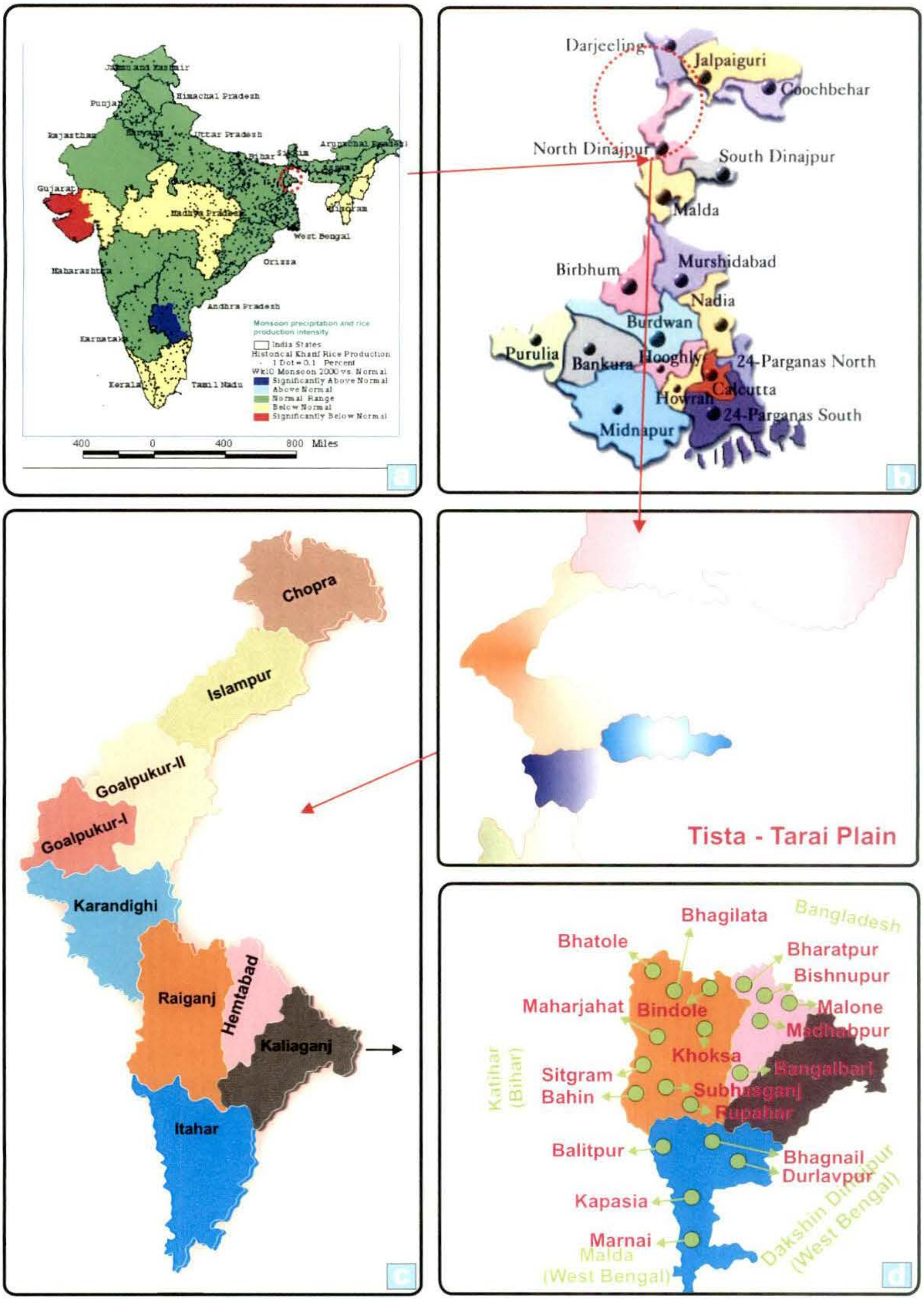
CHAPTER THREE

Materials & Methods

3.1 Location and climatic conditions: The District Uttar Dinajpur is situated between 26°35′15′′(N) – 87°48′37′′(W). The District comprises of two administrative sub-divisions – Raiganj and Islampur, encompassing an area of 3140 Sq. k.m. which is 15mt. above msl (Fig.3.1). The climate of this zone is sub-tropical humid in nature. The average annual rain fall varies from 2087 to 3000 mm, the maximum rainfall occurs during the rainy months of June to September amounting to more than 80% of the total rain fall. The annual average day night temperatures range between 19.7and 27.9°C with the mercury soaring even as high as 38°C in April and cascading to a low of 3°C in January. The relative humidity at 8:30 hours is 60% and 87% in March and July respectively. In almost every year the district variably experiences drought and flood (District Statistical Hand Book 2004, Uttar Dinajpur, Director Bureau of Applied Economics and Statistics. Govt.of West Bengal.)(Fig.3.2a-d and table.3.1).

3.2 Socio economic pattern and agronomic scenario: The District offers the special.agronomic patterns accounting 239500 agriculture dependant families, 88536 small farmers (5.22%) 135827 marginal farmers (8%), 242564 agriculture land less labour (14.29%). Among the two administrative sub-divisions, Raiganj comprises of 4 blocks, namely Raiganj (227 villages), Hemtabad (116 villages), Itahar (217 villages) and Kaliaganj (198 villages) each of which has distinct socioeconomic pattern with more than 90% rural population. Major cash crop in all the blocks is paddy (District Annual Plan on Agriculture, Uttar Dinajpur, 2002-2003. Govt. of West Bengal.).

The nature of the soil and the status of the nutrients in the paddy cultivated lands of the three blocks are shown in the table 3.1 and 3.2. Physio-chemical properties of the experimental soil were determined by standard methods: Particle size distribution of soil by International pipette method (Piper 1950), Soil texture by USDA system (Brady 1996), Soil PH by Potentiometric method (Jackson 1967) and total nitrogen (%) by modified Kjeldahl method (Jakson 1967).

