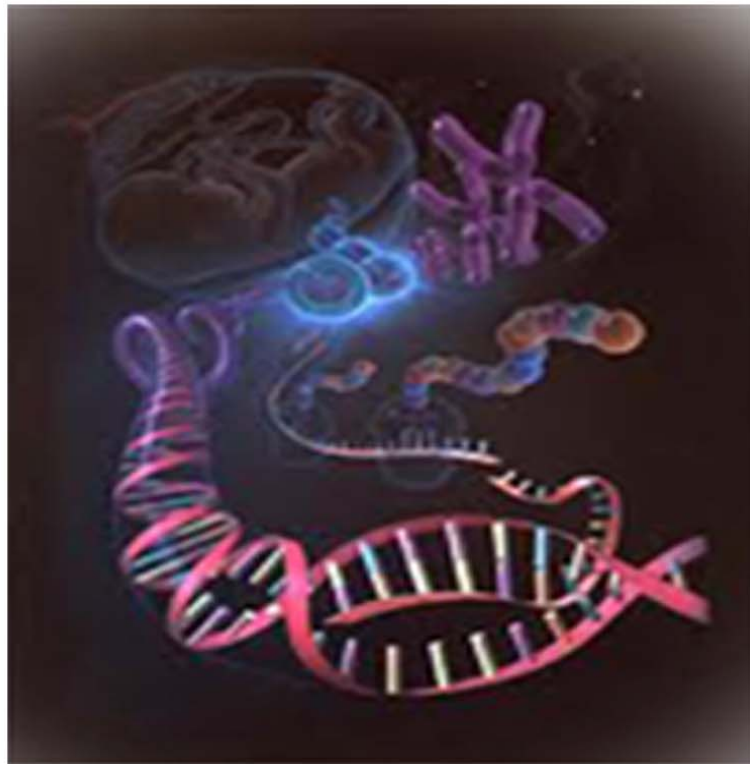




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Research Paper

MAJOR RICE INSECT PESTS IN NORTHEASTERN UP

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The major insect pests of rice crop encountered in northeastern part of the Uttar Pradesh are: (a) Root feeders such as termites, mole cricket, rice root weevil and rice water weevil; (b) Stem borers that include yellow stem borer [*Scirpophaga incertulas* (Walker)], white stem borer [*Scirpophaga innotata* (Walker)], striped stem borer [*Chilo suppressalis* (Walker)], dark headed stem borer [*Chilo polychrysus* (Meyrick)], pink stem borer [*Sesamia inferens* (Walker)], (c) Leafhoppers and plant hoppers such as : white rice leafhopper (*Cofana spectra* Distant), brown planthopper [*Nilaparvata lugens* Stal], whitebacked planthopper [*Sogatella furcifera* (Horvath)], the green planthopper [*Nephotettix nigropictus* (Stat.)], *Nephotettix virescens* (Distant), leafhopper (*Pyrilla perpusilla* Walker), (d) Defoliators such as swarming caterpillar or armyworm [*Spodoptera mauritia* (Boisduval)], oriental armyworm [*Mythimna separata* (Walker)], rice grasshopper [*Hieroglyphus banian* (Fabr.)], (e) Grain suckers such as rice earhead bug (*Leptocorisa acuta* Thunberg), and (f) other pests such as rice gall midge [*Orseolia oryzae* (Wood-Mason)], the rice leaf folders [*Cnaphalocrocis medinalis* (Guenee), *Marasmia patnalis* Bradley, *Marasmia exigua* (Butler)], the grain aphid [*Hysteroneura setariae* (Thomas)], pentatomid bug [*Nezara viridula* (Linn.)], rice mealy bug [*Brevennia rehi* (Lind.)], rice hispa [*Dicladispa armigera* (Oliver)], rice thrips [*Stenchaetothrips biformis* (Bagnall)], rice caseworm [*Nymphula depunctalis* (Guenee)], whorl maggot flies [*Hydrellia philippina* Ferino], zigzag leafhopper [*Recilia (Inazuma) dorsalis* (Motschulsky)] and the common cutworm [*Spodoptera litura* (Fabricius)].

Keywords: Rice pest, Stem borers, Leafhoppers, Planthoppers, Defoliators, Grain suckers, Leaf folders, Cutworms

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important crop in the world and grown in 117 countries, being a staple food of 2.7 billion people in Asia alone (Kumar *et al.*, 2009). India occupies number one

position in the world with regard to area under rice (44.6 million ha) and ranks second with regard to production (93.3 million tons, 2006-2007). Uttar Pradesh is responsible for the production of 14.5% of the country's rice

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(McCarthy *et al.*, 2008). However, with reference to productivity, India ranks between 15-18th among rice-producing countries.

Many species of arthropods inhabit rice fields, albeit most are not truly noxious to the crops. For instance, some 500 species of insects and spiders may appear in a rice field in a particular season. Of these only few are potential threat. The rest are either beneficial in the form of a wide range of predators (such as bugs and spiders) and parasitoids (mostly parasitic wasps) that contribute to keeping insect-pest organisms in check or innocent immigrants (neutral species) living on weeds or on organisms and under certain conditions serving as general prey for some beneficials.

There are more than 100 insect pests that inflict damage to rice-crop. Among them, stem borers, gall midge, plant hoppers, leaf hoppers, rice hispa, gundhi bug, case worm are the most important ones. The biology and ecology of these insect pests of the paddy crop have been dealt in detail by Pathak and Khan (1994), Dale (1994), Chaudhary *et al.* (2002), Islam *et al.* (2004), Wopereis *et al.* (2009) and others. However, unsprayed, irrigated rice fields have relatively few insect pest problems. This is largely attributed to natural biological control, which keep plant hoppers, most notably BPH, and other potential pests in check (Kenmore *et al.*, 1984; Way and Heong, 1994). In northeastern Uttar Pradesh, no systematic survey was carried out in recent past, hence, the present study was undertaken to get the information about the incidence of rice crop pests in the area so that their proper management tactics be evolved.

