825826.625		

Coefficient of variation: 12.8%, SED=25.1, LSD 05=52.3, LSD 01=71.2

Annex 2. ANOVA for plant height, from the spot with different pest population, Chitwan

Source of variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Treatment	2	691.750	345.875	26.52**
Error	21	273.875	13.042	
Total	23	965.625		

Coefficient of variation: 4.2%, SED=1.8, LSD 05=3.8, LSD 01=5.1

Annex 3. ANOVA for tiller number, from the spots with different level of pest population, Chitwan

Source of variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Treatment	2	787.00	393.50	109.45**
Error	21	75.50	3.595	
Total	23	862.50		

Coefficient of variation: 9.1%, SED=0.9, LSD 05=2.0, LSD 01=2.7

Annex 4. ANOVA for the panicle numbers/hill with different level of pest population, Chitwan

Source of variation	Degrees of Freedom	Sum of Squares	Mean Square	F Value
Treatment	2	1077.250	538.625	249.28**
Error	21	45.375	2.161	
Total	23	1122.625		

Coefficient of variation: 14.5%, SED=0.7, LSD 05=1.5, LSD 01=2.1

Annex 5. ANOVA for the Whitefly and parasitoid emergence from 50 Whitefly pupae, Chitwan

SV	DF	Whitefly			Parasitoid		
		SS	MS	F	SS	MS	F
Replication	4	163.20 (71.436)	40.8099 (17.859)	1.73 (1.79) ns	130.00 (57.558)	32.50 (14.389)	1.00 (1.02)
Treatment	3	7808.80 (3167)	2656.2679 (1055.921)	112.55 (1o5.76)**	7792.60 (3251.715)	2597.533 (1083.905)	80.25 (77.04)
Error	12	283.20 (119.813)	23.609 (9.984)		388.40 (168.835)	32.367 (14.070)	
Total	19	8415.20 (3359.011)			8311.00 (3478.835)		

Figure in parenthesis are the arc sign transferred values, Coefficient of variation: 9.0% , Coefficient of variation: 13.1%, SED=3.1, SED=3.6, LSD 05=6.7, LSD 05=7.8, LSD 01=9.4, LSD 01=11.0