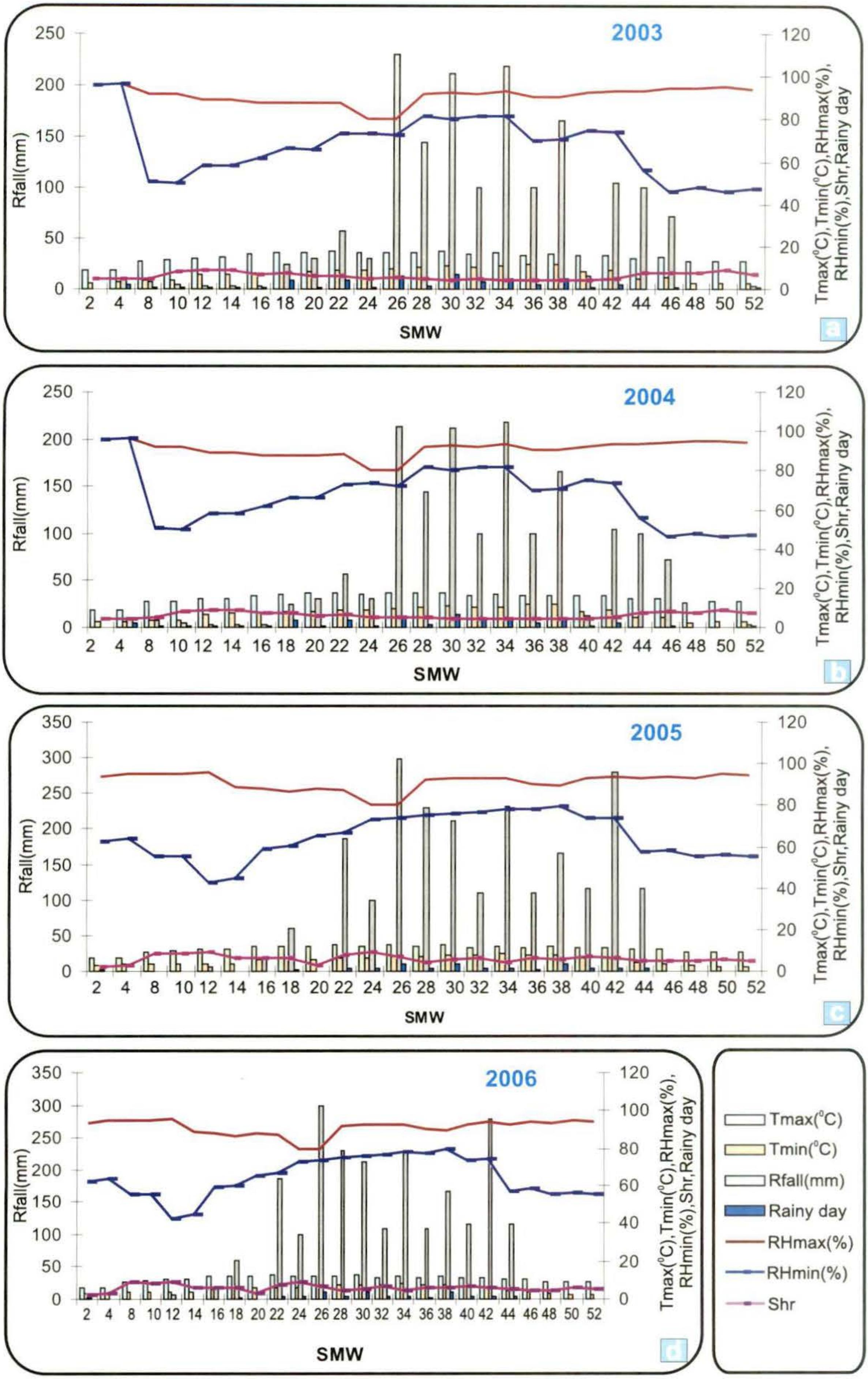


Figs. 3.1: Location of the District and the study area(a-d).

Table.3.1: Monthly data on climatic parameters (Mean ± SE) during the years of investigation (2003-2006)

Months	Forth night	Abiotic conditions during the experimentation						
		Temperature (^{0}C)		RH (%)		Sunshine (hours/day) (Shr)	Rainfall (Rfall)	
		maximum (Tmax)	minimum (Tmin)	maximum (RHmax)	minimum (RHmin)		Amount(mm)	rainy day
Jan	A	18.17±0.67	13.14±1.34	84.10±2.45	57.14±2.44	7.24±0.21	0.80±0.02	01±0
	B	18.45±1.11	15.12±1.11	82.62±2.33	58.61±2.67	7.92±0.23	1.14±0.01	01±0
Feb	A	19.82±1.21	18.12±2.12	81.21±2.11	67.92±3.11	7.01±0.31	4.12±0.11	01±0
	B	20.10±2.11	19.14±2.13	78.45±3.66	69.64±3.02	7.44±0.44	4.14±0.45	01±0
March	A	20.64±1.32	19.82±2.31	79.41±3.45	52.61±3.33	7.64±0.11	4.64±0.78	01±0
	B	23.12±1.32	20.21±2.44	80.21±4.11	58.64±2.34	7.81±0.31	5.25±1.11	02±1
April	A	28.92±1.12	21.64±2.33	81.14±4.23	69.14±1.67	7.84±0.11	7.14±1.34	02±1
	B	29.68±1.03	22.14±2.56	82.15±4.11	68.72±2.67	7.98±0.12	21.16±2.11	03±1
May	A	31.62±1.11	22.91±1.77	79.62±4.67	65.12±2.64	8.12±0.13	28.12±4.11	04±1
	B	32.12±1.45	24.72±1.67	81.81±3.56	65.48±3.44	8.41±0.12	31.64±3.25	03±1
June	A	34.18±2.11	25.70±1.78	86.20±3.44	67.10±3.78	8.80±0.21	78.72±3.21	03±1
	B	32.81±1.54	25.60±1.89	89.40±3.23	72.40±4.12	5.50±0.14	210.95±6.22	05±1
July	A	32.40±1.02	25.61±1.90	90.60±3.44	76.10±4.34	4.72±0.33	167.60±4.11	04±1
	B	31.90±1.32	25.71±1.56	88.60±3.67	75.80±4.67	5.58±0.21	142.70±2.23	03±1
August	A	30.52±1.23	25.83±1.66	89.41±3.78	75.40±2.67	6.47±0.33	116.80±2.67	04±1
	B	31.10±1.39	25.40±1.88	89.40±3.88	69.70±4.89	6.05±0.50	110.73±3.56	04±1
Sept	A	31.81±2.31	24.96±1.56	90.16±3.99	73.60±4.33	6.31±0.33	110.70±5.78	03±1
	B	29.50±3.12	24.20±1.44	89.16±2.34	69.20±3.22	6.97±0.24	108.30±7.33	03±1
Oct	A	30.38±2.23	22.18±1.34	88.90±2.67	60.80±4.23	8.38±0.27	45.74±4.23	01±1
	B	30.56±1.22	18.40±1.26	86.92±2.55	52.15±3.11	5.59±0.29	6.40±1.11	02±1
Nov	A	26.80±2.13	18.10±1.67	85.30±2.45	44.10±2.33	8.32±0.41	7.10±1.21	01±0
	B	25.10±2.78	17.05±1.34	84.80±2.51	43.70±2.41	7.89±0.31	6.80±1.32	01±0
Dec	A	22.60±2.67	11.70±1.33	95.78±2.23	64.22±2.11	7.21±0.33	1.02±0.56	01±0
	B	21.65±2.01	10.90±1.34	96.44±2.34	61.65±2.12	7.01±0.32	1.23±0.11	01±0

A-First fortnight, B –Second fortnight



Figs. 3.2: Data on climatic parameters during the study, a-d: 2003-2006.