MATERIALS AND METHODS

For the survey of rice fields in northeastern Uttar

Pradesh, four districts (Kushinagar, Deoria, Gorakhpur and Mahrajganj) were selected. The investigation was carried out for a period of crop (*kharif*) seasons, 2010. Sampling was conducted at the following randomly selected 8 sites: (1) Padrauna, (2) Ramkola (District - Kushinagar); (3) Deoria, (4) Bhatparrani (District - Deoria); (5) Chaurichaura, (6) Pipraich (District - Gorakhpur); (7) Mahrajganj, and (8) Partawal (District - Mahrajganj). Two districts Kushinagar and Mahrajganj are adjacent and near the foot of Himalayas and the climate is the typical terai. Remaining two districts, Deoria and Gorakhpur are south to the above districts. All the districts are well inundated by several rivers and riverines. More than 80% of the total annual rainfall is received during the crop season, July to October.

The insects were collected by adopting the methods of light trapping, netting, sweeping or hand picking depending upon the insect types. Most of them were observed to feed the rice plant at least some stages of its development whereas few seem to casual visitor. Most of the pestiferous insects were identified at the specific level by using keys (Barrion and Litsinger, 1994), photographs available (Pathak and Khan, 1994), and by taking the help of the subject experts.

Other insects of less economic importance as pest of rice plant could not be identified as specific level. Most of them belong to Lepidoptera, Diptera, Hemiptera and Hymenoptera. Few of them seem to be casual visitor in search of food or hosts (parasitic wasps). These insects may also serve as prey for spiders as few of them were collected from the spider-webs.

RESULTS AND DISCUSSION

Table 1 displays the incidence of 34 insects from the survey area of northeastern Uttar Pradesh

Table 1: Insect Pests Collected From Rice Fields In Four Districts of Northeastern Uttar Pradesh (Kushinagr, Maharajganj, Deoria and Gorakhpur)

Insect pests	Common name	Order-Family
<i>Brevinnia rehi</i> (Lind.)	Rice mealy bug	Hemiptera : Pseudococcidae
<i>Chilo polychrysus</i> (Meyrick)	Dark headed stem borer	Pyralidae : Lepidoptera
<i>Chilo suppressalis</i> (Walker)	Striped stem borer	Pyralidae : Lepidoptera
<i>Cnaphalocrocis medinalis</i> (Guenee)	Rice leaffolder	Lepidoptera: Pyralidae
<i>Cofana spectra</i> Distant	White rice leafhopper	Hemiptera: Cicadellidae
<i>Dicladispa armigera</i> (Oliver)	Rice hispa	Coleoptera: Hispidae
<i>Echinocnemus oryzae</i> (Marshall)	Rice root weevil	Coleoptera : Curculionidae
<i>Gryllotalpa orientalis</i> Burmeister	Mole cricket	Orthoptera : Gryllotalpidae
<i>Hieroglyphus banian</i> (Fabr.)	Rice grasshopper	Orthoptera : Acrididae
<i>Hydrellia philippina</i> Ferino	Whorl maggot flies	Diptera: Ephydriidae
<i>Hysteroneura setariae</i> (Thomas)	Grain aphid	Homoptera : Aphididae
<i>Leptocorisa acuta</i> Thunberg	Rice earhead bug	Heteroptera : Coreidae
<i>Lissorhoptrus oryzophilus</i> Kuschel	Rice water weevil	Coleoptera : Curculionidae
<i>Marasmia exigua</i> (Butler)	Rice leaffolders	Lepidoptera: Pyralidae
<i>Marasmia patnalis</i> Bradley	Rice leaffolders	Lepidoptera: Pyralidae
<i>Microtermes obesi</i> (Holmgren)	Rice termite, wheat termite	Isoptera : Termitidae
<i>Mythimna separata</i> (Walker)	Oriental armyworm	Lepidoptera : Noctuidae
<i>Nephotettix nigropictus</i> (Stat.)	Green planthopper	Homoptera: Cicadellidae
<i>Nephotettix virescens</i> (Distant)	Green planthopper	Homoptera: Cicadellidae
<i>Nezara viridula</i> (Linn.)	Pentatomid bug	Hemiptera : Pentatomidae
<i>Nilaparvata lugens</i> Stål	Brown planthopper	Homoptera: Delphacidae
<i>Nymphula depunctalis</i> (Guenee)	Rice caseworm	Lepidoptera: Pyralidae
<i>Odontotermes brunneus</i> (Hagen)	Termite	Isoptera : Termitidae
<i>Odontotermes obesus</i> (Rambur)	Termite	Isoptera : Termitidae
<i>Orseolia oryzae</i> (Wood-Mason)	Asian rice gall midge	Diptera: Cecidomyiidae
<i>Pyrrilla perpusilla</i> Walker	Leafhopper	Hemiptera : Lophopidae
<i>Recilia (Inazuma) dorsalis</i> (Motsch.)	Zigzag leafhopper	Hemiptera: Cicadellidae
<i>Scirpophaga incertulas</i> (Walker)	Yellow stem borer	Pyralidae : Lepidoptera
<i>Scirpophaga innotata</i> (Walker)	White stem borer	Pyralidae : Lepidoptera
<i>Sesamia inferens</i> (Walker)	Pink stem borer	Noctuidae: Lepidoptera
<i>Sogatella furcifera</i> (Horvath)	Brown planthopper	Homoptera: Delphacidae
<i>Spodoptera litura</i> (Fabricius)	Armyworm	Lepidoptera : Noctuidae
<i>Spodoptera mauritia</i> (Boisduval)	Swarming caterpillar	Lepidoptera : Noctuidae
<i>Stenchaetothrips biformis</i> (Bagnall)	Rice thrips	Thysanoptera : Thripidae

infesting rice crop from beginning of the seedlings until harvest. Following is their brief account. According to their feeding behavior, they are classified as follows:

A. Root Feeders

Examples of root feeders are termites [*Odontotermes obesus*, *O. brunneus* and *Microtermes obesi* (Isoptera: Termitidae)], mole cricket [*Gryllotalpa orientalis* (Orthoptera : Gryllotalpidae)], the rice root weevil [*Echinocnemus oryzae*] and rice water weevil [*Lissorhoptrus oryzophilus* (Coleoptera : Curculionidae)].

Termites. Three species of termites, viz., *O. obesus*, *O. brunneus* and *M. obesi* were observed in the rice fields but their incidence is noticed in patches especially under conditions of scanty rainfall or upland. They are polyphagous and have the widest range of host plants including trees. Termites are not the major pest of rice plant in this area. In some pockets in the target area, the termites were observed to feed on roots and on germinating seeds. These species are common in other states of India found attacking wheat and barley under rainfed conditions and attacks sugarcane, maize, millets and also a number of tree crops (Navarajan Paul, 2007).