Table.3.2: Nature of soil and paddy cultivation area (ha) in the three blocks

Blocks	**Sandy**	**Sandy loam**	**Loam**	**Clay loam**	**Clay**	**Total**
Raiganj	1000	30,000	3,200	600	400	35200
Hemtabad	860	12,000	1590	500	250	15200
Itahar	-	1,000	12335	17300	1000	31635

(-)-Data not available

Source: District Annual plan on Agriculture, Uttar Dinajpur 2002-2003. Directorate of Agriculture, Govt. of West Bengal.

Table.3.3: The status of soil nutrients in paddy cultivated lands

Blocks	**Carbon (%)**	**Range of nutrient status**			
		Av.P_2O_5 kg/ha	**Av. K_2O kg/ha**	**PH**	**EC m.mho / cm**
Raiganj	0.29-0.48	5.8-172	15-176	5.0-6.4	0.06-1.25
Hemtabad	0.24-0.52	21-200	27-367	4.6-6.1	0.05-0.31
Itahar	0.18-0.90	45-89	12-75	5.2-6.3	0.05-0.29

Source: District Annual plan on Agriculture, Uttar Dinajpur 2002-2003. Directorate of Agriculture, Govt. of West Bengal.

3.3. Site of investigation and agro ecological conditions of villages: The investigation was carried out in 20 villages in the adjoining blocks namely Raiganj (10 villages) Hemtabad (5 villages) and Itahar (5 villages). All the selected villages alienated from the nearby village by an average aerial distance of 10-18 km.

The respective serial number against the name of the villages denotes their relative position in north-south direction within the block. The agro ecological profile of particular experimental fields of the villages is furnished in table 3.4 The average value of the five plots in each of the villages has been computed.

Table.3.4 Agro-ecological profile of the villages

Sl No.	Village(s)	Nature of soil status			Cropping intensity (%)
		PH	N:P:K / ha	C %	
Block: Raiganj					
1	Bhatole	5.4	450.1:6.23:303.1	0.78	172
2	Bindole	5.7	410.2:7.14:270.8	0.81	189
3	Bhagilata	6.1	380.3:6.56:277.2	0.85	188
4	Khoksa	5.2	372.3:6.98:301.1	0.79	174
5	Maharajahat	5.0	377.4:6.75:299.1	0.77	193
6	Sitgram	5.3	389.4:7.22:278.9	0.67	176
7	Lohanda	6.0	489.5:7.89:304.5	0.85	188
8	Bahin	5.6	467.4:7.67:208.1	0.71	176
9	Subhasganj	5.8	488.6:7.96:287.5	0.66	186
10	Rupahar	5.3	438.2:7.77:278.3	0.68	189
Block: Hemtabad					
11	Bharatpur	5.7	429.4:6.98:290.8	0.72	214
12	Malone	5.5	466.3:6.98:287.9	0.75	221
13	Bishnupur	5.8	436.2:6.78:344.2	0.71	198
14	Madhabpur	5.1	467.3:6.99:342.8	0.73	199
15	Bangalbari	5.0	389.4:7.08:341.5	0.77	219
Block: Itahar					
16	Balitpur	5.8	490.3:7.55:389.3	0.81	169
17	Bhagnail	5.2	433.2:8.21:324.5	0.82	176
18	Chandigram	5.1	469.3:8.01:287.5	0.79	175
19	Durlavpur	5.9	428.4:8.00:341.4	0.80	162
20	Marnai	5.4	435.3:6.78:301.3	0.81	161

3.4 Description of variety: The description of the variety under consideration is given in the table 3.5

Table.3.5 Description of the varieties with their commercial characteristics

Variety (High yielding)	Parentage	Accession no.	Commercial characteristics				
			Qualities			Crop duration group (Seedling to maturation)	Yield q / ha
			Grain size	Tillering range	Insect resistance		
Swarna Mashuri	IR 20 x Pusa 33	IET 7029	Bold	High	Medium	Long duration (>140 days)	28.6-38.8

3.5 Identification of the pests and natural enemies: During the identification of the species their morphological characteristics together with the habitat of the pests were duly considered. Identification of the species was done on the basis of morphological characteristics of adult as described by Israel and Rao (1954). Kok and Varghese (1966), Rao and Nagaraja (1966), Grist and Lever (1969), Nishida and Tori (1970), Kapur (1984) and Senapati and Panda (1999).

3.6 Recording of data on the insect pest dynamics and incidence: Dynamics of the pest activity was assessed in two ways. Relative variability of the pest occurrence was noted as a prophylactic measure for immediate implementation of regulatory pest control protocol. The other process was mostly relied upon the assessment of pest induced damage which could be used for the corrective measure for designing future cultivation strategy. Present study encompasses both prophylactic and corrective assessment with an aim to formulate an easily accessible protocol for both present and future pest control strategy.

3.6.1 Estimation on dynamics

3.6.1.1 By quadrate estimation (Bandong *et al.* 1991)

3.6.1.1.1 Structural components: A simple quadrate of flat metal bars, was fastened to an anchoring bar with a wing nut screw. The anchoring bar allowed the quadrate to be raised as the crop grows. Quadrate was square (2 x 2mt. or 0.5 X 0.5 mt.) or rectangular (2.5 mt. x 2.5 mt.) to allow plants to be more easily grasped by hands and facilitated counting of tillers, leaves and insects. The anchoring bar was jabbed in to the soil at randomly chosen points in the fields. The quadrate was attached with its leading side open. Once the quadrate was firmly anchored the notched front bar was filled in to the place to enclose the sample plants in the quadrate (Fig.3.3a).

3.6.1.1.2 Operational system: The dynamics of the insect pests in each plot was recorded in terms of their availability within a particular quadrate form 15 day after transplanting (DAT) till the yellow maturing stage of leaves. At the time of operation attention was given to minimize the unnecessary mechanical disturbances to the plant canopy. Pests and natural enemies so observed were visually counted and tabulated. Average value of 10 quadrates from 20 x 20 mt. field was taken in to consideration.