Mole Cricket, *G. orinetalis*: The *G. orientalis* occurs in all rice fields under observation particularly in non-flooded upland rice fields. Severe infestations were observed in few nursery beds in Maharajganj district. The nymphs and adults both feed the roots and stems below ground and close to the roots. The entire plant dies if the attack is severe. The damage was greatest near field borders. Adult mole crickets are large, light brown in color and 25 to 35 mm

long. The forelegs are highly modified for burrowing soil. Adults are strong fliers, and are attracted to light traps at night. Female crickets burrow bunds and construct hardened cells in which the eggs are laid. Each cell contains 30 to 50 eggs that hatch in 15-40 days depending on the temperature. Each female may deposit several hundred eggs during its life span of more than 6 months. The mole crickets seldom cause economic damage to other cereals, legumes, perennial grasses, potatoes, vegetable crops, beet, sunflower, tobacco, hemp, flax, etc. (Gulii and Pamuzak, 1992).

The root weevil, *E. oryzae*: It is a small weevil, grey in color and is a primary pest of the grasses such as *Cyperus rotundus* L. and a secondary pest of rice (Sehgal *et al.*, 2001). It frequently occurs in Uttar Pradesh like other parts of the country (Tirumala Rao, 1952) and is active in irrigated rice during early crop stage. The adults as well as grubs attack paddy roots and affect the growth of plants. The grubs are not adapted for breathing under water.

The rice water weevil, *L. oryzophilus*: The adult weevils are about 3 to 4 mm in length and greyish brown in color with a darker brown V-shaped marking dorsally. They feed on leaves making longitudinal scars on the upper leaf surface, but generally do not cause economic damage. Larvae (white, legless with light brown head) are responsible for the main damage as they feed on roots and prune them. Small larvae can feed inside the roots, are between 0.8 and 4.7 mm long. The white, cylindrical eggs are less than 0.4 mm long. Severely attacked plants become yellow and stunted, with delayed maturity and reduced yield. Adults are semi-aquatic and can be found on or beneath the soil surface (Hill,

1983)). It also attacks many other wild grasses and sedges (Poaceae and Cyperaceae, e.g., *Agrotis*, *Axonopus*, *Cynodon*, *Cyperus*, *Echinochloa*, *Leersia*, *Panicum*, *Paspalum*, *Poa*, *Setaria*) which serve as alternative hosts for adult weevils in or near rice fields (Chen *et al.*, 2005)

Females lay eggs (singly) in submerged leaf sheaths above the plant crown. Larvae feed on leaf for a short period and then crawl down to the roots. There are 4 larval instars (last instar of about 8 mm long). Larvae have paired dorsal hooks to pierce the roots and obtain oxygen. The fourth larval instar forms a mud-coated cocoon attached to the roots.

Stem Borers

The stem borers are the major pests of rice crop, causing significant reductions in yield during certain outbreak years. Both noctuids and pyralids (Lepidoptera) constitute the main rice stem borers. Following species were observed causing damage to rice plants in northeastern Uttar Pradesh:

Yellow Stem Borer (YSB), *Scirpophaga incertulas* (Pyralidae : Lepidoptera): It is the most destructive and dominant species of only rice crop in northeastern Uttar Pradesh and is reported to occur throughout the country and other Asian countries. It has been shown to be more severe in lowland cultures. It affects the crop in the nursery, soon after transplanting and also in the pre-earhead stage. The female lays 12-16 eggs in a mass near the tip on the upper surface of tender leaf blade and covers them with buff colored hairs and scales. Sometimes the female also laid eggs on the underside of the leaves. The freshly hatched larvae bore into stem and feed internally causing death of central shoot 'dead

hearts' in vegetative stage and 'white earhead' at milky stage, respectively. This results in chaffy grains. The larvae feed on green tissue of leaf sheath. Infestation after the panicle initiation result in drying of panicle which may not emerges at all and those that have already emerges do not produce grain and appears as white head. Bora *et al.* (1994) and Malhi and Brar (1998) had studied its biology in detail. Recently, Satpathi *et al.* (2012) assessed the feeding by YSB larvae and its damage consequences on the paddy.

White Stem Borer (WSB), *Scirpophaga innotata* (Pyralidae : Lepidoptera): It feeds rice plant exclusively. The adults lay eggs on the leaf sheath during early tillering stage of the rice plant. The eggs hatched in the early morning hours. The caterpillar moves from the plant tip into the inner pit of the stem. It feeds on the pit of the plant, thus causing 'dead hearts'. The larvae can also drill entry and exit holes into rice stem. It feeds through the node causing the stem to break. Attacking during the tillering stage can result in 'white heads' or 'white panicles'. This results in partially filled grains or sometimes empty filled grains. Rice is most susceptible to borers during early tillering stage, tillering state and sometimes late tillering stage. Evidence of activity can be noticed by the tiny holes on the stem and tillers. Fecal matters can also be seen inside the attached or damaged plants. WSB is distributed throughout in Asia, Australia and pacific islands. Its detail biology, ecology and control measures were investigated by Li (1991).

Striped Stem Borer (SSB), *Chilo suppressalis* (Pyralidae : Lepidoptera). A polyphagous pest frequently occurring in the rice fields of almost all fields in the target area. It infests rice plants from

the seedling stage to maturity and may cause deadhearts and whiteheads during the vegetative and reproductive stages, respectively. The adult moths have pale yellow forewings with a few dark spots; the hindwings are white with wingspan about 25 mm. The female lays about 300 eggs in the morning in several batches on the undersides of leaves, usually along the main vein, and covers them with a brown secretion. After 6-10 days, the larvae hatch and start feeding on the leaf epidermis. Thereafter, they tunnel into the leaf sheaths, thus causing the leaves to yellow, and later, to die off. When the larvae reach the stem, they hollow it out one internode at a time, penetrating through successive nodes. One larva can destroy several plants. When young plants are attacked (which often happens while they are still in the seed bed), the first symptoms of damage is the dying-off of growing points and the surrounding leaves (dead heart). In contrast, infested older plants first show yellow, dried out leaves. Their outer leaves curl, the leaf sheaths turn yellow, and finally, the leaves fall off. Heavy infestation can lead to stems being hollowed-out completely, and to the formation of empty panicles, a condition commonly called 'white head'. It is an important insect pest of rice in India, south-east Asia, China, Iran and southern Europe (Pathak, 1968; Dale, 1994).

Dark headed stem borer, *Chilo polychrysus* (Pyralidae : Lepidoptera). The adult moth is light brown in color and can be identified by having 6-7 tiny black dots at the tip of the forewings. The hind wings are yellowish white. It has a body length of 10-13 mm and wing span of 16 to 25 mm. The adults are active during the night. The females lay eggs between 7 to 11 p.m. in batches of 20 to 150 eggs in longitudinal rows along shallow

furrows on both surfaces at the basal portions of the leaves. They overlap each other and are scale-like in appearance. The eggs are white when laid but turns black as it nears hatching. The newly-hatched larvae are greyish white with distinctly black head and prothoracic shield. The first instar caterpillar moves down to the leaf base and bores into the outer leaf sheath. The attacked leaf sheath first appears yellow and then gradually dries up. If the rice plant is thick, stout and succulent, the whole larval and pupal existence are completed within the peripheral leaf sheaths sparing the central culm. On the other hand, if the outer leaf sheaths are thin or dry, the caterpillar bores into the central shoot. One larva is usually found in a single stem. If the host plant is dead as a result of infestation or when it becomes congested with larvae, the larvae migrate to neighboring plants. In such cases, the points of entry are indicated by plugs of fecal matter. The last instar larva is creamy white with five distinct brown stripes along the back of the body. The head and body are sparsely covered with subtle hairs. The full-grown caterpillar, just prior to pupation, makes an exit hole below which the feeding tunnel is cleared and lined inside with a loose layer of silken frass. *C. polychrysus* is a major pest of rice plants in India (Dale, 1994). The caterpillars attack all stages of the rice crop. The young plants, when attacked, are killed in a short period having no chance of recovery. In the case of mature plants, the infestation results in the formation of deadhearts and whiteheads.

Pink Stem Borer (PSB), *Sesamia inferens* (Noctuidae: Lepidoptera): The adult moth 14-17 mm in length and is brown in color, the forewings being tan with dark brown markings. From a point in middle of the forewing, grey-black

lines radiate toward the wing tips ending in a thin terminal line of dark spots. There are tufts of hair on the pronotum. The hindwings are white. The female lays about 400 eggs, 30-100 eggs/batch in rows between the leaf sheath and stem. The eggs are not covered and hatch in about a week. The adult moths lay eggs on rice leaves and the larvae bore into the stem. Feeding in the stem during the vegetative growth stage of the plant (seedling to stem elongation) causes death of the central shoot forming a characteristic “dead hearts”. Damaged shoots do not produce a panicle, and thus, produce no grain. Feeding of stem borers during the reproductive stage (panicle initiation to milk grain) causes a severing of the developing panicle at its base. As a result, the panicle is unfilled and whitish in colour, rather than filled with grain and brownish in color. Such empty panicles are called “whiteheads”. In the northeastern Uttar Pradesh, low infestation on rice was observed in early July, when larvae cause deadhearts in seedlings. Severe infestations occur during September.

The pink stem borer, *S. inferens*, has been considered to be the least destructive among several rice stem borers because its outbreak in rice paddies usually results from an overflow from adjacent fields of sugarcane or other hosts (Dale, 1994). In rice fields, it usually coexists with the striped stem borer, *C. suppressalis* also in Taiwan (Liu, 1990; Huang *et al.*, 2008). In certain years, it may be the main pest of rice from early July to late September with 50-60% of the plants infested by mid-September (Garg and Tandon, 1982).

Leafhoppers and Planthoppers

With the widespread introduction during the green revolution in the sixties and seventies of fertilizers,

of improved varieties and of pesticides to rice crops, leaf- and planthoppers became important pests. Sixty-five species of planthoppers representing associated with rice agroecosystems are reported in tropical Asia (Hare, 1994; Dupo and Barrion, 2009). Of the total, most notably are the leafhoppers such as *Cofana spectra* (white rice leafhopper) (Hemiptera: Cicadellidae), *Pyrilla perpusilla* (sugarcane leafhopper) (Hemiptera: Lophopidae), *Nilaparvata lugens* (brown planthopper (BPH)), and *Sogatella furcifera* (whitebacked planthopper) (Homoptera: Delphacidae), the green planthopper (GLH) *Nephotettix nigropictus* and *Nephotettix virescens* (Homoptera: Cicadellidae).

The leafhoppers and planthoppers are sucking insects which remove plant sap from the xylem and phloem tissues of the plant. Severely damaged plants dry and take on the brownish appearance of plants that have been damaged by fire. Hence, hopper damage is called *hopper burn*. These insects are severe pests in Asia where they not only cause direct damage, by removing plant sap, but are also vectors of serious rice virus diseases, such as rice tungro virus transmitted by the green leafhopper, *N. virescens*, and grassy stunt virus transmitted by the brown planthopper, *N. lugens*.

Following species of hoppers were observed causing damage to rice plants in northeastern Uttar Pradesh.

White Rice Leafhopper, *C. spectra*. It occurs in all rice fields but is most common in rainfed rice at the end of the rainy season and is minor pest. The body is yellowish, the forewings grey-white with prominent veins and the head bears four black spots. It is the largest among the

species of leafhoppers and planthoppers. Adults rest on the lower surface of the leaves or at the base of the plant. They are highly attracted to lights at night. Eggs are laid in rows of 10 to 15 across the slit made by the saw-like ovipositor at the base of the plant above the paddy water. The number of eggs laid per female averages about 50.

It is a minor pest of rice and does not transmit any virus disease. Feeding by a large number of nymphs and adults may, however, cause typical sap loss. Leaf tips first dry up and later the leaf turns orange and curls. The pest causes stunting and yellowing of plants, and severe infestations cause plant death.

The Brown Planthopper, *N. lugens*: The adult planthoppers are ochraceous brown dorsally and brown ventrally. The tegmina are subhyaline with a dull yellowish tint. The females are little longer than males. It is dimorphic, with fully-winged 'macropterous' and truncate-winged 'brachypterous' forms. The macropters are potentially migrants and are responsible for colonizing new fields. At the time of colonization, the macropterous forms dominate in a rice field. After settling down on rice plants, they produce the next generation in which most of the female insects develop as brachypters and males as macropters. There are many factors which have been suggested to be responsible for wing morphism in the brown planthopper such as crowding during the development and reduction in the quality and quantity of food (Kisimoto, 1965), short daylength and low temperature (Johno, 1963).