3.6.1.1.3 Applicability in pest counting: By applying this method egg mass of YSB, dead heart (DH), white head (WH) caused by YSB, leaves damaged by BPH, grains damaged by paddy bug (PB) and the population of natural enemies were counted.

3.6.1.2 Light trap estimation

3.6.1.2.1 Structural components

Inexpensive light trap designed by the Entomological department, IRRI was used for pest monitoring with befitting modifications. *Kerosene* light source in the original trap was replaced by electric lights of different intensities. The funnel shaped exhaust cap extends 4 cm down into the lantern body for efficient removal of the accumulated heat inside of the glass. The lantern attached to a wooden support frame and was periodically hanged above the rice crop from the very date of transplantation. The frame has platform that supports basin of oily water to immobilize the fallen insects. Count was made on the following day (Fig.3.3b).

3.6.1.2.2 Operational systems

3.6.1.2.2.1 Seasonal estimation: 5 light traps (200 watt) were equidistantly placed in the paddy field (100 mt x 100 mt.), 8mt. above the ground level, with a collection pan (r=30cm.) below the light trap, from early vegetative stage to the ripening stage, in every fortnight. There were five replications in each year for the four successive years for pest estimation from each of the catches and in each block. Overall seasonal dynamics of all the pests and natural enemies was noted after installing light trap (200wt) in mono-cultural paddy field. However during the study on YSB brood emergence collection of four traps were collectively considered.

3.6.1.2.2.2 Periodic light trap estimation: 5 automatically monitored light traps (200 watt.), each in every paddy field (100 x100 mt.) was installed 8 mt. above the ground level, from early vegetative stage to the ripening stage from

6:00 pm. to 6:00 am. The catches were transferred to separate container at hourly intervals. The sexes were separated, counted and the percentage was worked out to find out the effective time for the installations of the light traps. If on a specific date rain occurred, collection was done on the following day.

3.6.1.2.2.3 Pattern of collection in two fields: Relative influence of three different proportional variations of organic and inorganic fertilizers on the bionomics of YSB population was assessed in the two paddy varieties. All the fields under observation were treated with 120 kg N / ha. Collection was done every fortnight and the average value of population was taken into consideration. In this case too, if on a specific date rain prevailed, collection was done on the following day.

3.6.1.2.2.4 Coloured light trap estimation for BPH population: Light trap with four different colours (green, red, yellow, white) were set up in the farmers agricultural fields from 5-19 weeks after transplantation (WAT) and the average pooled data for different colours were taken separately for subsequent analysis. Evaluation indicated the relative trapping efficacy of different colours. Selection of the traps were made in due consideration of the emitted light quality of the traps commonly adopted by the farmers.

3.6.1.2.2.5 YSB moth settlement during light trap collection: In order to understand the relative consequences of formation of damaging symptoms by YSB, light traps were set up throughout the cultivation season in three consecutive years especially from the early vegetative stage to the late tillering stage of paddy. The trap was placed at 6 mt. high with an operating period from 21:00 – 07:00 in three collection conditions system as specified below:

3.6.1.2.2.5.1 Collection of the yellow stem borer population in relation to the growth stages of paddy

Continuous period: Traps were installed uninterruptedly for 10 days from 18:00 – 06:00 hours either at vegetative or at tillering stage of plant. Moths collected under each separate operation at different distances encircling the 'trap zone' were counted separately.

Discontinuous period: Operation of light trap was done in discontinuity, 5 days at vegetative stage and the remaining 5 days at tillering stage. Moths collected at different distances under such conditions were taken collectively.

3.6.1.2.2.5.2 Collection of the YSB population in relation to the time of trap settlement: Traps were set up in the field either in early night (18:00-24:00) or at late night (24:00-06:00). Moths collected at different distances surrounding the trap area, under each operation were counted separately. The counts from different distance were evaluated against the distances from the trap zone under different application settings.

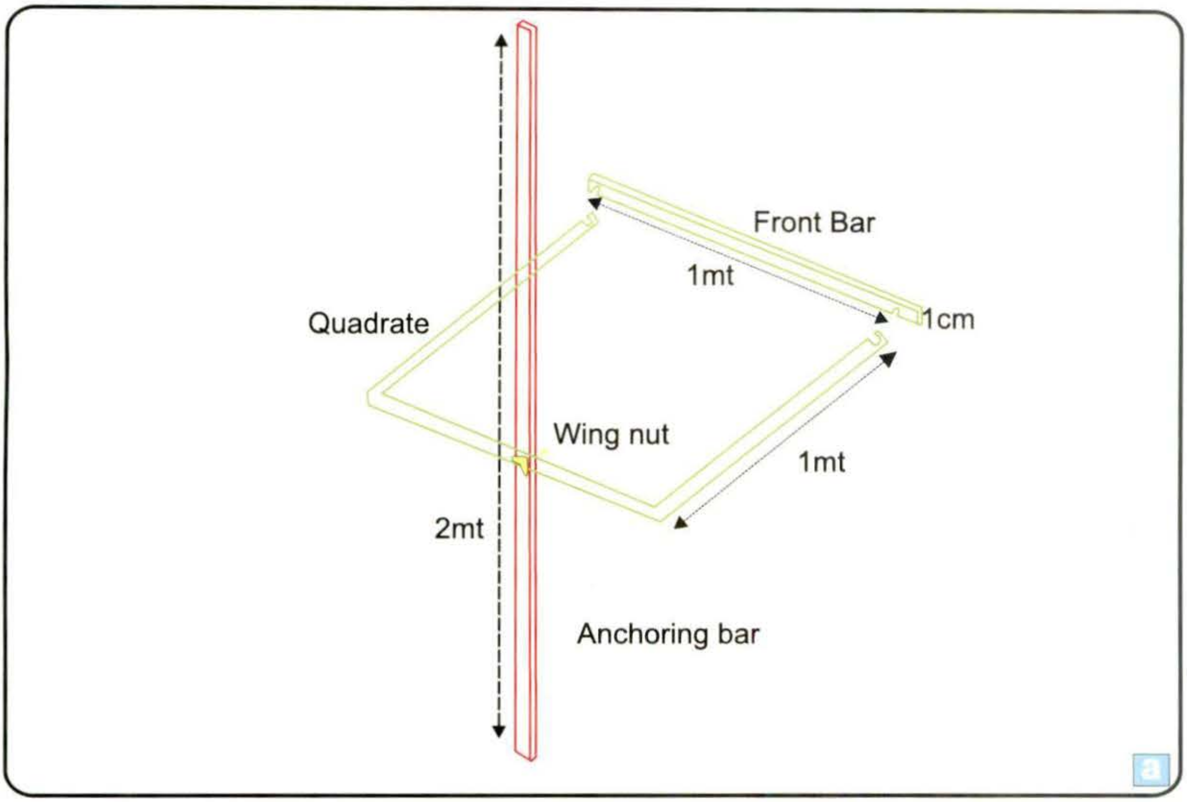
3.6.1.2.3 Applicability in pest counting: Pests collected under the trap operation was counted on the following day. A correlation study was made between the light traps catches with the prevailing meteorological conditions of the successive four years. Utility and the efficacy of the light traps were determined after assessing the differences of YSB field population and the consequences of DH and WH, before and after the installation of the light traps.