The honeydew excreted by the nymphs and adults at the base of the plants is covered with

sooty mould. It infests the rice crop at all stages of plant growth. As a result of feeding by both nymphs and adults at the base of the tillers, plants turn yellow and dry up rapidly. At early infestation, round yellow patches appear which soon turn brownish due to the drying up of the plants. This condition is called 'hopper burn'. The patches of infestation then may spread out and cover the entire field. Crop loss is usually considerable and complete destruction of the crop occurs in severe cases.

N. lugens is a vector of the virus diseases, e.g., glassy stunt, ragged stunt, and wilted stunt (Chen and Chiu, 1981).

The Whitebacked Planthopper *S. furcifera*:

The adult hopper is 3.5 - 4.0 mm long. Forewings are almost uniformly subhyaline with dark veins. There is a prominent white band between the junctures of the wings. The body is creamy white with the mesonotum and abdomen black dorsally and the legs, ochraceous brown. There is a conspicuous black dot at the middle of the posterior margin of each forewing which meets when the forewings come together. Macropterous males and females and brachypterous females are commonly found in the rice crop whereas brachypterous males are very rare. The planthoppers, especially adults, prefer to stay at the upper portion of rice stems. Adults are positively phototropic and hence are attracted to light traps.

S. furcifera prefers a young crop and often produces long-winged migratory forms before the plants flower. Both adults and nymphs suck sap primarily at the base of the rice plants which leads to yellowing of the leaves, reduced vigor and stunting of plants. Because seedlings are

attacked in the nursery, infestation is often carried through eggs into the transplanted crop. Severely attacked seedlings do not grow; are stunted, wilt and eventually die. If the infestation is at the panicle initiation stage, the number of grains and the panicle length decrease. But when attacked later, during the maturation period, grains do not fill fully and ripening is delayed. When the hoppers are present in large numbers late in the crop growth stage they are seen infesting the flag leaves and panicles. Gravid females cause additional damage by making oviposition punctures in leaf sheaths. Feeding points and wounds caused by egg-laying may later become potential sites for the invasion of bacteria and fungi. Moreover, the honeydew produced by the hoppers serves as a medium for mould growth.

The rice plants affected by the whitebacked planthopper appear uniformly in large areas throughout the field rather than as localized hopper burned patches as in the damage by the brown planthopper. This may be due to the difference in the distribution patterns of the two planthopper species. White backed planthopper, *S. furcifera* is widely distributed in Asia, Africa and South and Northern America (Nasu, 1967) but it was considered as a serious pest only in rice producing regions of Asia (Pathak, 1968).

The green planthoppers, *N. nigropictus* and *N. virescens*. Female of *N. nigropictus* is green and a black tinge on pronotum is absent. The male on the other hand has two black spots extending up to the black distal portion on the forewings unlike *N. virescens*, where the black spots on forewings do not extend up to the black distal portion. *N. nigropictus* also has a black tinge along the anterior margin of pronotum and a submarginal black band on the crown of the head

which is absent in *N. virescens*. Both nymphs and adults suck the plant sap and cause browning of leaves. Both the species are known to be vectors of virus diseases of rice such as rice transitory yellowing and rice yellow dwarf. Among the two species *N. virescens* causes more damage. They are more active during July to September in northeastern Uttar Pradesh.

The female inserts the eggs in rows under the epidermis of leaf sheath and may lay upto 40-50 eggs. The life-cycle occupies about 25 days, the egg and nymphal periods being 6 – 7 and 18 days, respectively. These insects are found distributed in all rice growing areas in Asia and Africa. The populations of *N. virescens* and *N. nigropictus* were dominant in tropics, including Srilanka (Fernando, 1967), Philippines (Nasu, 1967), Burma, China, Taiwan and Malaysia (Ghauri, 1971). The insect is active during July – November in different regions.

The leafhopper, *P. perpusilla*. *Pyrilla* is a pest of sugarcane in northeastern Uttar Pradesh (Butani, 1964) but occasionally it also infests paddy and wheat crops. The adults are white immediately after moulting but gradually turned straw colored, with pale green eyes, snout-like head with black spot positioned posteriorly. The apical area and the outer cleval wing margins have minute black spots. Both the adults and nymphs are very active, jumping from leaf to leaf on slight disturbance. Both life stages suck sap from the leaves of rice plant but most of the damage is caused in the nymphal stages.

Active stages of the life cycle favor the underside of leaf blades, particularly near the mid-rib, as resting and feeding sites. Adults are relatively inactive during the early morning,

evening and night, typically remaining on the under surface of leaves. Between around 10.00 a.m. and 3.00 p.m., they become more active and can be found on both upper and lower leaf surfaces and jumping between plants. Apart from India, it is distributed in Afganistan, Bangladesh, Borneo, Burma, Cambodia, Indonesia, Java, Nepal, Laos, Pakistan, South China, Sri Lanka, Sumatra, Thailand, and Vietnam (Khanzada, 1992; Kumarasinghe and Wratten, 1996).

Defoliators

A large group of insects belonging to several insect orders were observed to feed on rice leaves in northeastern Uttar Pradesh. Most common are the larvae and adults of beetles, caterpillars (e.g., swarming caterpillar or armyworm *Spodoptera mauritia* and oriental armyworm, *Mythimna separata* (Lepidoptera : Noctuidae) and grasshoppers (e.g., rice grasshopper, *Hierogluphus banian* (Orthoptera : Acrididae). Defoliation reduces the photosynthetic capacity of the rice plant and thereby decreases yields. However, when feeding damage occurs early in rice growth, plants have an ability to compensate for damage by producing new tillers. Thus, rice plants in the actively tillering stage of growth can tolerate a certain level of leaf damage without any yield loss.

Das *et al.* (2002) observed *H. banian* as a major pest of paddy in West Bengal.

Rice Swarming Caterpillar or Armyworm, *S. mauritia*: Rice swarming caterpillar or armyworm is considered to be a sporadic pest which occasionally causes serious losses to rice crop. The insect is polyphagous and infests various poaceous crops and weeds. Upland rice is its preferred host. The adult armyworm moth is

mainly brown with a complex pattern of creamy and grey markings. The trailing edges of the forewings have a fringe of dark and light patches. Wings of the male moth are more greyish. The hindwings are brownish white with thin black margins. The eggs are laid in a mass about 5 mm across. Young caterpillars are smooth-skinned and green with longitudinal lines, becoming brown with two rows of black triangles down the back. They pupate in the soil below the food plant. The pupa is dark brown in color.