3.6.1.3 Hill or area estimation

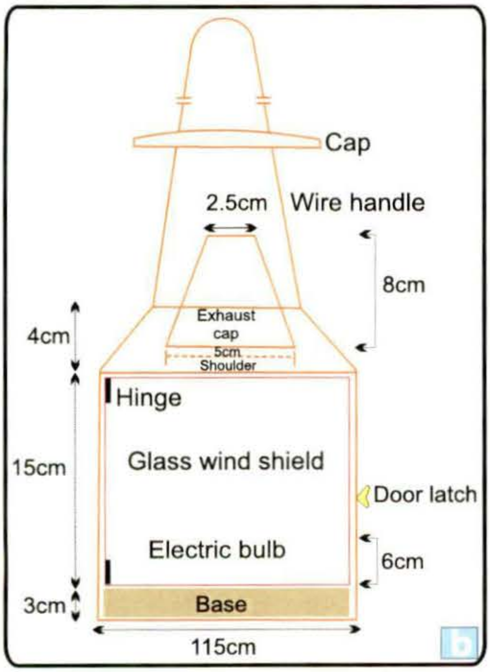
Assessment of the field population of both the pest and natural enemies was done normally on diagonally selected 20 hills from 20 x 20 mt. plot. However the number of the examined hills varied depending on the situation. The average value was considered as the relative occurrence of the particular pest and natural enemies. In some occasions pests or pest induced symptoms were assessed within specified area and the hills within the area were examined (Fig.3.3c).

3.6.2 Estimation on incidence

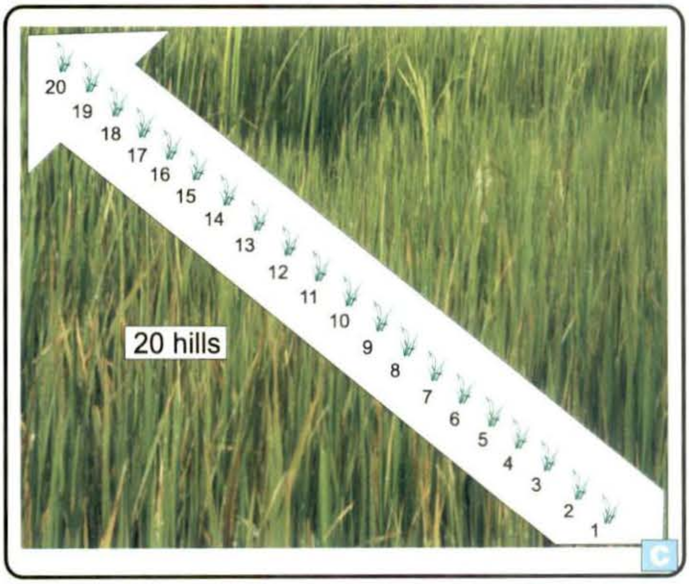
The population of the insect pests in each plot was recorded in terms of their respective damage produced to leaves or to plants, at weekly interval starting form 05 DAT till the yellow maturing stage of leaves . At the time of recording data, only fresh damage was considered.



The method of quadrate sampling (modified after Bandong, 1991)



Electric lantern (light trap)
(modified after IRRI, 1979).



Selection of 20 hills in a plot diagonally.

Figs. 3.3: Pest estimation protocol followed in the investigation.

3.6.2.1 Determination of yellow stem borer (YSB) incidence

3.6.2.1.1 Activity of the adult moths: The infestation of YSB was recorded in terms of number of DH and WH produced during vegetative and reproductive stages respectively in each plot. For assessing the stem borer damage during vegetative stage, 20 hills from each plot (25 x 25 mt.) were selected diagonally. Total number of tillers and stem borer infested tillers were counted there from. For estimation of WH, total number of panicle bearing tillers and the stem borer affected tillers *i.e.* WHs were counted in the same manner. The percentage of DH and WH of individual plot was calculated by using the following formula described by Singha and Pandey (1997).

$$\text{DH and WH \%} = \frac{\text{Number of DH / WH}}{\text{Total number of tillers}} \times 100$$

$$\text{\% of Damaged leaves} = \frac{\text{No. of damaged leaves}}{\text{Total No. of leaves}} \times 100$$

Depending on the severity of the infestation gradation was made as given in the table.3.6

Table.3.6: Scale showing the grade of infestation by YSB

Grade	Dead heart (%)	White head (%)
0	None	None
1	1 to 20	1 to 10
3	21 to 40	11 to 25
5	41 to 60	26 to 40
7	61 to 80	41 to 60
9	81 to 100	61 to 100

3.6.2.1.2 Study on YSB's egg mass: Fields were periodically examined from the early vegetative stage to the maturation stage of paddy. 20 hills were diagonally inspected from 25 x 25 mt. field area. When egg masses were observed the respective plant part was incised off and the percentage (egg mass/100 hills) was calculated.

3.6.2.1.3 Study on YSB's parasitized eggs: Four freshly cut leaves with YSB's egg clutches were collected at different growth stages from the paddy field at 5 days intervals and put inside a plastic vial which was plugged with wet tissue paper. The vials were kept with open end down in a jar/basin having 5 mm standing water for continuous wetting. A total of 64 leaves were collected from each paddy field (200 x 200mt.) and kept in 16 vials, each with 4 leaves, arranged in test tube racks, allowing necessary time for parasite emergence. The average percentage of parasitic emergence was put graphically after conducting the experiment in 5 replications.