The caterpillars damage rice crop by feeding on the leaves at night. The damage by early instar larvae is negligible and escapes notice. But the older caterpillars are voracious and can devastate a whole field within a short time. They feed mainly on young rice plants in the nurseries or shortly after planting. When a field has been stripped bare, they migrate in large numbers into adjoining fields to continue feeding. Their migration is facilitated by the absence of standing water in the fields. The plants are reduced to mere stumps which may die or even if they recover, do not bear earheads uniformly. The infestation starts at the onset of the monsoon. Larvae are nocturnal in habit and hide in crevices in the soils or under vegetation during the daytime. Recently, its biology, ecology and management strategies are described by Tanwar *et al.* (2010).

Oriental Armyworm or Rice-ear-cutting Caterpillar, *M. separata*: It is cereal pest infesting sorghum, millets, rice, maize, and wheat (Sharma *et al.*, 1982). The adults are grayish-yellow in color with dark-gray or reddish-yellow tint. Round and reniform spots on the forewings are light or yellowish with indistinct edges while reniform spots are with white point at lower margin. External wing margin is blackened obliquely from

top backward, with dark stroke and with a row of dark points.

Eggs are laid in 2-4 rows in groups of tens, on rice plants behind sheath of lower leaves and on radical leaves. Larvae have 2 wide black-brown and one intermediate light dorsal stripe, with black-brown lateral stripe along spiracle line; spiracles brown with black rim. Early instar larvae feed on dried leaves and later move on to green leaves for feeding. Older larvae are gregarious and voracious feeder at night, they cut off rice panicles from the peduncle, causing the most serious losses to the rice crop in northeastern Uttar Pradesh. Larvae pupate in soil caves. Pupae are yellowish-brown, shiny.

Rice Grasshopper, *H. banian*: The adult grasshopper is of medium size, the female measuring 30 - 55 mm and the male, 30 - 40 mm in length. It is dull green or yellow-brown. The lower body surface is brownish black. Eggs are laid in eggpods in soil containing about 35 eggs per pod. The nymphs are brownish yellow and later change to dull green and feed newly germinated rice seedlings and cause them to wilt. Adult grasshoppers feed on the leaves and shoots and sometimes cut the earheads. If the emerging inflorescence is attacked, the resulting grains become chaffy.

H. banian has been reported as a pest of paddy from central UP by Usmani *et al.* (2012 and from Gujarat by Das *et al.* (2002).

Grain Sucking Insects

The rice earhead or *gandhi* bug, *Leptocorisa acuta* (Heteroptera : Coreidae) is the major sap sucking pest of paddy in all four districts of northeastern Uttar Pradesh. Apart from rice it also breeds on a variety of grasses. It is widely distributed rice pest

in India and other rice growing countries. The female lays 200 - 300 eggs on leaf blade in long rows of 10 - 20 eggs and the incubation period is about 6-8 days. The slender greenish nymphs become adults in 14-17 days. The adult survived for 3 - 4 months. Both the nymphs and adults suck the sap of grains during milking stage and thus make them chaffy. Whole panicle becomes white colored (chaffy) under severe infestation. Rai (1981) studied its life history and Nigam and Verma (1985) estimated the loss caused by it. The stink bugs or rice bugs are known for the foul odor produced by the scent glands on their abdomen. The bugs are grass-green to pale yellow-brown in colour, with long slender body. They have long antenna, about the same length of their body. Damage early in the development of the grain prevents the filling of the grain. Later attack results in *pecky rice* which is referred to as the condition of the grain after being sucked by stink bugs and the grain being subsequently stained by the bacteria or fungi which enter the puncture wounds. In some countries the market price of pecky rice is reduced.

Other Insect Pests of Rice

Other herbivores in rice fields observed in northeastern Uttar Pradesh that can be potential insect pests include the rice gall midge *Orseolia oryzae* (Wood-Mason) (Diptera: Cecidomyiidae), the rice leaf folder complex of which three have attained pest status: rice leaf folder *Cnaphalocrocis medinalis* (Guenee), *Marasmia patnalis* Bradley and *Marasmia exigua* (Butler) (Lepidoptera: Pyralidae), the grain aphid *Hysteroneura setariae* (Thomas) (Homoptera : Aphididae); pentatomid bug *Nezara viridula* (Linn.) (Hemiptera : Pentatomidae), rice mealy bug *Brevennia rehi* (Lind.) (Hemiptera :

Pseudococcidae), rice hispa *Dicladispa armigera* (Oliver) (Coleoptera: Hispidae), rice thrips *Stenchaetothrips biformis* (Bagnall) (Thysanoptera : Thripidae), rice caseworm *Nymphula depunctalis* (Guenee) (Lepidoptera: Pyralidae), whorl maggot flies *Hydrellia philippina* Ferino (Diptera: Ephydriidae), zigzag leafhopper *Recilia (Inazuma) dorsalis* (Motschulsky) (Hemiptera: Cicadellidae) and *Spodoptera litura* (Fabricius) (Lepidoptera : Noctuidae).

Asian Rice Gall Midge, *O. oryzae*: Eggs were laid parallel to the midrib either singly or in groups. Newly hatched maggots moved between leaf sheath until it reached a growing point of apical or lateral buds. The newly hatched maggots were grayish with a pointed anterior end. The maggots fed inside the developing bud and cause damage to the growing points producing characteristic gall in the plant transforming regular tillers into tubular galls which dry off without bearing panicles. The manifestation of injury is in the form of silver shoot or onion shoot. The pest starts infesting the plants in seed bed and can continue to do so until booting stage. They are active during September-October.

It is also destructive in some parts of Kerala, Orissa, Andhra Pradesh, Madhya Pradesh, Jharkhand and Bihar. It also breeds on a number of grasses such as *Paspaladium geminatum*, *Paspalum scrobiculatum*, *Panicum* spp., *Ischaemum ciliare*, *Cynodon dactylon* and *Eleusine indica*. In northeastern UP, the loss caused by this pest is very low but in Jharkhand, Prasad (2011) estimated 20-70% loss due to infestation of rice gall midge.