3.6.2.2 Determination of Brown plant hopper (BPH) incidence

3.6.2.2.1 Seasonal dynamics: The relative abundance of BPH was assessed by proportional *flag leaf* area damage on 20 diagonally selected hills and the average value was taken in consideration. The gradation was done following the table 3.7

Table.3.7 Scale showing the grade of infestation by BPH

Rating scale	Nature of damage
0	None
1	First and second leaves of most plants partially yellow
5	Pronounced yellowing and stunting
7	More than half of the plants wilted or dead
9	All plants dead

3.6.2.2.2 Determination of the extent of damage

Suenaga and Nomura (1970) estimated the loss induced by BPH by using damage index calculated from the equation:

$$\text{Damage index} = \frac{[(1\,A + 2\,B + 3\,C + 4\,D)/4\,T]\,100}{T \times 4}$$

Where, A indicates the number of tillers with the upper two leaves undamaged and the rest withered; B, the number of tillers with all except the flag leaf withered; C, the number of tillers with all leaves withered but with panicles still alive; D, the number of tillers with leaves, stems, and panicles all withered; and T, the total number of infested tillers.

3.6.2.3 Determination of gall midge (GM) incidence

3.6.2.3.1 Determination of the extent of damage: Damage by gall midge (GM) was recorded after the production of silver shoots (SS)/onion leaves all through the tillering stage, by counting total number of tillers / 20 hills diagonally of each plot (25x 25 mt) and the number of 'silver shoots' or 'onion leaves' produced. While recording data, only fresh damage was considered in each date of observation. Side by side percentage of parasitized galls(PG%) was also noted The percentage of damage was worked out from the data thus using the following formula :

$$\text{Percentage (\%) Silver shoots} = \frac{\text{Number of SS / Onion leaves} \times 100}{\text{Total Number of tillers}}$$

Depending on the intensity of infestation gradation was made following the table 3.8

Table.3.8: Scale showing the grade of infestation by GM

Rating scale	Nature of damage (%)
0	None
1	11 to 20
5	21 to 35
7	36 tom 50
9	51 to 100

3.6.2.3.2 Effect of GM on the yield generation: The relative effect GM induced tiller production was assessed in terms of paddy yields. This was done from different number of seedling / hill and the yield attributes were assessed in a split plot design in three replications. The variety was planted in a 6 x 12 mt^2 plots. The main plot was equally divided into four subplots having 3, 5, 7 and 9 paddy seedlings / hill.

(*Leptocorysa* sp.) were released in each cage with five replications in the same

3.6.2.4 Determination of paddy bug (PB) incidence

3.6.2.4.1 Determination of the extent of damage: Damage by paddy bug (PB) was recorded after counting the percentage of unfilled grains at maturation stage. 20 panicles were diagonally collected from each of the 5 plots (25 x 25mt.), grains were threshed and percentage of unfilled grains was calculated and accordingly tabulated (Table.3.9).

Table.3.9 : Scale showing the grade of infestation by PB

Rating scale	Nature of damage
0	None
1	11 to 20
5	21 to 35
7	36 to 50
9	51 to 100

3.6.2.4.2 Field examination: The relative effect of the paddy bug (PB) on the grain filling was assessed in terms of the visible number of puncture spots on the grains. Panicles were randomly selected from the field from which 1000 grains were considered. Grains were sorted in to different grades depending on the number of punctures and weight and then calculated as percentage.

3.6.2.4.3 Field experimentation: At early flowering stage, panicles were randomly selected and encaged in cylindrical glass vials (60 x 10 cm.). Each vial enclosed five panicles from the same field. 2, 4 or 6 nymphs of paddy bug (*Leptocorysa* sp.) were released in each cage with five replications in the same field. Vial with no nymph was considered as control. Vials were checked daily and a stable insect density were maintained until harvest. Grain discoloration, percentage of unfilled grains, number of punctures/grain and the weight of all the grains in a cage were recorded.

3.7 Methods for assessing yield attributing characters

3.7.1 Measurement of leaf width : For measurement of leaf width, five leaves from five randomly selected shoots, one from each hill / plot were considered at maximum growth stage and when infestation was found low. Mean values were determined.

3.7.2 Length, breadth and dry weight of leaves: 10 cm of each of the 5 cut leaves were taken, the breath of the cut leaves were recorded (in mm.) and dried. Weight of dried leaves was recorded at 15, 30, 45 and 60 DAT.

3.7.3 Leaf area index (LAI): The destructive plant samples were taken from each individual plot (25 x 25mt.).The green leaf lamina of all the selected plants was separated out and from that 10 cm. was taken. The middle portion of long leaf lamina was cut in a rectangle size. The breadths of the each cut pieces were measured. The cut portions were dried at 65°C, allowed to attain a constant weight and weighed on a digital balance. By using area / weight (a/w) factor of the cut portions, the total leaf areas were calculated for each treatment. From the dry weight of leaves, LAI was worked out according to the formula given by Waston (1947).

$$\text{Leaf area index (LAI)} = \frac{\text{Average area of total number of leaves}}{\text{Ground area from which leaf samples were collected}}$$

LAI was measured on four occasions at 15 days interval starting from 15 days after transplanting (DAT).

3.7.4 Number of panicles: Total number of panicles were recorded from 20 diagonally selected plants of each plot at harvest. Thereafter, average number of panicles was worked out.

3.7.5 Number of grains/panicle: 20 panicles were diagonally selected from each plot, threshed individually and the grains were counted. The average of grains / panicle was worked out.

3.7.6 Thousand grain weight: From the threshed product of each lot, thousand grains were counted, dried and their weights were recorded (in gm.) for each plot separately.

3.7.7 Length of panicle : 20 individual panicles were selected randomly from each plot and the length was recorded (in cm.) and averaged .

3.7.8 Grain yield: After harvesting the stalks were sun dried and subsequently threshed. After cleaning thoroughly, the produce from each plot were weighted and calculated as yield q/ha. Similarly straw yield was determined.

3.7.9 Harvest Index: Harvest index was calculated by the following formula and expressed in percentage.

$$\text{Harvest Index} = \frac{\text{Grain yield}}{\text{Total biological yield (grain + straw)}} \times 100$$

3.8 Assessment of the impact of cultural practices on pest incidence

3.8.1 Growth stage specific application of pesticides

3.8.1.1 Selection of pesticides: The relative efficacy of four commonly used insecticides was assessed at different stages of paddy growth till the time of maturation. Selection of a pesticide was made in due consideration of its lethality to the target organisms, spectrum of toxicity and the market availability with specific recommended dose. The pattern of application strategy is given in the table.3.10

Table.3.10 Name of the pesticide with the application strategy at the respective growth stages of paddy

Name of the pesticide	Dose(/ ha)	Growth stages of paddy when applied
Methyl parathion	2% @ 6kg	Seed bed
Endosulfan	35% @ 1500ml	Vegetative
Phorate	10% @ 1kg	Reproductive
Monocrotophos	36% @1200ml	Ripening

3.8.1.2. Matrix combination for pesticide treatment: Relative status of the pest abundance was evaluated after application of pesticides at different growth stage combinations. Growth stages which received no pesticide protection (NSP) was considered as no input while the fields which received the protection at all the growth stages (ASP) were measured as the maximum input. The relative dynamics of the pests were assessed under different combinational application of pesticides against the ASP and NSP protection as designed in the table.3.11

Table.3.11 Matrix combination for pesticide treatment

Category of input	Sub category with nomenclature	Growth stage specific insecticidal protection			
		Seed bed	Vegetative stage	Reproductive stage	Ripening stage
Single stage protection	SSP (1)	+	x	x	x
	SSP (2)	x	+	x	x
	SSP (3)	x	x	+	x
	SSP (4)	x	x	x	+
Double stage protection	DSP (1)	+	+	x	x
	DSP (2)	x	+	+	x
	DSP (3)	x	x	+	+
	DSP (4)	+	x	+	x
	DSP (5)	x	+	x	+
	DSP (6)	+	x	x	+
Triple stage protection	TSP (1)	+	+	+	x
	TSP (2)	x	+	+	+
	TSP (3)	+	x	+	+
	TSP (4)	+	+	x	+
All stage protection (maximum input)	ASP	+	+	+	+
No stage protection (no input)	NSP	x	x	x	x

(+) = Insecticide applied, (x) = No pesticidal protection

3.8.1.3 Effect of pesticide application, field size, border distance on BPH and spider abundance: Fields of different sizes (100 and 1000 mt^2) cultivated with the variety *Swarna Mashuri* (MTU 7029) were treated with carbofuran at the rate of 1 kg/ha on 60 DAT against the field without pesticidal treatment, considered as control. Abundance of BPH and the spider population was counted on the day immediately after pesticide treatments in all the plots. Hill estimation of the respective population was done with a gap of 2 mt from the border of the field covering a total distance of 10 mt to a perpendicular transects. Experiments were carried out in three replications and the average data were graphically plotted.

3.8.2 Application of fertilizer

3.8.2.1 Consequence of different types and mode of fertilizer application: The relative influence of both the inorganic and the organic sources of fertilizers upon the dynamics of the pest abundance were assessed. Decaying straw (45 days), cow dung (60 days) and *Dhaincha* (*Sesbania* sp.) were considered as chief organic source while urea was taken as the prime inorganic component. Urea was applied in three modes, mud ball, alley (band placement), and three alternative split proportions. The abundance of the pest was recorded under the application of three doses of both inorganic and organic fertilizer. A comparison was drawn between the yield potentiality of paddy under different modes and sources of fertilizer applications.

3.8.2.2. Efficacy of growth stage dependent split application: Relative importance of inorganic and organic fertilizers upon the pest bionomics and the yield attributing characters were assessed under 14 different proportional combinations of inorganic and organic fertilizers at four growth stages of paddy in five replications. In each stage collectively 120 kg N was applied. The growth stage dependant variable combinations are given in the table 3.12.

Table.3.12: Growth stage dependent split application of inorganic and organic fertilizer.

Treatment	Split proportion (%)		Inorganic split proportions (%) in relation to the growth stages of paddy		
	In organic	Organic (only at main land preparation)	1st split at 10 DAT	2nd split at MTS	3rd split at PIS
FT 1	100	00	60	25	15
FT 2	100	00	40	40	20
FT 3	75	25	30	30	15
FT 4	75	25	20	35	20
FT 5	75	25	30	20	25
FT 6	25	75	15	10	00
FT 7	25	75	05	15	05
FT 8	25	75	05	15	05
FT 9	50	50	30	10	15
FT 10	50	50	30	15	05
FT 11	50	50	20	20	10
FT 12	00	100 (two phase)	00	00	00
FT 13	00	100 (single phase)	00	00	00
FT 14	00	00	00	00	00

DAS-days after transplantation, MTS- Maximum tillering stage PIS- Panicle initiation stage

3.8.2.3 Response of the variety to fertilizer and impact on pests and natural enemies population: Each plot collectively received 120 kg N /ha though the split proportion varied in accordance to the growth stages of paddy. Only organic and only inorganic fertilizer applications were considered as 'limiting input' while 'no fertilizer' was regarded as control. Yield attributing characters like plant height, panicle length, panicle number, grain number/ panicle and the final yield were recorded separately for each split application stages. The abundance of the pest and natural enemy was counted by hill estimation for each of the application stages. Cost: Benefit (C:B) was calculated collectively considering the total input prices and the market value of the yield.

3.8.3 Water stress management

3.8.3.1 Effect of water stagnation: Relative occurrence of the pests under three specific water depth regimes (2.5, 5.0 and 7.5 cm) was examined. Fields were inspected periodically from the seedling to tillering stage and the abundance of the pests was counted by hill estimation. Field under 'restricted water treatment' was considered as control. Alternative storing and draining of water from the field was done by conventional methods.

3.8.3.2 Interactive role of water management with fertilizer treatment:

The water use efficacy and grain yield under different water management practices were evaluated in respect of different combinational application of fertilizers, tillage and sowing dates. Two different doses of N:P:K fertilizer (F1-80:40:40 and F2-120:60:60), three alternative modes of plantation techniques (T1-sowing the seeds in dry field condition, T2-spouted seeds in puddle condition, T3-Transplantation) were considered under two variable water stress management (S1=submergence only at tillering and flowering stage, S2= submergence throughout the crop growing period). The average value of three observations was considered.

3.8.3.3 Water use efficiency (kg/ha/cm):

It was determines as the efficiency of the soil to retain the water. 100 gm soil was taken and then woven dried .The differences of the weight were noted and the water retention capacity was calculated.

3.8.3.4 Interactive role of fertilizer application, hill distances on leaf area index generation: The interactive role of three specific doses of inorganic (urea) N fertilizer application (F1-0, F2-40, F3-80, F4-120 kg/ha) and four spacing conditions (S1-10 x 10 cm, S2- 10 x 20 cm., S3- 20 x 20 cm., and S4-20 x25 cm.) upon the generation of the leaf area index (LAI) in relation to the occurrence of the BPH population was evaluated at respective growth stages (15, 30, 45 and 60 DAT) of paddy in three replications. The average values were correlated statistically.