Rice Leaf Folder, *C. medinalis*: The adult moths are yellow-brown in color, small, and are 10 to 12 mm long and are nocturnal. Adults hide on the

host plants during the day and only take short flights when disturbed. Eggs are laid singly or in rows in batches of 10 to 12, parallel to a midrib on both surfaces of young leaves and rarely on stems. First instar larvae crawl to the base of the youngest unopened leaf and begins to feed. The second instar migrates to an older leaf and folds the leaf together. Infestation usually occurs during late growth stages of the rice crop. The larvae fold the leaves and scrape the green tissues of the leaves from within and cause scorching and leaf drying. Each larva is capable of destroying several leaves by its feeding. Under heavy infestation, each rice plant may have several rolled leaves, which severely restricts its photosynthetic activity. When plants are attacked in the boot leaf stage, grains are partially filled. Jagadeesha Kumar *et al.* (2009) studied its biology.

The rice leaf folder has a very wide distribution in various parts of the world. The places from which this insect has been reported are, Srilanka, Philippines, Pakistan and Malaysia (Kulagod, 2009) which make it clear that it enjoys wide prevalence in almost all rice growing areas. Leaf folder once reckoned as minor pest has now assumed the status of a serious pest with the advent of high yielding rice varieties with broad leaves and indiscriminate use of insecticides leading to decimation of its natural enemies (Chatterjee and Prakasa Rao, 1997).

Rice Leaf folders, *M. patnalis* and *M. exigua*: Both the species are common in northeastern Uttar Pradesh. *M. patnalis* is shade-loving and is considered as a major pest of rice in some areas. Forewings are pale yellow with a greyish marginal band. Hindwings are also pale yellow but whitish basally. The forewings of *M. exigua* have light-

yellow and brown markings. The biology of both species are more or less similar. Eggs are laid singly or in groups of 2 to 9 on the upper side of the leaves but sometimes eggs are also seen on leaf. The newly-hatched larvae tend to be gregarious for some time and then start feeding on the leaves. The second instars draw the leaf margins together and stitch them with contractile silk. Both ends of the leaf roll are left open. The larva feeds on the green tissue leaving conspicuous white scars on the leaf blade. Pupation takes place within the leaf roll. The pupa is not enclosed in a cocoon but is surrounded with silken frass and faecal plugs.

Grain Aphid, *H. setariae*: The grain aphid is frequently encountered in the field of paddy during late September to middle of October mostly in northern districts of northeastern UP. It was also reported from other plants in this area such as *Cyperus rotundus* L. and *Scirpus articulatus* L. (Cyperaceae) and *Andropogon vulgaris* Raspail, *Cynodon dactylon* (L.) Pers., *Dactyloctenium aegypticum* (L.) Willd., *Digitaria ciliaris* (Retz.) Koeler, *Hordeum vulgare* L., *Oplismenus burmannii* (Retz.) P. Beauv., *Panicum* sp., *Zea mays* L. (Poaceae) (Chaudhary, 2009). The grain aphid is small, brown with dark siphunculi and a pale cauda, usually forming colonies at the bases of spikelets and is often attended by ants. Hindwings have always a single oblique vein. The infestation of the aphid was observed from September to October. Their site of infestation was the apical leaves, stem of plants and spikelets. The life cycle completed within 7-8 days and it reproduced for 13-14 days. The rate of reproduction on an average was observed to be 2.84 to 4.55 nymphs per day. There were two moultings at an interval of 2 days and first nymph

was produced within 7-8 days. The extent of infestation is very low.

Pentatomid Bug, *N. viridula*: It is a highly polyphagous bug feeding on a variety of vegetables and crops. The adult stink bugs are shield-shaped and are usually apple or jade green color, but may occasionally be a reddish brown. Adults can live for several months. Eggs are deposited on the undersides of leaves in clusters of more than 40 and resemble a nail keg or small drum. All nymphs are about as broad as long, dark in color, with red and white or yellow markings on their bodies. The fourth and fifth nymphal stages may be two color phases - light to dark green or black - with characteristic yellow, red and green markings. Adults are very active fliers. When disturbed they fly away or fall to the ground or to lower portions of the plant. The 'stink bug' is so named because of the strong odor emitted from scent glands when disturbed. Their green color blends with the foliage making them difficult to find the bugs feed by piercing plant tissue with needle-like stylets. The actual feeding puncture is not immediately visible. Adults and nearly all nymphal stages feed on plant tissue. Feeding injury becomes visible sometime after actual feeding. It is also not pestiferous in northeastern Uttar Pradesh. However, it attains pest status on several vegetable crops in the world (Todd, 1989).

Rice Mealy Bug, *B. rehi*: The adult females are wingless, oblong and 3-4 mm long. They are bulky and remain stationary on the stems behind leaf sheaths at the base of plants. The body is soft, pinkish, and covered with white waxy threads. Males, pale yellowish, are seldom found in the colonies. They have a single pair of wings and a style-like process at the end of the abdomen but lack mouthparts. They are slender and much

smaller than the females. The females lay eggs singly, more or less in a chain, inside the waxy threads. Eggs are yellowish white. Newly-hatched nymphs remain crowded within the waxy threads for 6 to 10 hours before they disperse to various parts of the same plant or to adjacent rice plants. Nymphs are first yellowish white but turn dark yellow after a day. They become fixed between the leaf sheath and stem by driving the proboscis into the stem. The body gets covered with a waxy material in about a day.

The mealybugs occur in colonies attached to the stem and leaf sheaths of paddy plants. They suck sap from the plant. White waxy stuff protruding from between the leaf sheath and the stem is the typical symptom of the presence of the pests. As a result of the infestation, the plants become stunted and the older leaves turn yellow. High incidence inhibits panicle emergence and plants may even dry.

Rice Hispa, *D. armigera*: The adult is a small bluish black beetle, measuring about 5 mm in length and has a number of small spines on the body that give it a characteristic appearance. The adults lay eggs on nursery plants which are embedded in the leaf tissue towards the tip. Damage is caused by both the grubs and adult. Grubs feed by tunneling lower and upper epidermis resulting in regular translucent white patches like leaf-miners.

It is common in wet-land environments and sporadic outbreaks have been reported from almost all states of India. Adults scrape chlorophyll between the veins and so white parallel streaks are visible. Feeding on veins results in the formation of blotches on the leaves.

The rice hispa is regarded as one of the major

paddy pest in paddy growing areas of India (Hazarika *et al.*, 2005; Chakraborty and Deb, 2012). Losses that incurred to the growing paddy crop are insurmountable (Nath and Dutta, 2002, 2003). Extent of loss may extend up to total crop failure, in occasional cases (Hazarika *et al.*, 1991).