3.8.4 Tillage and land preparation: Effect of different combinational operation of variable land preparation techniques on the subsequent generation of the alternative hosts was assessed. Plowing (P), harrowing (H) and rototilling (R) were considered as the preparatory sources. P1(one plowing), P2 (two plowing), P3 (three plowing), P1H1 (one plowing + one harrowing), P2H1(two plowing + one harrowing), P2H2 (two plowing + two harrowing) P1H2 (one plowing + two harrowing), P3H3 (three plowing + three harrowing) and P1H1R1 (one plowing + one harrowing + one rototilling) were considered as the preparatory conditions. Effects of alternative combination on the weed abundance and species composition / mt^2 in relation to the pest activity were noted.

3.8.5. Hill spacing and microclimatic variation

3.8.5.1 Field experiment: Seedling was transplanted at different hill distances (10 x 10 cm., 20 x 20 cm., 25 x 20 cm) and the generated microclimatic environment was assessed at tillering stage after application of 120 kg N fertilizer / ha. Evaluation was done at three specific zones (base, middle and upper part of the canopy) along the length of the plant. Temperature (°C), relative humidity (%) and light intensity (%) of the three respective zones were recorded with the help of lux meter and the average value of 10 observations was taken into consideration.

Light transmission ratio (LTR) was calculated using the formula given by Yosida *et al.*(1972).

$$\text{LTR}(\%) = \frac{I}{Io} \times 100$$

Where, I and Io were the light intensity at ground level and top of the canopy.

3.8.5.2 Laboratory experiment:

Niche specificity of lady bird beetle and BPH was studied in two laboratory conditions.

3.8.5.2.1 At constant light: Temperature preference of lady bird beetle (LBB), *Menochilus sexmaculata* and BPH were experimented at constant light. A square elongated glass vial (65 x 6 x 6 cm) kept horizontally on a table. Six thermometers at six zones (Z1 to Z6) were placed perpendicularly and equidistantly from one end of the vial. Two metallic beakers were attached with the two terminal end of the vial. An ice block was kept in one beaker while the other was filled with hot water. The temperature gradient thus established inside the vial was allowed to stay fixed for 30 minutes. LBB and BPH each 50 in number were released separately from the entry hole, located at middle of the vial and the hole was plugged by cotton. LBB and BPH showed preferential aggregation depending on the temperature gradient. Individuals of each aggregation were counted and accordingly preferred zone was recorded and average value was calculated out of three replications.

3.8.5.2.2 At constant temperature: Semitransparent cellophane paper was wrapped in different layers of 2,4,6 around a square elongated glass vial (60 x 6 x 6 cm) to create variable light intensity gradient against the constant room temperature. LBB and BPH were released separately from the entry hole. The aggregation of the both the populations in different illuminating zones was noted. Light intensity was measured at 6 different transected zones of the vial against the 'least light' and 'maximum light' condition by lux meter. The average room temperature was noted. The experiment was conducted in three replications and the average value was taken into consideration.

3.8.6 Management of alternative host

3.8.6.1 Determination of effect of weeding on pest performance: Consequences of irregular hand weeding commonly practiced by the farmers, upon the field weed generation and the availability of the YSB's egg masses was periodically noted from different fields. Further the symptoms of DH and WH were assessed in due consideration of the episodic removal of the weed masses from the cultivaton fields. Weed mass so collected from different fields were weighed (gm.) and accordingly correlated with the number of YSB eggs and DH+WH. Among the observations the best suitable practice was suggested.

3.8.6.2 Effect of different weeding practices: Different grades of hand weeding (HW) practices were performed to quantify the relative effect on all the pest performance and yield generation. HW was performed in different combinations of time schedules.HW1 (50 DAT), HW2 (30 + 50 DAT), HW3 (75 DAT) and HW4 (50 + 75 DAT).HW0 was treated as 'no weed control' field.

3.8.6.3 Assessment on weeds by visual scoring scale: Depending on the variable performance of the weed population different grades were constructed. Fields were periodically inspected from the vegetative stage till harvest under different management systems and the average collective performance of the weed community were accordingly graded following the table 3.13

Table.3.13: visual scoring scale for weed assessment

Weed performance	Category	Grade
Weed density	Low	L
	Moderate	M
	High	H
Weed abundance	Lower	Lw
	Same	Sm
	Higher	Hg

3.8.6.4 Determination of the species abundance: Weeds were randomly collected from the experimental field (1x1mt.). Collections were dried and weighed separately under different cultivation protectional measures. In each treatment weed abundance was scored using 'visual scoring scale' and the performance of YSB in relation to weed density was measured after counting the number of DH and WH and considering the final yield. The effectiveness of the treatment stage was determined by calculating the C:B value.

3.8.7 Age of the seedlings: Relative influence of different ages of seedling (30, 45 and 80-85 days) upon the occurrence of the YSB and BPH population in relation to the yield generation was evaluated against the process of double plantation techniques by hill estimation.

3.8.8 Crop rotation: Effect of the available crop rotation practices upon the dynamics of the pest was recorded at the maturation stage of paddy in terms of the damage symptoms. Side by side relative adoptability of a particular rotation practice by the farmers was also considered. A comparison was drawn between the ranges of pest infestations under the prominent crop rotation practices.

3.8.9 Calculation of C:B : Calculation of C:B was done on the basis of 'total input value' against the 'total out put value'. When determining the relative efficacy and impact of a particular cultural practice on the benefit, the other remaining expenditure was taken as constant. Benefit ratio was assessed separately for fertilizer and pesticide applications. Superiority of the suggested cultivation module (CM) in comparison to that of the other available protocols like natural bio control (NBC) schedule based protection (SBP) and need based protection (NBP) were assessed and accordingly the C:B was calculated.

3.8.10 Assessment of knowledge attitude and perception of the farmers (KAP): Groups of farmers of variable ages with different educational background were interviewed on a prepared questionnaire and accordingly inference was drawn regarding their view for a particular cultivation practice. Farmers so responded to a particular question were noted either in accordance with their age group or educational background.

3.9 Methods of statistical analysis: The data obtained at each type of investigation were analyzed statistically by the calculation of variance, by linear and nonlinear correlations, by various graphical representations and by regression equations (Gomez and Gomez 1984). For comparison of 'F' value, F table (Suedecor and Cochran 1967), for computation of critical difference,'t' table (Fisher and Yates 1963), for comparison of 'r' value, 'simple linear correlation co-efficient' table (Suedecor and Cochran 1967) were followed.