Oriental Rice Thrips, *S. biformis*: Adults are brownish-black, about 1-2 mm long, and are either wingless or have narrow, elongated, heavily-fringed wings which are folded along the body at rest. Young larvae are almost transparent, but become yellowish-white after their first moult. The adult female cuts slits into the leaf epidermis with its ovipositor and inserts one of its 25-150 eggs into each of them, so that the upper halves of the eggs remain exposed. The two larval instars, which both ingest food, are followed by the comparatively inactive prepupal and pupal stages, which do not feed. Normally, all stages remain inside the rolled leaves; even the mobile adults hide there most of the time, except for migration.

Larvae and adults of rice thrips puncture plant cells with their mouthparts and ingest their contents. The insects prefer to feed on the growing tips of young leaves, which consequently roll inwards at the margins. The patches of empty and therefore translucent epidermis cells appear as silvery streaks. Later, they turn yellow-brown, and as infestation progresses, the leaves start wilting from the tip down and become 'scorched'. Plants remain stunted and in severe cases, they may be killed completely.

Oriental rice thrips is currently widely distributed in Europe, Asia and Oceania, Caribbean island of Trinidad and the northern part of South America (in Sallam *et al.*, 2013) and is mainly associated with rice, but it has been recorded attacking

sugarcane plants in India (Madan *et al.*, 1989).

Rice Caseworm, *N. depunctalis*: Rice case worm is a serious pest of paddy that attacks young rice plants in waterlogged paddy fields in northeastern UP. Moths are nocturnal in habit and are attracted to light. They are delicate, white with luscious markings and black specks on wings. Female moths are larger than the males. Usually eggs are laid during night. The freshly laid eggs are light yellow, smooth and spherical. They are laid in batches of about 20 on the underside of leaves floating on the water. The eggs turn dark yellow as they mature. Larvae are transparent green in color with light brownish orange heads.

The damaging stage is the larvae that live in sections of leaves cut from young rice plants and rolled into tubes called cases. The leaf cases floats to carry the larvae from one plant to another during the day and at night the larvae climb plants to cut off leaves to make new cases, or feed on severed leaves on the water surface. Rice at seedling and tillering stages are the preferred host but does not occur after maximum tillering. The caseworm is widely distributed in rice growing counties of Asia, Australia, America and Africa (Dale, 1994).

Whorl Maggot Flies, *H. philippina*: The adults are gray and have transparent wings. They can be identified on the basis of following characters : a silvery white frons and cheeks, antennae are dark gray with a silvery tinge in the inner portion of the second segment and 7-10 arisal hairs, grayish mesonotum with silvery white and brown tinges, abdomen is silvery white to gray with blackish brown in the middle of the three basal segments. They have yellow legs except for the femora.

It is a semi-aquatic whorl maggot. It is common in irrigated or flooded fields and feeds on the central whorl leaf of the vegetative stage of the rice plant. The adults are active during the day and rest on rice leaves near the water. The female adult lays individual eggs on the leaf surface. They stick to the leaves because of a gluey substance secreted by the female. Neonate maggots feed on the unopened central leaves. Heavily damaged plants are stunted with few tillers. The leaves have white or transparent patches. They easily break from the wind. Slightly damaged leaves have pinholes.

The rice whorl maggot were not recorded in the Asian countries until the early 1960's but now assumed pest status in many parts of Asia (Sain, 2000). It occurs in severe form in certain high yielding varieties in Andhra Pradesh, Tamil Nadu and Orissa. It also breeds in *Cynodon dactylon*, *Echinochloa crusgalli*, *E. colona*, *Fimbristylis miliacea*, *Eleusine indica* and *Paspalum scrobiculatum* (Dale, 1994).

Zigzag Leafhopper, *R. dorsalis*. The adults can be identified by the color pattern of the forewings which are white with light brown bands taking the shape of a 'W' and giving the wing a zig-zagged pattern. Body length is 3.5 - 4.0 mm. Egg are laid in rows within the leaf sheaths. The ovipositional sites can be located with difficulty as small brownish spots; sometimes micropylar ends of eggs protrude from the leaf surface. The nymphs are yellowish brown in colour and are found both on leaves in the upper parts of the rice plant and on tillers near the base.

Adults make their first appearance during the rainy season, June-July, in the rice nurseries and newly-planted fields. Their number gradually increases to reach a peak during August-

September. Damage appears first on older leaves. Young seedlings wilt and die when it is abundant. However, it usually occurs in low population densities and seldom causes significant damage to the rice crop by removal of plant sap. Adults are highly mobile and enter rice fields in the early growth stages.

Common Cutworm, *S. litura*. It is a highly polyphagous species having several common names, such as cluster caterpillar, common cutworm, cotton cutworm, cotton leafworm, rice cutworm, taro caterpillar, tobacco budworm, tobacco caterpillar, tobacco cutworm, tropical armyworm, infesting rice infrequently. The adult moth has dark purplish brown forewings with numerous spots and light colored lines. The hindwings are whitish, narrowly banded along the outer margin. Moths are nocturnal and hide during the day at the base of rice plants and grassy weeds. Eggs are laid on leaves in clusters and are covered with buff colored hairs. Newly-hatched larvae are small, and blackish green with a distinct black band on the first abdominal segment. They feed gregariously for 3-5 days before they disperse. Mature larvae are stout, smooth, dull grayish in color, with a bright yellow stripe down the back and along each side of the body. There are black crescent spots next to the stripes. The head is black to dull brown with a yellow V-shaped marking.

The young larvae feed on leaf surfaces from the edge towards the midrib. As they grow, they become voracious. Young rice plants are often cut at ground level while older plants are only defoliated. The common cutworms are generally a problem on upland rice because it needs dry soil for pupation. It is distributed throughout rice growing countries of Asia, Australia, Oceania,

South America infesting over 120 plant species including many vegetable, fruit and ornamental crops (Dale, 1994; Pathak and Khan, 1994).

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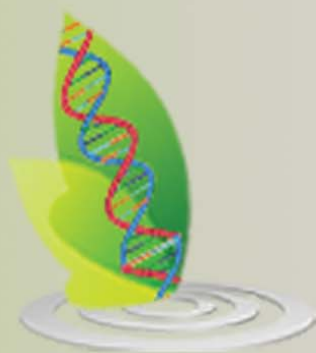
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